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Proceedings of the II International Triple Helix Summit

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Preface

The Second International Triple Helix Summit was held in Dubai in the UAE, during the period November 10–13, 2018, at the Address Dubai Marina Hotel. The first summit was held in Germany in 2017. These summits are planned by the Triple Helix Association and co-organized by local entities. In the case of the Dubai summit, in addition to Triple Helix Association, the Dubai summit was also academically sponsored by the British University in Dubai, University of Dubai, American University of Ras Al Khaimah, Mohammed bin Rashid School of Government, and Al-Maktoum College of Higher Education, Dundee, UK. Supreme Council of Energy and Dubai Tourism were the government sponsors. Al Sahel Contracting was the private sector sponsor.

The themes of the Dubai summit included the role of Triple Helix in transforming nations into knowledge-based economies, the role of Triple Helix in building sustainable economy, the role of government and public policy in developing Triple Helix systems, entrepreneurial universities and their engagement with the Triple Helix systems, smart cities and overcoming security challenges, More Effective Triple Helix Management and partnership, and the challenges for effective partnership and interaction among Triple Helix actors.

During the summit, new students awards were introduced for the first time, with best student paper in areas of Innovation, Entrepreneurial and Sustainability, as well as the overall best conference paper and best case study paper.

The summit was held under the patronage of HH Sheikh Ahmed bin Saeed Al-Maktoum, the President of Civil Aviation Authority in Dubai and the Chancellor of the British University in Dubai. The gala dinner was attended by HE Dr. Thani AlZoudi, the Minister of Climate Change and Environment, who delivered the keynote speech of the event. There were over 50 paper presentations along with 7 keynote presentations and 12 workshops, dealing with different themes of the summit. Representations from academia, industry, and government were evident. UAE, Italy, Spain, Greece, UK, India, USA, Russia, Africa, South America, and more were represented at the summit.

Dubai, United Arab Emirates

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Contents

The Influence of Transformational Leadership Style on Innovation Behaviours: The Case of the Government Sector of the UAE

Ahmad Abdulqader and Khalid Al Marri

Abstract The UAE is putting a lot of efforts and investments to increase its innovation capacity within its various entities to be able to meet citizens needs. Therefore, the country is heavily investing in the development of its human resources. Previous studies have illustrated the importance of having an environment that is conducive to innovation within organisations, and that the innovation behaviour of employees is impacted by the style of leadership of the line managers of these employees. Transformational leadership was in particular found to be the most effective style in terms of fostering employees' innovation. However, such relation was not explored in a country like the UAE. This paper aims to fill this gap, by studying how the transformational leadership style in a public organisation within the UAE as perceived by the employees impacted the innovation behaviour. A questionnaire was used to gather input for the study, adopting 2 widely accepted scales to measure the 2 variables under study. The results indicated that employees perceived their line managers to practice moderate levels of transformational leadership, and employees exercise moderate level of innovative behaviour. A correlation and a regression analyses were conducted to study the relationship between the variables, and the findings indicated that transformational leadership has a moderate impact on innovation behaviour of employees within the government sector in the UAE. This finding not only fill a gap in the literature, but also suggest practical actions that could be taken to increase transformational leaders within the country. A main limitation in the study is the target sample achieved, which is not only low, but also not very representative of multiple governmental entities within the country, which limits generalizability. Future research should take into consideration these limitation, as well as the differences that the demographics of the respondents could bring to the findings.

Keywords Transformational leadership · Innovation · Innovation behaviours · UAE · Leadership style

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1 Introduction

To ensure greater responsiveness to the citizens' needs, public organisations around the world encounter several challenges. Accordingly, organisations must adopt a new leadership style focused on innovation. Such a leadership style requires an organisational culture that fosters involvement and effective participation of employees in decision-making. Furthermore, organisations must be flexible to adjust to rapid changes in the business environment and ever-increasing uncertainties. Therefore, leaders should be determined and able to inspire employees to increase their participation and work enthusiastically towards achieving the organisational goals. Hence, an organisation must enhance their organisational innovativeness to ensure competitiveness [32]. Generally, leaders are regarded as a crucial factor in stimulating innovative behaviour of employees, which is critical considering how competitive and dynamic has the business environment become [14].

In recent years, the focus of organisational researchers has been on exploring the influence of transformational leadership on innovation [15]. In particular, top leaders have unique abilities to identify environmental changes and trends and to initiate innovative measures for increasing organisational effectiveness [13]. Effectiveness, in turn, stimulates organisational innovation [27]. Policies of development, training, promotion, selection, and recruitment foster effective leadership, which leads to improved performance, innovation, and overall well-being and health of the organisation. On the contrary, the consequence of a lack of good leadership is frequently insufficient or absent motivation of employees to efficiently and innovatively carry out their tasks.

Although it is commonly accepted that leaders are crucial for fostering innovation of employees, the current literature lacks integration of innovation and leadership research [10]. Hence, the aim of this paper to explore how transformational leaders influence the innovation behaviours of employees working in the government sector within the UAE. The UAE was selected for a number of reasons. First, it has achieved impressive results in terms of human resource development recently. Considering its scarcity of natural resources apart from oil, the UAE is forced to develop its human capital. Unlike numerous other countries in North Africa and the Middle East, the UAE has significantly reduced illiteracy. What is more, it attracts highly skilled professionals from abroad, and it is a significant importer of human capital. What is more, it is known for pursuing innovation in all spheres of life, in particular on a governmental level. In fact, 2015 was declared as the national "year of innovation." Hence, the UAE represents a particular case of innovative leadership, and this study has a potential to bring important practical implications.

The study will contribute to the literature on the topic of leadership as it will provide empirical data to be used to enable public sector entities to enhance their capabilities to innovate not only in the UAE, but of other developing countries as well. When compared to other neighbouring countries, the attention the UAE pays to the development of its innovativeness capacities is enormous. Consequently, it is a unique case in the region as it regards the development of human resources to be of utmost importance. Moreover, the contribution of this research lies in the fact that it will provide in-depth insight about the impact of leadership styles on an innovative behaviour of employees, which is assumed to lead to increased satisfaction of citizens by the performance of the public sector. Additionally, this study will allow leaders of the public sector to assess the need to formulate and implement human capital policies and accordingly enhance the work quality and efficacy of employees. The following section will look on the literature on transformational leadership and innovative behaviour. Subsequently, the methodology and design of this research will be discussed. The last section will present empirical findings and discussions, as well as study limitations and recommendations for further research.

2 Literature Review

2.1 Transformational Leadership

There are various definitions of leadership. As Shaw and Stogdill [35] reported almost all authors who have defined the concept have their own definitions. However, the most comprehensive definition is the one offered by Winston and Patterson [38]:

> One or more people who selects, equips, trains, and influences one or more follower(s) who have diverse gifts, abilities, and skills and focuses the follower(s) to the organisation's mission and objectives causing the follower(s) to willingly and enthusiastically expend spiritual, emotional, and physical energy in a concerted coordinated effort to achieve the organisational mission and objectives.

The popularity of the topic of leadership among researchers and scholars has resulted in the development of numerous theories on leadership in previous decades. The leadership theories and frameworks aimed at explaining leadership styles are transactional, transformational, situational, charismatic, democratic, participative, laissez-faire, autocratic, and bureaucratic [22, 23]. There are exceptional differences in organisations and their cultures globally. Hence, depending on the context, different leadership styles are required. More precisely, a certain leadership style useful for one organisation might not be applicable in the peer organisation. Hence, not a single leadership style can in all cases lead the most optimal organisational behaviour. Considering that the adequate leadership style depends on the specific context and situation, leaders must be aware about exhibiting individual styles. Accordingly, the question is to what extent can a given stale of leadership exhibited by managers influence an innovative behaviour of employees within the organisation? In the contemporary ever-changing business world, flexible and adaptable leadership styles needed to respond to changes are overcome challenges. Two specific leadership styles are regarded as adaptive and modern, namely Transactional Leadership and Transformation Leadership [6]. Therefore, this research will focus solely on Transformation leadership styles and explore its impact on innovative behaviour of employees.

The term transformation leadership was proposed by Downton ([11], cited in [17]). It is one of the most acknowledged styles of leadership and its focus is particularly on charismatic and effective aspects of leadership. Furthermore, there are different definitions of transformational leadership proposed by scholars. Burns [8] described transformational leadership as the process through which leaders cause a major change in the behaviour of their followers. Transformational leadership style allows employees to be mindful of the importance of their performance and tasks in relations to the general benefit of their organisation (Jones and George [18], cited in [20]). It also enables them to identify and pursue their own professional growth and career progression.

The main difference between transformational and transactional difference is that the latter focuses on completing the tasks and receiving recognition and rewards for quality performance. There are two sub-constructs of transactional leadership:

1. Management-by-exception: Leaders have confidence that their subordinates will meet the expected standards when completing their duties. Hence, the status quo is maintained as long as they achieve the set targets, which means that there are no aspirations for further development.
2. Contingent reward: To ensure a superior performance of subordinates, managers guide them in completing the tasks. Rewards and recognition are used to motivate employees to achieve organisational goals.

Hence, subordinates achieve satisfactory performance in exchange for having their physical or material needs met [33]. The examples of needs are promotions and salaries. Nevertheless, this leadership style also includes punishment for a weak performance and unacceptable behaviour. However, it is important to underline that the drawback of exchanging benefits between leaders and subordinates is in the fact that it stimulates subordinates to work only for obtaining the rewards and not for reaching their full potential [40].

2.2 Innovative Behaviour

For a long time, innovation has been singled out as the primary factor for organisational success [21]. Generally, innovation scholars agree that the process of innovation consists of the following stages: the stage of initiation, and the stage of execution [42]. In the same line, it can be argued that innovation represents the creation of a novel and original idea, and the execution of it to create a new service, process, or product [37]. Furthermore, organisational innovation refers to the generation of new useful and valuable products and services in an organisational context [39]. This study adopts the following definition of innovation: all efforts exerted to start and execute new concepts for the objective of achieving particular business goals effectively.

Innovative behaviour is critical for organisations in adapting and responding to the changing environment and quick technological development [19]. It is very important to create efficient operational and strategic practices and initiatives. Frequently, it is accomplished through continual organisational innovation [25, 34]. Hence, leaders are required to be able to identify opportunities for innovation and implement successful new practices. The crucial question for researchers is what enables organisations to generate and implement innovations. Both in the public and private sector, a leadership style critically impacts the organisational innovation. In the UAE, the public sector has a decisive economic role as it is dominant in providing services and goods. Hence, the urgent question is what is behind the extent of pursuing innovation by organisations in the government sector? Through this paper, the author argues that the prime driver of innovation is the transformational leadership style. The following section will introduce the literature on the nature of the relationship between transformational leadership and innovation and innovative behaviour.

2.3 Transformational Leadership and Innovation

Many previous studies on leadership recognised that transformational leadership is as a facilitator of innovation [12, 25]. Importantly, leaders assist their subordinates in demonstrating greater altitudes of innovation at the workplace [36]. The effect of transformational leadership is echoed in morality, enablement, and motivation. Such effects eventually result in innovation. Mumford et al. [24] claim that transformational leaders motivate subordinates to enhance their performance continually and guide them in following innovative approaches to their daily tasks. The increased motivation levels are highly likely to lead to improved organisational innovation. Practicing transformational leadership can also encourage employees to see the vision of the organisation as meaningful [4]. It can also leads them to better perceive their contribution towards the accomplishment of the objectives of the organisation [29].

It is essential that leaders—who can be considered to be transformational—use intellectual stimulation and inspirational motivation to improve organisational innovation [14]. Moreover, they should be able to achieve changes to meet the interests of both leaders and employees. In particular, the role of transformational leaders is to stimulate creative ideas. Previous empirical studies demonstrated that transformational leadership style and innovation behaviour of employee have a positive correlation. To illustrate, a previous study on Australian Hospitals found that transformational leadership positively influenced innovative work behaviour of employees. Moreover, this study showed that more innovative behaviour is exhibited by employees when male managers display transformational leadership [31]. Likewise, García-Morales et al. [16] studied 164 Taiwanese pharmaceutical firms and discovered a positive link between transformational leadership style and organisational performance and innovation. Pastor and Mayo's [28] research showed that the transformational style used by 76 CEOs and presidents of largest companies in Spain is more beneficial for the development of skills of subordinates than the transactional leadership style. In a different study carried out by García-Morales et al. [16] on 408 Spanish organisations, transformational leadership was found to have an influence on innovation, organisational learning, tacit knowledge, absorptive capacity, and slack knowledge.

According to these studies, transformational leaders foster innovation activities within the organisations and at the same time make sure that innovations will have the market success. So far, only relatively few studies have dealt with the impact of leadership style on innovation in the Arab world. For instance, Yahchouchi [41] explored how 158 workers of the Lebanese University perceive the style of their manager's leadership and its influence it brings on organisational commitment. According to the study results, the Lebanese leadership style is closer to transformational than to transactional. Moreover, correlation and regression analysis revealed the influence on the organisational commitment of employees resulted from the transformational leadership style of the managers. Another study conducted on the Ministry of Interior in Saudi Arabia found transformational leadership to be positively related with the innovation behaviour of employees [1]. The study of Al-Nasani [3] concluded that there is transformational leadership has a positive impact on innovation on educational institutions in Syria. Al-Gamidi's [2] study in Saudi universities showed that department heads exhibit transformational leadership behaviour less than deans and vice deans. One more study carried out in Saudi Arabia showed that managers working for governmental entities do not exhibit sufficient features of transformational leadership. Few other studies were conducted in the UAE and looked at impact of the leadership style on organisations. For instance, Transformational leadership was found to be positively impacting team performance within organisations in the UAE, which in turn can lead to more innovations [30]. However, and to the best of the researcher's knowledge, there are no studies that have tried to investigate the relationship between transformational leadership and innovative behaviour of employees within the UAE. This gap in the literature is what this study aims to partially fill.

3 Conceptual Framework

The reviewed literature evidently suggests that transformational leadership has a positive impact on the innovative behaviour of employees. Therefore, the following is the hypothesis:

H1. There is a positive relationship between transformational leadership and innovative behaviour of employees working in the government sector.

More specifically, the aim of the study is to investigate if transformational leadership is a crucial factor of organisational innovativeness through exploring the perceptions of the followers employed in the government sector in the UAE. In the following sections, the research methodology will be presented regarding a sample, population, and measurement instruments, and data collection and analysis will be introduced.

4 Methodology

This part of the paper will explain the research design and methodology, the sample, variables, measures, and tools used for analysis.

4.1 Design and Sample

To explore the relationship between the innovation behaviour of employees of entities operating in the government sector and the leadership style, the primary data were acquired through a survey questionnaire. The researcher adopted a convenience sampling approach to arrive at respondents. For this reason, a single public entity within Dubai was selected for this study given the researcher's good access to possible subjects for the study. The target sample included the respondents with diverse backgrounds and career levels. Survey Monkey was used to distribute 47 questionnaires, which also represents the size of the workforce of this entity. The response rate was 42%, as the researcher received responses of 20 employees. Given the time during which the study is conducted, and the unavailability of the majority of the employees during the summer vacation, the response rate was not as expected. The language of the questionnaire was English, given it is the common language across employees. Initially, the pilot study was carried out with 3 respondents to ensure clarity and validity of the questions. Subsequently, the final draft of the questionnaire was given to the target sample on July 9, 2017. They had 15 days on disposal to fulfil it.

In this study, the Multifactor Leadership Questionnaire (MLQ-5x) by Bass and Avolio [5] was adopted to examine the transformational leadership styles, but only considered the 12 items related to transformational leadership. The 22 items questionnaire of Scott and Bruce [34] was used to measure respondents' attitudes about innovative behaviour practiced in their organisations. All questions were close ended, divided into four parts. The first part was a cover letter aimed at explaining the study objective; the way gathered data would be used by the researcher, and how the confidentiality of the responses and the privacy of the respondents will be ensured. The second part included 6 items related to the personal profile and demographics of the respondents. The third part included 12 items aimed at measuring the leadership style of line managers. The 5-point Likert scale was used. The fourth part included 22 items aimed at measuring the job satisfaction of employees. The 5-point Likert scale was also used. The Statistical Package for Social Science (SPSS) version 23 was used to carry out the data analysis.

4.2 Variables and Measures

There are two primary variables in this study:

1. Transformational Leadership
2. Innovative Behaviour

The independent variable is the leadership style. The Multifactor Leadership Questionnaire (MLQ-5x) of Bass and Avolio [5] is widely used to measure the leadership style. The short version of this questionnaire consists of 20 items and the longer one of 100 items. In this study, the short version will be used to minimize the effort of the respondents, and considering that both versions have the same purpose and similar validity and reliability [26]. The dependent variable in this study is innovative behaviour. A reliable questionnaire of Scott and Bruce [34] was adopted, and 22 items were used to measure respondents' attitudes about innovative behaviour practiced in their organisations.

The author conducted Cronbach's alpha test to verify the validity of the scales used in the study. The test on the leadership style scale yielded a value of 0.945, which indicates a very high validity. When the same test was conducted on the innovation behaviour, the score was around 0.41, which is considered a poor internal consistency. In an effort to improve the consistency, a further analysis was conducted to verify if the validity can be improved by deleting certain items from the scale. The researcher found that an improvement in the alpha score can be increased to 6.7 if the items "Assistance in developing new ideas is readily available", and "This organisation gives me free time to pursue creative ideas during the workday" are deleted. Hence, these questions were dropped from the scale. In light of the small sample size of this study, the unstable alpha coefficient is something to be expected [9].

5 Data Analysis, Main Findings and Interpretation

The research aim is to investigate the nature of the relationship between transformational leadership as perceived by employees within the government sector in the UAE, and the innovation behaviour of employees. In this section, the data analysis and the findings will be discussed. Table 1 presents correlations analysis. According to the results, the employees surveyed in this study perceive their line managers to be considered transformational leaders at a moderate level (63.5% = 3.1/5). Concerning innovative behaviour, employees within subject entity do behave innovatively also at a moderate level (63% = 3.1/5). There is a weak positive correlation between transformational leadership and the innovative behaviour of employees practicing

Table 1 Correlation analysis

		Transformational leadership	Innovation behaviour
Transformational leadership	Pearson correlation	1	0.41
	N	20	20
Innovation behaviour	Pearson correlation	0.41	1

innovation in the UAE public sector. The p value resulted from the correlation analysis is equal to 4, at the 0.01 significant level. Despite the weak correlation, the first proposed hypothesis is accepted, and it confirms previous research findings.

Apart from the correlation analysis, a regression analysis was carried out to explore to which extent the transformational leadership—in this research is considered the independent variable—can explain the variation of the innovative behaviour of employees (which is the dependent variable). From the analysis, r2 is found to equal to 0.15, which means that 15% of the variation in the innovation behavior of employees in the UAE government sector is explained, or accounted for, by the variation in the transformational leadership of line managers. The results also showed that transformational leadership directly and positively impact innovation behaviour of employees. Therefore, H1 was supported.

6 Discussion and Implications

This research theoretically contributes to the literature. Confirming the existing research, it was revealed that there is a positive relationship between the independent variable—transformational leadership—and the innovative behaviour of subordinates, which is in line with previous studies [1, 3, 31], [7]. According to the results, the transformational behaviour represents 15% of the variation found in the innovative behaviour in the UAE Government sector. Hence, it is recommended to managers to practice this style of leadership to foster innovation. More specifically, it is recommended to:

- Stimulate subordinates intellectually by encouraging them to think in creative ways, broaden their interests, and approach realistically to challenges and opportunities in the dynamic business environment.
- Share a common vision of the organisation for the future and to motivate subordinates to work together to achieve it.
- Establish individualised, participative, and interactive relationships with subordinates and to aspire to meet their higher needs.

Furthermore, transformational leadership should be an essential part of the training programmes offered to line managers and leaders in the UAE. This study shows that public organisations should organise transformational leadership training courses and select supervisors with adequate leadership skills priors to implementing the programme of innovation.

7 Limitations and Future Research

This study has several limitations. First, its focus was on the public sector. Accordingly, it is not possible to generalise them on the private sector in the UAE. Furthermore, it is challenging to compare findings due to a lack of similar studies of the relation between the two variables within the UAE and other Arab countries. Also, the perceptual data are based on the subordinates' evaluation of direct managers, and not on a comparative evaluation of managers. Also, this study has the cross-sectional design. It would be better to carry out a longitudinal study to explore the influence of transformational leadership on innovation behaviour in the long run.

Considering those limitations, it is recommended that further studies have a longitudinal design for exploring the influence of transformational leadership on innovation. What is more, in this study, only a survey technique was used. In the follow-up, qualitative methods should be employed to reveal how the behaviour of leaders encourages and enhances innovation behaviour of employees. What is more, only the transformational leadership style was considered in this study. Commonly, it is argued that transformational and transactional leadership styles are similar. Therefore, both leadership styles should be considered in further research to determine which one has more impact on employee innovation. Finally, this study explored the immediate relationship between the leadership style of managers and innovation behaviour. It is suggested that further research also investigates the mediating factors such as organisational support, commitment, and job satisfaction.

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The Role of Mohammed Bin Rashid School of Government in Capacity Building Towards Making Dubai a Leading Innovative City of the Future—Case-Study

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Abstract Dubai has consistently improved its ranking to be the most innovative city in the world. The Dubai Innovation Index 2018 has ranked Dubai as the 14th city out of 30 on the index (Sutten in Dubai rises up Dubai innovation index 2018, [1]). The top performing cities were Hong Kong, followed by New York, London, Singapore, and Seoul. The Global Innovative Index 2018 placed the UAE at the top of all Arab countries, reflecting its status as one of the world's most innovative countries (Dutta et al. in Global innovation index 2018: energizing the world with innovation, [2]). Innovation is also part of the UAE Vision 2021, which focuses on innovative Emiratis building a competitive economy. Several steps and initiatives have been undertaken to promote and encourage innovation across all sectors such as Mohammed bin Rashid Centre for Government Innovation, Government Innovation Labs, CEO of Innovation, Year of Innovation, National Innovation Strategy, Free Zones, and many more (United Arab Emirates Government Portal in Innovation, [3]). Education is one of the key pillars of the UAE National Innovation Strategy 2015, which demonstrates the government's commitment to enhance the nation's capacity to innovate and create (United Arab Emirates Government Portal in Innovation, [3]). By realizing the need and potential, Mohammed bin Rashid School of Government launched the first-of-its-kind Master's degree program in innovation management. The program aims to empower professionals to develop their creative expertise within the context of innovation management in public and private sectors in the UAE. The program was designed to help students improve their ability to analyze and solve problems with the help of contemporary innovation management perspectives and innovation strategies. The MIM is an executive master's degree program accredited by the Ministry of Education and is offered on weekends. The program is into its 2nd year and 28 students are currently enrolled. There are six core modules concluding with a dissertation and all students need to apply the acquired innovation knowledge learnt during the MIM to produce papers that address real innovation issues.

Keywords Innovation · Ideas · Design thinking · Students

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1 Introduction

Innovation has become part of UAE's strategic directions; the Government is working to develop an integrated system of innovation in public sector through innovation strategies, policies, process and procedures. The aim is to produce innovative government services, processes, management and create awareness to increase competiveness of UAE, and to convert it into organized corporate culture practiced within the government.

The government employees aim to pursue graduate degrees in innovation to learn, and discover innovation methods and to align their skills with government directions. The new approach creates necessity for innovation across departments and CEOs' have an undeniably positive influence on the public servants to earn degree in innovation management. Aside from government encouragement, other employees in private sector pursue innovation degrees, as their chosen profession requires innovation qualifications while many are considering to change their career or becoming entrepreneurs.

The Master in Innovation Management (MIM) program is designed specifically for professionals wishing to develop their skills and understanding of the management activities undertaken within the context of the evolving and complex world of innovation management. Primarily the student cohort are individual students selected and sponsored by various government departments as part of the government training and development initiatives. The MIM program supports the 2015 UAE Innovation Strategy, as it has been designed to help students improve their ability to analyse and solve problems in the context of contemporary innovation management scenarios.

A number of universities are offering programs in innovation: University of Wollongong; Rochester Institute of Technology; Hamdan Bin Mohammed Smart University; American University in Dubai; and, Khalifa University of Science and Technology (*Source* CAA). These programs mainly are geared towards corporate business sector. Whereas, innovation program at MBRSG caters to both the private and public sector organizations. This gives us an edge over other institutions as we can capitalize on a large population of aspiring leaders working in the government sector.

2 Program Learning Outcomes

Students completing the MIM program are able to:

1. Critically evaluate the ethical and cultural dimensions of innovation management in the public and private sectors.
2. Understand and apply innovation theory, process, structure and systems.
3. Synthesize the purpose, design, functions, and character of innovation management.

4. Apply a critical selection of appropriate research instruments and advanced problem solving skills to utilize knowledge from the external and domestic factors and drivers that determine innovation management.
5. Appraise the role of innovation management driving local outcomes.
6. Use effective leadership and teamwork skills to solve complex public organizational problems and communicate policy decisions.

3 What Does Master of Innovation Management Teaches?

MIM at Mohamed Bin Rashid School of government focuses on methods of innovation, service innovation, competitiveness, and leadership dynamics. The program moreover offers research methods and the student is requested to submit a dissertation paper that addresses real innovation issues in his/her work environment.

In dissertation, the students are engaged in research development of original work, as they will carry in-depth study of the selected issue in the goal of producing innovative and creative analysis. Students work will help us understand the issues and matters in real work environment linked to innovation through knowledge creation. Their dissertations are important to School and the successful one will be designed and uploaded into the MBRSG website; on the other side, the Student will learn new techniques, which will show ways to look at issues and it will thrive their learning and understanding.

The MIM is targeting to shape high-qualified employees to meet the innovation market requirements, which will benefit them in achieving their career path ambition. Therefore, the Master of Innovation Management adds to learning environment by focusing on innovation issues in scholarly methods.

– The MIM is innovative because it evaluates the ethical and cultural dimensions of innovation management.
– It focuses on applying innovation theory, process, structure and systems.
– It is scholarly because it applies a critical selection of appropriate research instruments and advanced problem solving skills.
– It is demanded because it meets the government requirements and it appraises the role of innovation management driving local outcomes.
– It is developmental because it uses effective leadership and teamwork skills to solve complex problems.

4 Delivery Mode

Each taught MIM module is delivered as integrated units over three weekends each semester. In each full-day session there are two 3-h units which are further divided into a lecture and a seminar. There are 36 contact hours per module. A robust program of

Directed Independent Learning, use of e-resources and individual academic advisor support supplement block teaching. The program can be completed in 1 year.

The delivery of each module is designed to allow students to actively engage with the material and critically reflect on the delivered content. Modules are delivered over staggered weekends, which allow time for reflection between delivery sessions. Sessions are delivered between 9:00 am and 5:00 pm each day. Students cover two units in each session. Following the intensive teaching sessions, the students are given time for independent study and critical analysis and reflection, before resuming for a final two-day period. During that time, students work on assignment(s) that measures their analytical skills. The following table lists modular structure of the program.

MIM711	Frontiers of innovation
MIM712	Public sector innovation
MIM713	Service innovation
MIM714	Microeconomics of competitiveness
MIM715	Research methods
MIM716	Strategic management and leadership dynamics
MPP901	Dissertation

5 International Field Trips

The school aims to add to student learning experience by introducing them to international best practices, by taking them to best performed academic intuitions and advanced technological companies in the world. The school has organized three international trips to China, Japan and South Korea. The students were able to compare between their institutional innovations strategies and introduced strategies, were able to ask questions about their research projects effectively and were able to gain insight at the nature of the work across sectors.

6 Introducing Design Thinking Lab

To support classroom discussion the design-thinking laboratory was introduced to all students in the program to encourage self-learning, thinking analysis and problem solving. The goal is to permit equal participation to help the students generate ideas for a particular issue and express everything that comes to minds. The instructor introduces to the students the problem statement and encourages group discussion; all ideas are counted in including odd, funny or unusual idea to help finding creative

Table 1 Design thinking steps

Problem Identification →	Ideas collection →	Idea incubation →	Reporting
The instructor will provide the students with the problem statement and encourage discussion to help finding solutions to the problem.	The instructor will encourage the students to write down all ideas that come to mind, they can write or draw.	The instructor will ask the students to get all ideas into reality and to look into the problem whether it will close the gap or not.	The instructor will request the students to write report on the grouped ideas.

solutions. The instructor then asks the students to take down notes of ideas related to the problem and they should not worry about the quality of the idea (see Table 1).

7 Careers and Employability

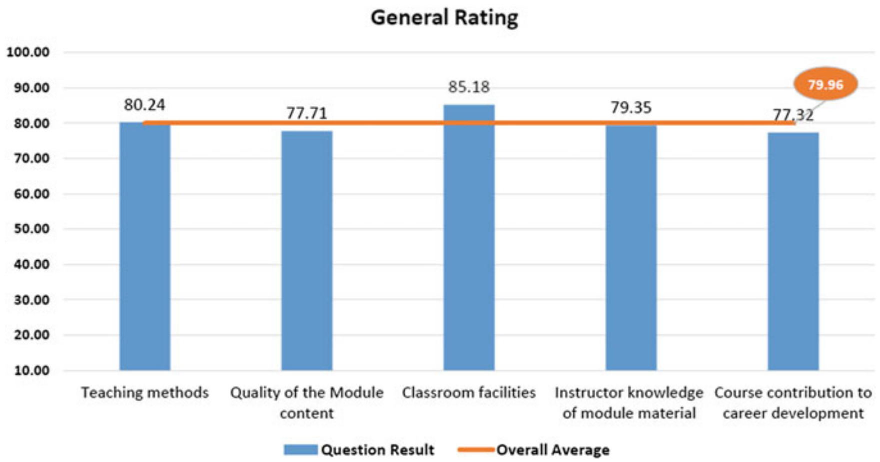
An increasing number of public and private sector entities are becoming aware of the imperative to innovate in order to remain viable in the 21st Century. The creative process of generating ideas for new products, services and new business models is a human skill and the future of innovative leaders looks bright. Master of Innovation Management (MIM) graduates will find themselves working in a range of public and private sector organizations in areas of new business development, innovation project management and innovation consultancy. They will work in product and service contexts across a variety of industries. Their daily jobs will involve supporting development teams when new products are being developed, and they devise and initiate new products and services themselves, becoming new business developers. They also act as consultants to small and medium-sized enterprises, advising on organising businesses for innovation.

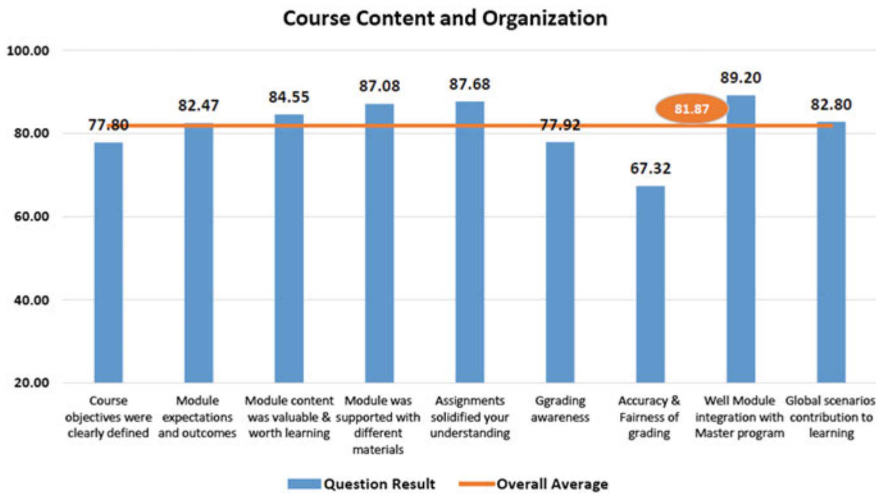
8 Students' Feedback

– An interesting course whose strength is to outline the different types of innovations.
– The course is really useful and well designed.
– Course provided knowledge and understanding on writing policy briefs in the areas of innovation management.
– Use of innovative teaching methodologies.
– Instructors' knowledge and use of examples, case studies and MOC studies for enhanced learning.
– It blends theory with practice.

– Establish exchange channels with government entities, other universities, innovation labs and so on to have a broader understanding of innovation.

The student satisfaction rate for Masters of Innovation Management Courses is **81.10%**. The following graphs demonstrate the student satisfaction result per module.





9 Innovation Dissertation Topics (In Progress)

The students' research projects are designed and supervised around the topics of innovation addressed by Dubai Government. The research topics are influenced by best practices and the course instructor directs the students to design their research projects with a combination of practice and theory by referring to theories of creativity and innovation. Example research topics (1) The Perception of Healthcare Practitioners and Citizens in Dubai Regarding the Perceived Benefits of Patient Portals Used in Hospitals in the City. (2) How can Dubai Media Incorporated Expand its Exposure through In-flight Entertainment. (3) Development of English Language Proficiency for Emirati Students in Public Schools by using Innovative Methods.

10 Student Achievements

Student award, the students of master of innovation management (MIM) have participated in research award and won the competition on future food security in the UAE. The minister of Food Security Her Excellency Mariam Al Maheiri later awarded them personally.

11 Conclusion

The Master of Innovation Management (MIM) is a program that is dedicated to build public sector innovation skills in Dubai and the Arab world. The program is designed to help public servants improve and solve their work related issues innovatively. The first batch of students will graduate in the coming semester; their experience from the field trips and scientific research will stimulate new ideas and will add to their chosen career field. MIM graduates will be the driving minds of creativity and innovation in their institutions and in Dubai.

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Entrepreneurial University and Its Engagement in the Triple Helix System: Roadmapping to Leading Innovation on Early Stage: The Technology Transfer Office Whole

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Abstract This paper presents as main contribution the standardization of complex areas in the development and empirical demonstration of a managerial roadmap tool applied to the TTO (Technological Transfer Office) scenario, which primary role is to anticipate trends in technological and innovative skills at the level of firm to meet the demands from smart cities solutions, among University engagement and Industry. Implementing roadmapping on early stage in innovation provides convergence in key-technologies at the Nuclear an Energy Research Institute, addressing structural, regional, institutional role in Intellectual Property and complementarities to development market front-to-end through chains in health, environment, food, agriculture, energy, chemistry, education, entertainment and arts in the context of the knowledge economy.

Keywords Innovation convergence · Market orientation · Capital intellectual Property polices disclosure

1 Introduction

The objective of this work was to attend the demand to highlight the relationship between the protagonists of the university-industry-government of the innovation system called Triple Helix [18]. In the constitution of the Fourth Helix model according to Carayannis and Grigoroudis [13], society is often determinant in establishing the level of demand, it is a user of innovation and also presents a strong link in

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the generation of knowledge and technologies through its function, application and utility curve.

To the view to the long-term survival of distinct institutions and the reduction of their exposures and vulnerabilities from the environment that can provoke the systemic and non-systemic variables relations between controllable and non-controllable variables, the institutions launch the function of forming interconnected structures in a network, interconnecting the supply chain and clusters to stretch the link to efficiency and sustain a competitive advantage to attend market demand more and more efficiently.

It is notable the movement of institution integration to a channeling of strategies, the objectives and decision making together to aggregate value along the chain in the effort to obtain the market differential in the construction of sustained competitive advantage. The configuration along the chain provides specialization of roles between each actor in the network, and each member is responsible for adding value in the delivery of the product and/or service to a level above the competition focused on meeting the multiple wants and needs of the end customer or society. It is still expected that each actor is contemplated by the aggregation of value, since the idea is for the partners to develop, economically or otherwise, in the way that motivates, integrates and develops, thus reinforcing the link between the partners network.

Due to the growing importance of innovative technologies in the current economy, it is necessary for institutions to have the *know-how* to perform good management and development in this subject at the firm level in the context and conjunctural competitive environment, bidding a context of liability and trust in the governance structure between the parties to the long-term relationship, performing mature of structural policy disclosure axis.

Established in 1957 as the world center for nuclear cooperation, the International Atomic Energy Agency (IAEA) works with its Member States and multiple partners around the world to promote the safe and peaceful use of nuclear technologies. Among the priorities of the IAEA agenda was to balance the work of the main areas such as: technology transfer, security, protection, and technology verification and evaluation. It aligns the support to Member States in the use of nuclear science and technology in the achievement and economic development of global goals and challenges, from meeting growing energy needs and protecting the environment to improving food security and human health [24].

In its latest review, the Manual has added the economic impact of innovation and the ability to leverage and integrate organized economic systems, including local, regional or global varieties. At the institution level, it is possible to measure organizational innovation, product and process innovation, and marketing innovation [30]. To the technology transfer to be used as a driving force for a new cycle of expansion of national development, it's fundamental the articulation between the business sector and the origin of research centers and science institutions. This a promising path of technology licensing or generation of technology-based companies, stimulating the protection of intellectual property and the transfer of technology and the modernization and regulation of research activities with socio-economic impact.

The nuclear area is a special thematic area in this government triennium 2017–2019 [29]. The nuclear area has an important role to play in consolidating a diversified, sustainable and efficient energy matrix, as well as applications in industry, health and agriculture, requiring continuous, basic, applied and technological scientific research. Under the management vision structured by key indicators, it requires the understanding of purpose of the firm's Master Plan of generating sustainable value to stakeholders. Kaplan and Norton [26] propose the structure of strategic maps in backing of decision making, converting intangible assets into future benefits, through the management of key indicators.

Roadmapping is one of the most widely used tools as predictive exercise [3, 6], supporting systematic planning and standardized strategy development. Many countries have developed standardization of roadmaps in various areas reported in intelligent systems, identifying significant opportunities and challenges associated with standardization in complex areas [2, 23].

The most valuable market-based marketing assets are brand value, customer value and intellectual capital, as they influence and capture value to the institution [35, 37]. In the Knowledge Age, Sveiby [38] points out that in recent years the research on measuring Intangible Assets has produced a number of proposed methods and theories. The author considered that the main point in choosing the appropriate methodology is to define what motivated the initiative and more, that any adequate methodology was not find that serves all purposes. The most popular purposes are for public reporting, compliance, and for managerial control and not for learning, as, according to the author's, it should be the primary purpose to initiative. According to him, the reasons for the measurement of intangible assets can fit in:

- Monitor performance;
- Acquisition/Merger (Evaluation);
- Report to Stakeholders (Justification, Public Reports);
- Oriented investment (Decision Support);
- Discovery of hidden values (Learning).

2 Objective

The main objective is the definition of the institutional role of innovation actors in the conjectural context of IPEN among University of São Paulo, Industry and Estate in Brazil scenario.

The specifics objectives constitute:

To define Government general competences in the conjectural context;
To define University competences in the conjectural context;
To define Industry competences in the conjectural context;
To define TTO competencies, skills and abilities in the conjectural context;

To present results from exhibitions, program and projects performed by the TTO in the conjectural context among University, Government and Industry.

3 Literature Review

As long as the higher competition on the environment, more the institutions development ability to respond to the environment forces or, instead, to be proactive leading the change [20]. The first step in the strategic formulation management it's the establishment of mission and vision of the business. The mission is the fundamental purpose of existence of a firm, constituted of base values and ground of activities and functions destined to a certain market. The vision, in turn, is the statement of an ideal and makes explicit the long-term direction and strategic intent [4].

Innovation is vital in improving supply at all touch of supply chains of products and services, influencing and affecting the competitiveness of supply chains beyond the firm's boundary, strengthening peer relationships, and integrating agents [1]. Positively enlarge productivity, and efficiency at the global level in the development of sectors sensitive to national sovereignty [28].

It is imperative to understand the mechanism that propitiate the innovation system and produce it, inserting it into a solid organized and integral economic in order to mitigate traditional social exposure in early stages. It prioritizes the institutionalization of integrated management to the managerial decision-making based on the institutional performance oriented to increase the intelligence capacity in the structured decision-making in the management of intellectual capital. It implies in the formulation of public policies in the scope of generation, sharing and diffusion of information, knowledge and intelligence creating isonomy in the satisfaction of the common business of stake-holders as a disruptive factor in the level of innovation along the supply chain. It will seek to list aspects of institutional leadership that can leverage the skills and practices of technological development and innovation in the short and long term in the formation of public policies in Intellectual Capital [14, 34].

The essential competence or a core competence is a hall of activities that the firm does especially better in relation to its competitors, usually becoming a set of skills or stocks of experience in some activity. Normally, when a firm has core competencies in any area important to market success, these skills form the basis for the development of competitive advantage. Firms develop partnerships or strategic alliances with other(s) institution(s) that have complementary competencies, allowing them to gain new markets, develop new technologies or launch news products [33].

The integration of core competences strategic presents four approaches: (i) concentration: focus and one and only one business sector; (ii) vertical integration: its involves the extrapolation of dominium boundaries in the supply chain or distributions channels; (iii) concentric diversification: its evolves of the entrance of new business related from the original core competence and, (iv) conglomeration diversification: it's a strategic that the expansion of business boundaries was not related between the parties [4].

Productive restructuring and competitive pressures in developed economies since the early 1980s have instituted new and more efficient organizational forms. It is in this context that strengthens the articulation of agents as networks, chains and productive arrangements whose fundamental objective is the complementation of resources, information and skills. Thus, competence and skill in establishing governance and coordination. Governance defines relationships of hierarchy, control, and power structure to establish rules and parameters for the other members of the chain. Coordination, on the other hand, ensures implementation and adherence to these rules [34].

When governing and coordinating productive chains, one should not define the subject only in relations of interests, but of structures supported by public policies, at their various levels [36]. Suzigan [40] pointed out that measures taken by developed countries to restructure their productive sector involved consideration of the nature of macroeconomic policy, the impact of these policies on employment, business strategies and technological incorporation.

In the field of microeconomics, the supply of capital, nature and labor and are classic, tangible production factors that drive development. The supply of technological production factor is conceived with the greater displacement of the market equilibrium, causing potential increase of the frontier of production, of greater market efficiency [32].

According to Pindyck and Rubinfeld [32], the Government acts to correct market failures, reduce risks and uncertainties, minimize exposure to externalities and asymmetry of information in the effective fulfillment of the democratic system of technological transfer as a structuring axis of national and social justice in strategic areas of developing countries. The strategic importance of government marketing planning increases when supply and demand are disconnected [12, 10].

Publicly funded researchers and research institutions of Science, Technology and Innovation (**S&T&I**) are under increasing pressure from partners to go-to-market to bid results to industry. This phenomenon is more recent in Canada than in the USA, in both countries, technology transfer offices (**TTO**) have been established to manage relations between researchers, the private sector and other technology transfer offices [10].

Customer Equity appears as an economic-financial metric, beacon, flow-value calibration mediator, while the geometric structure of the network relations to and with its agents directs the optimization of the application of resources and potentiates the probability of return of the investments [27]. Many studies have pointed out that economic analysis through the client base is a more secure and direct method for the evaluation [22, 21]. This approach assumed that all parties have same opportunities to make choices to achieve greater benefits at lower cost, assuming that individuals have the available options that maximize their choices [11] and that the market is efficient [19].

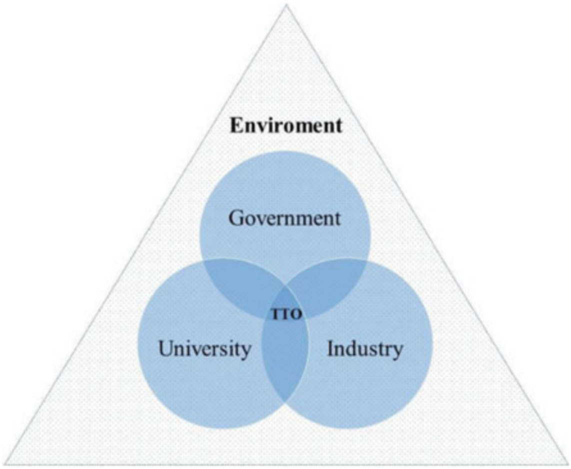

Fig. 1 The Triple Helix social structure. *Source* Adapted from Etzkowitz and Zhou [18, p. 41]

The Triple Helix social structure (Fig. 1) integrates an important approach in the isonomy and symmetry of the relations of and between the peers. **TTO** being hybrid organization witch the hydrous flows institutions the meeting of the common business, approaching and retro-feeding the cohesion of relationship over time [17].

In the path of positively influencing the political environment, managers have a collection of strategic options to lead the best path in the entropy of the technology transfer system, improving security, protection and market regulation, through the development of public policies, social, ethical and environmental responsibility. The increase of legitimacy and institutional reputation is achieved with the increase in the level of attendance of the social demand among the stakeholders [4].

Based on the bibliographical review carried out with deepening in the 120 empirical cases, Perini [31, p. 111] set-up a denomination of a customer—**customer is an intangible asset**: customer is a scarce resource, desired and expensive to maintain, these factors being more in competitive markets. Customer is an intangible asset when it stores value as it which consolidates benefits which transformed into monetary value at some point in the future. **Customer is a tangible asset** in that it interacts with tangible assets (products and machinery) and intangible assets (brands and intelligence) to the value creation. Customer has a direct relationship with the generation of cash flow while other intangibles do not.

4 Methodology

How can we advance the social understanding of cities and increase the possibilities of creatively addressing urban problems? [2] The evolution of the Scientific Administration to Systemic Administration implies in the development of abilities, competences together of innate characteristics of the leader in four fundamental roles

(1) To plan, (2) To organize, (3) To implement and (4) To control [4]. For Cooper and Schilndler [16, p. 32], "the empirical research and critical terms refer to the requirements for the researcher to test subjective beliefs against objective reality and have the results open for further testing."

The elaboration of frameworks and applied structures [1] of the institutional design of the strategic roadmapping in the technology transfer was compose from the model of the Triple Helix [18, 17]. The conjectural context applied in the IPEN-CNEN/SP, was characterized relating the strategic theory of administration of causes of formation of networks and habitats of innovation to the path of greater regulation in the design of institutional roles in convergence with the industrialized country models and guided by the OECD manuals for collecting, reporting and using data on innovation.

The model of the initial triple helix of IPEN-CNEN/SP was drawn up, evidencing mainly the business competences of displayed sections of each statutes, laws and management committee reports and strategic programs to optimize a bidding in the context related from the institutional historical thematic exhibitions [5].

The Oslo Manual was characterized by a proposal for Guidelines for the Collection and Interpretation of Data on Technological Innovation, which aims to guide, standardize concepts, methodologies and construction of statistics and indicators of Research & Development in industrialized countries. It's main contribution was to define internationally parameters aligned in order to parameterize data collection, concepts and language, it defines terms and it clarifies the dissemination of results to the creation of a culture of technological development and innovation [7–9, 30].

Description of contemporaneous phenomena and formation of social memories to spread and contribute do innovation culture was observed. It refers to official documents that define institutional competences, relating the form of the relationship with the literature, prioritizing the efficiency and institutional cohesion of technology transfer to society and customer as the first need.

5 Results and Analyze

Developing the role of Government, University and Industry, "emerging from the Chrysalis to become new social vocations" [18, p. 41].

In the conjectural context, the Government field of Fig. 1 is represented as The National Nuclear Energy Commission [15], a federal authority created by Law No. 4,118 of August 27, 1962, linked to the Ministry of Science, Technology and Innovation, with administrative and financial autonomy, with legal institution under public law, with headquarters and jurisdiction in Rio de Janeiro—RJ, Brazil in accordance with the attributions contained in Laws 6,189, December 16, 1974 and No. 7,781, dated June 27, 1989, and in Annex I of Decree No. 5,667, of January 10, 2006, has the following institutional purposes:

I collaborate in the formulation of the National Nuclear Energy Policy;

II carry out research, development, promotion and rendering of services in the area of nuclear technology and its applications for peaceful purposes as provided for in Law No. 7,781, of June 27, 1989; and

III regulate, license, authorize, control and supervise such use.

The Nuclear and Energy Research Institute (IPEN-CNEN/SP) is held at São Paulo, Capital, one of the 10 biggest cities of the globe with high density on population and market demand for a response to urban growth and regional plans associated. The IPEN-CNEN/SP is an autarchy linked to the Secretariat of Economic Development, Science, Technology and Innovation of the Government of the State of São Paulo and managed technically and administratively by the National Nuclear Energy Commission (CNEN) of Science, Technology, Innovation and Communications (MCTIC) of the Federal Government.

According to the IPEN-CNEN/SP Master Plan (2010–2020), the strategic objectives highlight as first priority (a) the construction of a Brazilian Multipurpose Reactor, (b) Radiopharmacy development, (c) Innovation Development and (d) Human resources planning. The IPEN's mission is: "Our commitment is to improve the quality of life of the Brazilian population, producing scientific knowledge, developing technologies, generating products and services and training human resources in nuclear and related areas" [25].

The IPEN-CNEN/SP holds eleven (11) research centers, which most researchers are physicists, chemicals, electrical or mechanical engineers, mathematicians and statisticals. The subject of institutional research center was illustrated in Fig. 2.

In the conjectural context, in Fig. 1 the University of São Paulo [39] is a public university, maintained by the State of São Paulo and linked to the Secretariat of Economic Development, Science, Technology and Innovation (SDECTI). The talent and dedication of faculty, students and staff have been recognized by different world

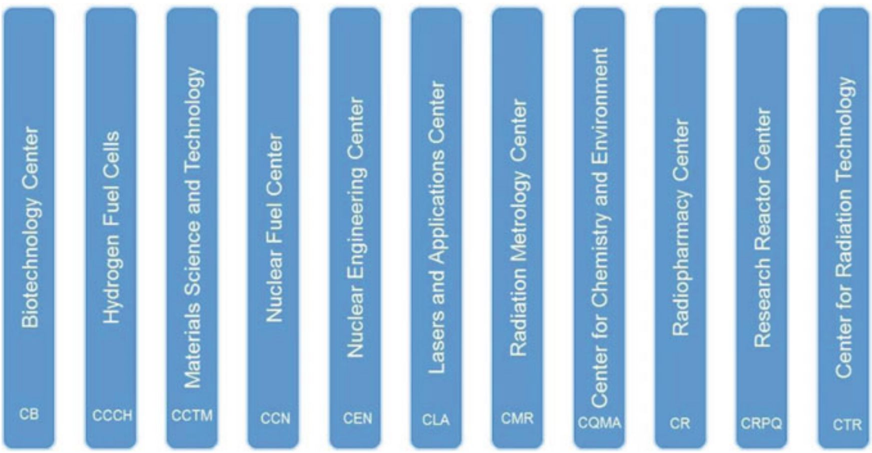

Fig. 2 Institutional research centers. *Source* IPEN [25]

rankings, created to measure the quality of universities based on several criteria, especially those related to scientific productivity.

The University of São Paulo (USP), created by Decree 6283, dated January 25, 1934, is a special regime autarchy with didactic-scientific, administrative, disciplinary autonomy and financial and patrimonial management. In its Statute the purposes are:

I promote and develop all forms of knowledge, through teaching and research;
II to provide higher education for the training of persons qualified to carry out research and teaching in all areas of knowledge, as well as to qualify for professional activities;
III to extend to society inseparable services from teaching and research activities.

The Industry in Fig. 1 can absorb total meaning of marketing in the Customer Equity theory. The vectors that influence customer equity vary from sector to sector. While some segments are focused on short-term transactions, others focus on long-term relationships. The structure of the customer equity is explained by the Brand Value, Retention Value and Value of Value. The Value of Value is defined by the objective evaluation, utility of a brand, the relationship between what is perceived as value and how much is paid of what was perceived as value delivered, being quality, price and convenience its determinants. Brand Value is defined as the subjective and intangible assessment of the brand by the customer, being influenced by the marketing actions of the company and by the experiences and associations of the customer in relation to the brand. The value of retention is the client's perception of the strength of the relationship between him and the company, being influenced by loyalty, recognition, affinity, and other programs [35].

The TTO role actual is to advise IPEN-CNEN/SP on the protection of intellectual property rights and the use of scientific and technological knowledge, through partnerships and technology contracts, for the benefit of Brazilian society. The TTO aims to manage innovation policy with the following minimum attributions in implement, improve and ensure the maintenance of institutional policy to encourage the protection of creations in intellectual properties policy like licensing, patents, project innovation and other forms of technology transfer.

In Brazil, according to Decree 9.283 of February 7, 2018, the incentive for innovation has provided the increasingly strategic positioning of the NIT(s) Nucleus of Technological Innovation to overcome conflicts of the technology transfer system and leverage Brazil among the countries of higher S&T&I development. Table 1 synthesizes the institutional exhibitions of technologies in early stages, which become a year program to attempt patents in potential to shape the smart cities solutions.

The objective of this work was to meet the demand to highlight the link between brands, clients and economic and social value drivers, making links between marketing and finance disciplines. Complex and sophisticated models were avoided, while the development of an empirical institutional model bidder was demonstrated through the empirical application of simple and intuitive concepts, from information available in reports and public information that can be readily used by any investor or administrator or interested party. The results indicated that the customization of

Table 1 Institutional technology exhibition of IPEN Brazil

Year	Themes	Research centers	Patents displayed	Invitations	RSVP[a]	Attended
2015	Biotechnology	CB	5	89	17	16
2015	Lasers	CLA	5	125	21	6
2017	New materials health and environment	CB	19	237	73	35
		CCTM				
		CLA				
		CQMA				
		CTR				
2018	Green technologies	CQMA	17	166	52	13
		CCTM				

[a]RSVP is the acronym of the French expression "Répondez S'il Vous Plait" which in Portuguese means "Responda Por Favor". It is very common to see this acronym in invitations to events such as marriage rituals, where confirmation of presence is essential

empirical models are indicative of precursors of economic value, promote economic synergies and experiences to the target public in a way that generate and transform economic, social and cultural values over time.

6 Conclusions

To learn from the demand for solutions from big cities and improve the possibilities of creative solutions to the urban problems are one of goals from (**S&T&I**) Institute. A combined relational and cultural approach to the Transnational Nuclear and Energy Research Institute and the most representative academic institution of Brazil, University of São Paulo (USP), and other arrangements and possible formats on beginners, start-ups, spin-offs, business incubators, focusing on alignments and construction of cooperation network to the demand from smarts cities.

Such this conjectural and transitory context in early innovation on creation knowledge with quality value to stakeholders, the TTO must development new competences and skills to address challenges to shape the future, specialty in development marketing and commercial skills on trust and liabilities environment competences instead technology and product development. The key success remarks enlarge *welfare state* in the context of development country.

This prism of utility is typical of the greater intensity of the marketing techniques, being able to be classified in ways to improve the Technological Transfer and Diffusion, being the use of these techniques an activity of the (**S&T&I**) Institutions, that they are Bidders. The prioritization of Customer Value theory to the Quadruple Helix prism, invokes the scale of innovative activities, the characteristics of the (**S&T&I**) Institutions and the internal systemic factors in the reduction of uncertainty and risk minimization, appreciating the maintenance of guarantees of the long-term relations of the understanding the dynamics of the precise relations to the stabilization of the innovation environment.

The descriptive and explanatory analysis dealt with by results found through principles of analysis of local phenomena and international institutional brand reach, as well as its extension of exposure beyond the firm's boundary after the exhibition period, bringing to light collaborations, partners, students, industry, universities and government collaborations of results obtained by through systematic feedback actions between researchers and institutional committee decision-makers.

The roadmapping of technological bid exhibitions organized from the TTO is a key-trend action in the construction of dialogue and point of contact to match supply and demand to attend smart cities solution. The **Political Action Committees (PACs) are formed** in order to standardize the leadership structure and provide representation of diverse interests, and improve the rationality and quality of the management committee decision process.

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The Role of the 'Triple Helix' Model in the Development of Emerging Economies

Anju George

Abstract A healthy synergy between Government, Industry and Academia is instrumental in the creation of smart cities with sustainable economies. Each of these stakeholders in their specific capacities needs to streamline their techniques and methodologies to approach the way cities function in an innovative manner. Adoption of inclusivity is key to efficient city planning, and this involves removing barriers to building effective partnerships, such as discriminatory red tape, ineffective bureaucracy, and the like. By 2050, as per estimates released by the UN in the month of May, about 2 in 3 people will be city dwellers, with the boom concentrated in India, China and Nigeria. Burgeoning, yet resilient economies, need the right tools to embark on a journey of growth and prosperity. The imbalance between the roles played by the government, industry and institutions tends to be felt more so in situations where the relations between these systems are ambiguous, and sometimes even non-existent. This paper aims to understand the complexities behind these interactions, the challenges to brokering sturdy alliances, and the solutions that a 'Triple Helix' prototype will bring to cities. Where knowledge-based development is of high priority, managing spheres of government through informed public policy, academia through education, and industry though sustainable trade, will not only add value to cities, but help in framing innovative solutions to global problems including climate change and economic depression. Fostering growth of cities in all its dimensions is a vital step to paving promising futures for the generations to come. This article is intended to start meaningful dialogue on what a 'triple helix' model can achieve, and can then serve as a guide that launches benchmarks for performance of the sustainable development of emerging economies.

Keywords Sustainable economies · Challenges · Triple helix · City dwellers · Knowledge-based development · Emerging economies

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1 Introduction

The need to bring about change in the way cities are modelled cannot be overstated. The perspective of roles played by government, industry and academia in the journey to innovative excellence needs to be studied again with a whole different mindset.

Citizens and planners alike have been making informed decisions, but based on some inherently problematic principles. Here is where the implementation of the Triple Helix model is absolutely necessary for the healthy functioning of cities.

Innovation and Innovation Management are essential instruments that can aid in managing changes that society and its productive sector are facing, so as to investigate how the right balance between competitiveness, trade demands, social equity and sustainable development can be brought about in cities [6].

This paper aims to understand and hopefully make the readers aware of the benefits of employing a Triple Helix model through a couple of case studies.

2 Triple Helix Model

The Triple Helix model is a spiral model of innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalisation. The Triple Helix denotes the university-industry-government relationship as one of relatively equal, yet interdependent, institutional spheres that overlap and take the role of the other [8]. This triadic relationship is how a knowledge-based economy comes to life, which draws upon the benefits of each of these three spheres. The key takeaway from this observation is that there is a healthy overlap between the functioning of the spheres, rather than each sphere just acting on its own as individual entities (Fig. 1).

Another important aspect of a Triple Helix model is the linkage between government, industry and the institution. There have been methods that have been tried and tested before, though nothing can be said about what the best recipe for the creation

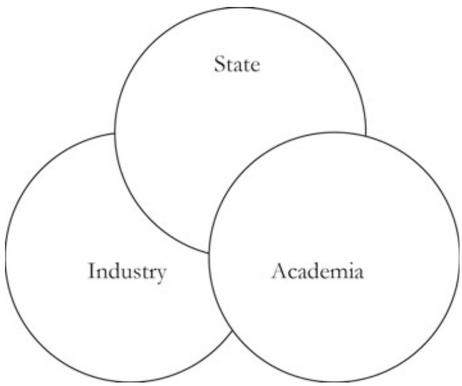

Fig. 1 Overlapping of institution a spheres that harbour collaboration and cooperation

of a healthy city really is. The linkage should neither be one that is of a hierarchical nature with a top-down approach, nor should the linkage be one where separate entities act alone without being influenced by the others. The link should instead consist of the spheres overlapping with one another, where there is mutual collaboration, informed dialogue and valid inter-entity informational exchange across a myriad of disciplines and sectors.

2.1 Why Triple Helix Is Pivotal in the Building of Smart, Sustainable Cities: Importance of Steady Partnerships Between Academia, Industry and Government

The fastest urbanisation rates in the world are occurring in the continents of Asia and Africa. The emerging economies of today, like India, strive to excel in their path to progress. Cities in India today are faced with challenges that need well thought-out solutions. The solutions need to be brought about with the aid of the Triple Helix model. Implementing the model at top levels is not enough. Actually understanding what the model is, the workings of a successful model and the benefits that can be reaped by adopting the model are absolutely pivotal to creating healthier, dynamic cities. A lot of research papers have evidenced a very strong correlation between alliances and the surge of dynamic, innovation-driven cities.

Crowley in his 2011 paper ‘Streets Ahead: what makes a city innovative?’ theorised how firms and entrepreneurs, who are at the core of the workings of a city, can be the ones who actually drive the supply and demand for innovation [5]. Institutions, both governmental and educational, will then spread the knowledge garnered and drive innovation from very different angles. All of this can and will only happen if there exists a conducive environment for all of this to happen. The only way to do that is for all of the three sectors, university, industry and government, to be able to attract human talent, otherwise known as the ‘creative class’, a term founded by none other than a pioneer on cities, Richard Florida. This forms the base for a healthy innovation ecosystem to burgeon that Mulas et al. talk about in their paper [10]. Mulas et al. defines innovation ecosystems as a collection of stakeholders, assets and their interactions in city environments that result in innovation (primarily technology-based). The stakeholders discussed in this paper refer to each of the three entities. Each of them has very vital stakes in the city. The benefits that each of these stakeholders reap through the entire journey are for them to enjoy and then put back into the system to reap even larger benefits.

Every so often, we stumble on the term ‘smart city’. What really is a smart city? Does ‘smart’ only mean intelligent with respect to technology, or does the word ‘smart’ only start the conversation to what a city should aspire to be? We always tend to ignore the essence of the makings of a city. We label cities with interesting though ambiguous adjectives and think our discussions are on the right path to discovering them. But, that is most often not the case. Anthony Downs said, “‘Smart Growth’ is a code word for whatever the user of this term wants to achieve concerning metropolitan development. Yet different users of the term have totally different goals, so ‘smart growth’ can mean almost anything.”

The creation of innovation districts in cities around the world can be a positive after-effect of employing the Triple Helix model. What exactly are innovation districts though? They are compact urban models that are now emerging in cities which have higher education institutions at their core. Connections with industrial organisations are made here and platforms are launched for the sharing of ideas. There are many universities that have strong linkages to industry. The United Nations Industrial Development Organisation (UNIDO) is one such example. According to the Brookings Institution (Washington-based research group), ‘innovation districts can spur productive, inclusive and sustainable economic development and grow employment while simultaneously addressing the rising poverty and social inequalities in cities’.

The Triple Helix theory that Henry Etzkowitz has popularised has also brought to the fore the concept of Science Cities. They are ‘regional development projects, based upon university-industry-government collaborations, that creatively synthesize local and national resources to achieve science-based economic growth. They typically have an entrepreneurial university as their cornerstone [7].’

Below is a case study in South Africa where the concept of Open Innovation was adopted [11]. Chesbrough defined ‘open innovation’ as the use of purposeful inflows and outflows of knowledge to accelerate innovation internally while also expanding the markets for the external use of innovation. South Africa is not only warming up to the idea of open innovation; as a country it has welcomed this concept with open hands and sees open innovation as a viable method for innovation within businesses.

2.1.1 Case Study: Regional Connect Project, South Africa

The Regional Connect Project was a collaboration between 5 entities: the Research Institute for Innovation and Sustainability (RIIS), the University of Namibia, the Southern Africa Innovation Support Programme (SAIS), the National Business Technology Centre (NBTC) in Zambia and the Eduardo Mondlane University (EUM) in Mozambique [11].

The Regional Connect Project uses an Open Innovation platform that connects technology seekers with providers. The Challenge was open to anybody who was capable of providing ‘intelligent’ solutions. The notable takeaway here is the fact that there was almost no money that needed to be invested towards the programme for the setting up of the proposal that would later be showcased by the participants/future clients. The reason for the almost nil cost was attributed to SAIS subsidising the costs.

Only 5 organisations accepted this offer of participation. Nobody knew why. The Business Development (BD) team of Regional Connect sat down to find out what the probable causes of this were. They summed up technical incompetence, aversion to risk and the lack of awareness to be few of the key factors to have brought about this dismal result.

It is not enough to be a leader in innovation; the common man should be educated enough to make informed decisions. Governmental schemes should be introduced to raise awareness, and industrial stead worthiness is an absolute must.

2.1.2 New City Initiatives

China is home to about 500 smart city pilot projects alone, spread across small and big cities. The Smart Sustainable Pioneering Models Project will ‘evaluate successful models using smart means to solve urban issues from cities and local governments worldwide, present best practices from around the globe to improve strategy, design, operations and maintenance in developing smart urban areas, along with technology and infrastructure, to ensure residents’ needs can be met efficiently and in a timely manner’ [13].

The port cities of the Indian Ocean are also vying for competition to attract investors and fresh talent. Bilateral and multilateral partnerships will garner support for local initiatives to work successfully. By promoting greater awareness, forming a deeper understanding of the actions being taken by the region’s port cities, and by encouraging the sharing of experience on projects, the aim is to identify areas that have the potential of bringing about positive change [2].

3 Challenges to Efficient City Planning in Emerging Economies

One of the challenges to efficient city planning is the lack of funding provided by governments towards R&D (Research and Development). This is probably why these economies are sometimes referred to as ‘catching up economies’ [9]. In North American and European countries predominantly, there is a profusion of research universities. The students and faculty of these universities give their time to studying global cases, analysing data and finding out workable solutions. On the other hand, the ratio of research institutions to the total number of institutions in the Global South is pretty upsetting. As per a recent 2018 article published in the Economic Times, although India’s investment in science (measured in Gross Expenditure on R&D, GERD) had tripled in the past decade, the ratio remained stagnant at 0.6–0.7% of the Gross Domestic Product (GDP) [12]. Therefore, the need for the government to play a more prominent role in transitional economies cannot be emphasised more.

The other challenge that emerging economies face is discriminatory red tape. India is one of those countries that are faced with this phenomenon almost on a daily basis across all sectors.

3.1 *Case Study: Navi Mumbai, India*

The Trans Harbor Link in Mumbai, one of the most popular traffic-ridden metropolises in India, was proposed as a 14-mile series of pillars supporting an eight-lane highway and a rail line (Fig. 2). This artery was much needed, as it would have relieved huge amounts of pressure that the financial capital was now facing, and would ultimately bring about fresh growth and welcome change to a new satellite city, Navi Mumbai (New Bombay). The bridge was designed keeping in mind the heavy choc-a-blocs especially in rush hour. This bridge would supposedly reduce the travel times between the city centre and Navi Mumbai by a considerable amount. Unfortunately, this infrastructural masterpiece, the country's longest sea bridge, was never built. There are talks now, after 3 decades, on how this is finally becoming a reality.

There is a flip side to this story as well. The scores of fishermen who will be affected by the construction of this bridge is that unpleasant side of this story [4]. The sealink will supposedly disrupt fishing activity of about 3000 fishermen who now have their livelihoods secure because of their daily catch along the Thane creek. A lot of these fishermen know what good this project will do for their State despite the harm it will eventually cause them. So, all what they want is for a decent compensation and a means for a daily livelihood once the bridge is constructed.

This bridge remains to be both a symbol of India's emerging economic aspirations and the entrenched bureaucracy hindering its development [3]. This does not happen to be a one-off case. Intractable red tape has, in fact, poisoned not only Mumbai, but India from the time one can remember.

Fig. 2 Locational map of proposed Mumbai trans-harbour sea-link

The next problem is the poor match between the educational (research) sector, and the needs of the industry and society at large, known as 'skills mismatch'. The only way this problem can be resolved is by brokering alliances between the three spheres. Dedicated professionals who can tackle problems of this nature and draft solutions as part of an overarching framework need to be a part and parcel of each of these spheres. These personnel need to be in constant dialogue with one another on the progress, developmental changes and improvements that can be brought about, both long and short-term.

It is in situations like these that one can understand the importance of not just the governmental institution, but governance, and a healthy relationship between academia and the government. It is informed policy that should guide governance. R&D of educational institutions should bring to the forefront the results of research—previous and ongoing—carried out. The data and analysis presented should be transparent, clear and impactful enough to guide policy that can bring about a sea of change for the betterment of cities.

The delivery of services to every section of the society is an extremely vital task, more so in areas that are impoverished. To ensure that the delivery is both effective and efficient, the concept of free expression needs to be revisited. The largely disadvantaged communities do not have a voice. If these communities have as much a right to live in the country as much as their richer neighbours do, then these ugly situations cannot be normalized in any context. The citizens should demand nothing short of serious action. Resolutions will then become a huge part and parcel of how just governance is administered.

Governance deficit arises due to high levels of corruption in the delivery of public services in low-income economies. The negative relationship between corruption and economic growth is largely felt where bureaucratic red tape is high [1].

4 Need for Innovation

Innovation is key especially when it comes to efficient city-building. People have been flocking to cities for some time now. Cities will be taxed with growing populations, pollution, and inaccessibility to basic services and amenities, to name just a few. There will come a time when cities will not be able to handle much more. So, this should be our calling, us cit(y)zens should take action.

The first step to taking action is innovative management. We need to put our heads together to find out how best to tackle these problems; we need to innovate new solutions that may not have been recognised as reliable before. The response to these challenges should lead to the birth of innovative cities. Solidiance, a corporate advisory group, ranked cities according to human talent, knowledge creation, technology, government and global integration in a research paper in 2013, and had placed Singapore as 'the most innovative city in Asia'. In yet another contest held by the Wall Street Journal, Citigroup and the Urban Land Institute, the results of which were released in March named Medellín in Colombia to be the most innovative city in the world. This is not a paper that reveals the results of polls and bases ideas on those results. It is, in fact, a paper that aims to understand what the real makings of a good city are.

We have been broaching about why innovation cities are important and why innovation is key to sustainable growth of cities, but can we really pin down the actual definition of innovation? The term may seem broad to many, ambiguous to some others, and mean different things to the rest of the lot. If not give a dictionary definition of innovation, we can at least point out some of the essential elements of innovation.

Openness, diversity and freedom of expression (whatever the stratum of society the person belongs to) are absolutely necessary. Innovation cities should be the way forward, as there is a human element to innovation cities, which smart cities (that prioritise technology) often tend to ignore.

5 Conclusion

It is in the midst of such conversations that one can say that the adoption of the 'Triple Helix' prototype can really break barriers between industry, academia and industry. The end user of a city will benefit from meaningful dialogue on how innovation can blur these barriers. Ideas should be brought to the table on how people can be retained in cities. Generic discrimination should be a strict no-no when brainstorming sessions are conducted. Talented and educated persons who have a lot to offer will unnecessarily be sidelined if discrimination is not wiped out at every hierarchical level. The Triple Helix model will only be successful if this approach is adopted in full earnestness.

Although the transition towards inclusive innovation will not be an automatic one, inclusive innovation provides a plausible scenario for increased social and environmental sustainability on regional, national and global levels.

Cities are to be experienced and not merely seen. We, as educators and city planners, need to change the outlook of people who are involved in the process of city planning, either directly or indirectly. These persons could belong to a very wide spectrum of people - they could be politicians, innovators, teachers, students, citizens, industrialists or cit(y)zens themselves. As city planners of the future, we need to be able to bring that common ground so that there is effective communication between and amongst all of those involved.

Let me end this research paper with Robert Goodman's quote, "We architects and urban planners aren't the visible symbols of oppression, like the military or the police. We're more sophisticated, more educated, and more socially conscious. We're the soft cops."

Let us be the soft cops that Goodman talks about. Let us introduce change by being informed. Let us pass those ideals over to the urban planners of tomorrow. Let us not be emblematic of what oppressors do, instead let us be socially conscious and come out of our bubbles that we sometimes unknowingly confine ourselves by.

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Bridging Academic Inventors—TTO Managers Schism: The Lean Canvas for Invention

Arabella Bhutto and Cynthia Furse

Abstract The aim of this paper is to bridge knowledge asymmetries between academic inventors and professionals of the technology transfer offices (TTO) by developing a tool—Lean Canvas for Invention (LCI). This tool is to educate academic inventors for incorporating the integral pre-commercialization components such as involvement of stakeholders, patent literature and market review in research proposals. This information has the potential to improve quality of invention disclosures to TTO and to increase chances of commercialization. This paper through interviews explores challenges (Cn) of TTO professionals and proposes solutions (Sn). As inventions disclosed, TTO managers initiate a technology transfer process and explore for patentability and market. If such aspects are considered by academic inventors, at the earlier stage of research process, chances of commercialization strengthen. The Cn and Sn are then adopted to develop an educational tool—LCI, to bridge the knowledge schism and improve the quality of invention disclosures. Cn and Sn are clustered with respect to five components and six sub-components, each with respective checklist required for writing a research proposal for invention. Evaluation of LCI by TTO at the University of Utah for "Acceptability", "Usability" and "Guidance" is given. Feedback from TTO directors, TTO managers and academic inventors helped in development of a pre-commercialization research development tool—LCI. Based on findings and analyses, this paper validates the utility of the LCI as guidance for academic inventors to improve alignment of inventions with the technology transfer process.

Keywords Technology transfer office · Entrepreneurial university · Academic inventors · Knowledge asymmetries · Lean canvas for invention

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1 Introduction

It is evidently learnt that Technology Transfer Office (TTO) is a mechanism of entrepreneurial universities for supporting academic inventions through intellectual property (IP) and commercialization services [55]. TTO professionals perform role of intermediaries between universities and industries for moving inventions through the invention disclosure process to patents and market launch. Their responsibility is of an interactive nature between government, universities, industry and stakeholders [14, 18].

During interactions TTO professionals handle challenges such as motivating academic inventors for entrepreneurial activities, bridging knowledge asymmetries for IP and royalty regimes, relationships with industry experts, understanding early stage of technology and cooperating for moving IP to market [47] etc. These challenges are partially due to knowledge asymmetries [5] between academic inventors and TTO professionals, as they possess different types of archetypal characters [4]. Keeping in view the knowledge asymmetries, this paper develops a tool—LCI for guiding inventors in writing research proposals by incorporating components to bridge knowledge asymmetries and investing their time and grants on technologies with more chances of commercialization.

2 Knowledge Asymmetries

Knowledge asymmetries between technologists and business professionals are due to different education, information sources, competencies, modes of expression and expectations [4, 46]. However, managerial strategy, the recreating missing components [5, 11] can fill knowledge asymmetries and help them relearn through mentoring and knowledge exchanges [2, 38, 57]. Therefore, specially designed technology transfer training, which so far remains missing even in comprehensive technology education programs [20], may reduce these knowledge asymmetries. Heath and Heath [17] discussed about lack of common language, and is observed between science, engineering and business [37]. Academic inventors possess science and technology knowledge, yet TTO professionals require knowledge of technology readiness level (TRL), patentability and market viability. Both sources of knowledge are desired for a formal technology transfer process, yet often this responsibility is left to TTO professionals, with naive participation from academic inventors [26].

Knowledge itself is seen as complex and person embodied [41], and therefore its creation and exchange is highly dependent on the level of prior knowledge [8, 36, 54]. In case where knowledge asymmetries exist, the effective exchange becomes difficult and requires substantial efforts to transfer inventions into products and services [15]. Therefore, in absence of knowledge exchange from inventors, TTO professionals handle challenges and technology transfer becomes difficult and less successful.

Therefore, it calls for strategy supporting a technology transfer process through carefully designed tool—LCI to make this knowledge exchange effective.

3 Business Model Canvas

The formal technology transfer process encompasses a variety of activities with aim of sustainable economic development through formation of new firms [25, 32]. The business model is a useful framework to link ideas and inventions to economic outcome [7] and to explain the logic of businesses through established mechanisms [27]. The model focuses on components such as customers, value proposition, partners, key resources etc. to predict economic viability and is supported by canvas, as a visualization tool, presenting components and their interconnections [39]. This canvas is utilized extensively by academic entrepreneurs through the iCorps mentoring mechanism established by the National Science Foundation [35] to nurture knowledge exchange, entrepreneurship and commercialization of technologies [53]. It is visually effective tool for converting ideas into tangible formats, specifically designed for entrepreneurs focusing on problems, solutions and competitive advantages [31]. Its use as a mentoring tool to entrepreneurs is widely accepted, however, cannot be assumed for academic inventors/researchers before initiating technological developments. Rather it is more effective when technology has already been invented and trying to demonstrate its feasibility. It is utilized late to impact the early conceptualization of an invention, however, its concept is borrowed to design a new tool—LCI, feasible for the early stage of research conceptualization with more chances of commercialization.

4 Research Methodology

This research aims to build a new tool—LCI in an under-researched aspect of literature related to knowledge asymmetries between TTO professionals and academic inventors, at the time of invention disclosures, through adoption of concept of business model canvas. Since this study involves understanding phenomenon causing knowledge asymmetries, the qualitative methodology is fit [58]. A single case design [58] of a top ranked entrepreneurial university, University of Utah for aspiring entrepreneurs by offering 40 mentoring courses, competing in the Entrepreneur challenges focused on business models, and launching companies was selected. Technology and Venture Commercialization (TVC), a TTO of the University of Utah is responsible for filing patents, licensing technologies and launching companies. Even being a top ranked entrepreneurial university, TVC handle many challenges in getting patents and licenses for inventions. A difference between numbers of inventions disclosed, number of patents issued and number of licenses, shown in Fig. 1, endorse their challenges. It clearly shows that not all inventions possess capacities of patents

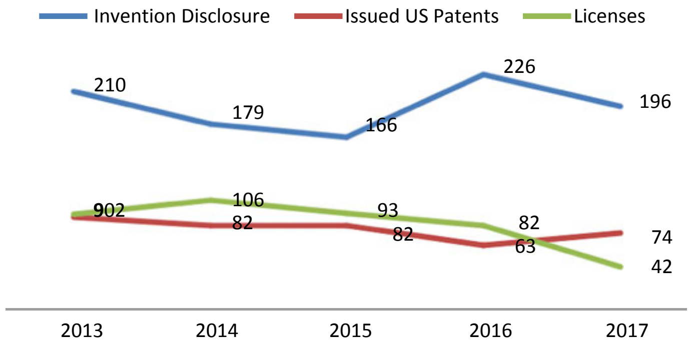

Fig. 1 TVC profile showing number of invention disclosed, patent issued and licenses annually

and licenses and its partial reason is those missing components, which are causing knowledge asymmetries. In-depth 20 interviews with academic inventors and TTO professionals led to explore those missing components. A purposeful sampling strategy helped in learning from information rich respondents [40] associated with different stages of the invention disclosure process. Academic inventors were chosen with two criteria: First, they won research grants for inventions and second, they tried to establish companies with the help of TTO. TTO professionals were chosen based on their relevancy with different teams of IP, new venture, TRL, grants and investments. The interviews led in exploration of number of Cn and Sn.

The open inductive coding [33] of interviews helped in listing missing components under Cn and Sn categories. In addition, through data triangulation [9, 23, 44] documents used by TTO professionals during the invention disclosure process were analysed. This all guided the development of a tool—LCI comprises of five components and six sub-components. The LCI was evaluated by TTO professional and academic inventors. A semi structured survey questionnaire was designed to evaluate the "Acceptability and Usability" of the LCI for technology transfer process" and as "Guidance for academic inventors".

5 Challenges (Cn) and Solutions (Sn)

In traditional research process, inventors conceptualize ideas and invent technologies, which they then disclose to the University TTO. TTO professionals then initiate the knowledge exploration process for IP, market viability and TRLs. In-depth Interviews helped in exploring Cn and Sn of this process.

C1 (Real-World Problem Identification): The academic inventor tends to focus on science and technology of the invention with less emphasis on its alignment with real-world practical problems. Despite asking in invention disclosures if the invention can solve a practical problem, the answers are often vague or immature.

S1 (Stakeholders Involvement): This challenge needs involvement of the end users' perspectives. The involvement of stakeholders at the earlier stage of the invention can help inform the academic inventor about their problems, often raising intriguing research questions. Through contacts with the end users, technologies can be developed that suit their needs [20] and early involvement allows room for creative solutions and the intensive exchange of ideas [3]. Considering simple questions such as "what is to be invented?", "why is it needed?", "whom will it be useful for?" and "what pain will it reduce?" can lead towards acceptability of inventions in markets. It is worth noting that inventions may have confidentiality concerns, so involvement of TTO responsible for negotiating confidentiality agreements is needed. During interviews, one of the academic inventors who has already commercialized his research added that, "*Discussions with stakeholders should be a part of the research process, as it is eye opening and also changes views. In addition, such findings lead towards improvement of existing inventions and towards new ideas."* Another inventor, who was not able to commercialize his research said that, *"if I had met with stakeholders earlier, I would have devised my prototype a little differently, thereby making it more useful for their needs. By the time I met with them, I did not have additional grants to make this revision, and therefore was not able to commercialize my work*".

C2 (Lack of Patent Review): Developing a research question begins with literature review for novel ideas, which typically relies on research articles in journals and conference proceedings. The inclusion of patents by academic inventors is relatively rare, yet this is a key tool to help IP managers explore the novelty, obviousness and freedom to operate. Often well after the research is completed, the patent review may expose existing solutions that call into question the novelty of the idea and prevent patenting the invention. At the time of filing a patent whether or not an invention infringes others' patents is important to consider. Sometimes an invention depends on earlier technologies and might need an access to other patents. If access is costly chances of commercialization may shrink.

S2 (Review of Patent Literature): Including the patent literature along traditional research articles will provide a more complete understanding of the technical landscape, and then the chances of developing a novel idea and its patentability may increase. In addition, regulatory standards may favor or may preclude certain solutions [6] so a review of standards can increase patentability and market adoption. Furthermore, whether or not an invention relies on prior patents is important to consider. Research is not limited by existing patents, and can use the technology without infringement, but commercialization would require the licensing of prior art that is used in the invention. The academic inventors and IP managers must have full assessment of the prior art through patents, citations, and International Patent Classification (IPC).

C3 (Lack of Review of Existing Solutions in market and in R&D pipeline): The knowledge of competitive advantage plays a very important role towards commercialization and is gathered by reviewing existing solutions in markets. Academic inventors most often do not review this aspect. Rather, this falls to TTO including mapping customer segments, current alternatives, barriers to adoption and unique selling points [45]. The existing solutions do not reside only in market but may exist in the R&D pipelines. In order to find the exact gap and to understand value proposition [42], point of parity and point of difference [19], knowledge of market and R&D pipeline solutions is important. If invention is not matured enough to display the science behind it, then TTO cannot move it forward.

S3 (Review of Existing Solutions in market and R&D pipeline): Including a review of existing solutions in research proposals may strengthen its novelty. Information such as "what solutions exist?", "how are these limited?", "what has been tried?", "what has failed?" and "why did it fail?" can assist inventors in aligning inventions with gaps of practical problems. The knowledge of patent citations, license status of patents, owners and assignees can help in exploring existing solutions. In addition, near-term solutions in the R&D pipeline and their assessment through conferences and meeting other inventors is necessary. Inventors may find this information earlier to share with IP managers.

C4 (Publishing vs. Patenting): Academic inventors are driven by the "publish or perish" culture of academics [21]. They must publish in order to promote and this short-term fuse typically drives the need for speed of publication. On the other hand, for patents it is important to not to disclose features of the invention.

S4 (Provisional Patents): The review of patents can help understand the novelty and competitive features of an idea to file a patent. Most often, a provisional patent is filed quite early in the technology development, because of the intention of the inventor to disclose the work at conference or in journal publications. According to an IP manager, "*The higher the competition, the sooner the patent should be filed, because once provisional patents are filed, the inventions can be published and then continuation of patents can take place as inventions advance further.*"

C5 (Academe vs. Industry): Faculty involvement improves the performance of licenses [1], but academic inventors generally do not have training to lead a startup company commercializing their inventions. Many do not have interest or capacity of doing this, but rather prefer to stay in academia [12]. This is generally in the best interests of the university, as well as of inventors, who are likely to be strong faculty members. However, those academic inventors having personal interest and a commercialization-biased mindset are definitely helpful in the technology transfer process.

S5 (Inventor as Consultant): Rather than encouraging academic inventors to assume business leadership roles, including them as a consultant is often better. Early interactions with stakeholders may help academic inventor have realistic expectations of their business acumen, and may facilitate putting together strong management team for startup. Leveraging industrial relationships and experience of academic inventors increase chances of patents, licenses, consultations and establishment of companies [38] and can improve founding teams' relations with external agents to lead towards commercialization [16].

C6 (Low Technology Readiness Level): Inventors seek grants to accomplish research and accumulate resources such as laboratory space, equipment and skilled teams. Their focus remains on the basic part of research, with very few exceptions that focus on the resources desired to convert the basic research into applied solutions.

Inventors mostly work on the initial level of TRL 1-2 [50], however, the invention needs to move up the scale from invention to discovery, validation, and so on [29, 50].

S6 (Funding for Translational Research): Traditional academic research grants are generally limited to TRL 1–2, so additional industry-based grants are needed to move up the scale. Here, stakeholders' interactions may be leveraged. Along with a company inventors may obtain SBIR (Small Business Innovation Research) and STTR (Small Business Technology Transfer) grants [28] to support proof of concepts and development of minimum viable products. If research proposals mention TRLs and if partial funding for advance levels are obtained or at least methodologies for seeking grants are conceived, then chances of commercialization further increase. Stakeholder's priorities and engagement, as one of the key ingredients, affect the proposed implementation efforts. One of the academic inventors endorsed that, "*Understating needs of stakeholders and incorporating these in a research proposal increases the quality of the grant application; talking to them and incorporating their names, companies and support letters in the grant applications improve chances of acceptance of funding*".

Overall Cn and Sn emphasize on real-world problem based inventions with chances of commercialization, through a systematic route that identifies end users' problems, and develops solutions with plans of moving towards higher TRLs. The involvement of academic inventors in the commercialization process is recommended as their experience help in building networks outside the academic arena [43]. To enable this, a tool—LCI is proposed for conceptualization stage of the research process. Usually, at the time of invention disclosure, TTO professional understand the maturity of inventions and make calculated decision of investing time and financial resources for advance stages [47]. The LCI can educate academic inventors to consider Cn and incorporate Sn, to resolve challenges at the earlier stage of inventions and save resources of TTO to be wasted on inventions with less chances of commercialization.

6 Developing a Tool—Lean Canvas for Invention

The tool—LCI, shown in Fig. 2, provides a framework for research development that incorporates the proposed solutions (S1–S6) and bridge the knowledge asymmetries to facilitate the transfer of invention from lab to market. It incorporates interrelated components derived from interviews and its development is based on benefits associated with the business models canvas [39] that enable users to create mental models to communicate with peers [34] and help an entrepreneur define a Minimum Viable Product (MVP). The LCI framework, with components: Problem Identification, Literature Search, Existing Solution, Market Landscape, Novelty, Research Question, Research Methodology, Key Resources, Funding, Team Capacities, and Research Outcome, will help an academic inventor define a Most Valuable Research question

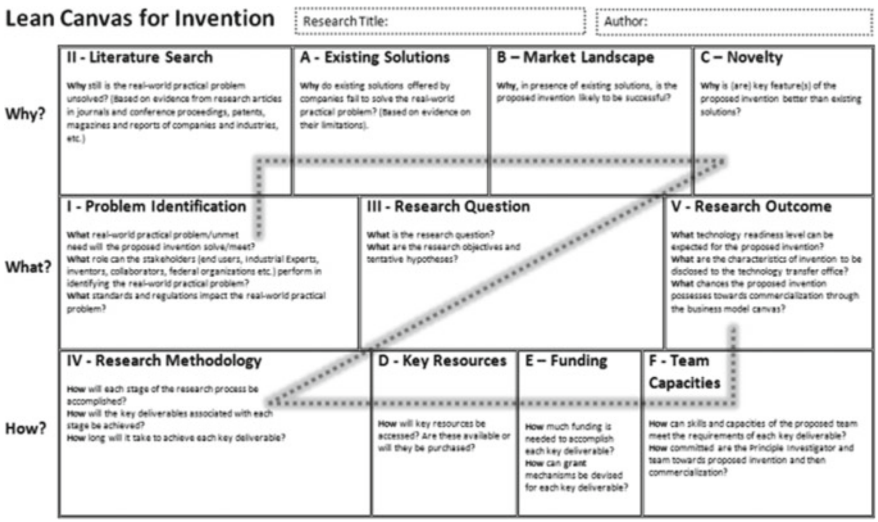

Fig. 2 The tool—Lean Canvas for Invention (LCI)

(MVRq), informed by academic literature, patents, market landscape and stakeholders' interviews. Although the LCI could be readily used by an individual researcher, but it is actually designed to target a full research team (professor(s) plus students, etc.).

The research process [51] is based on a research problem that may originate from an observation (practitioner oriented) or previous studies (scholarly oriented) [52]. An invention may base on either, but if on observations and interactions with stakeholders for problem identification, chances of commercialization strengthen. A well-conceived research problem has four elements: idea, support, implication and contribution [51]. It addresses an explicit research question [22] associated with "idea" and "support" of literature and is answered by research methodology. The "implication" and "contribution" deliver the research outcome in the form of lessons learned and how to apply in practice [51]. If the research outcome is associated with scales such as Technology Readiness Level (TRL) or System Readiness Level (SRL) may solve challenges of the TTO managers [13]. A research proposal needs a focused approach towards science and technology, however, its disintegration with end users raise challenges for TTO professionals. The LCI can formalize the review of literature including patents, market and end users' interactions, thus helping academic inventors consider these aspects in their inventions to be able to address more challenges of TTO managers. The following five components and their six sub-components are proposed for the LCI.

I *Problem Identification* [48] added that inventions with poor fit with user requirements and with lack of understanding of the product application reduce the commercialization potential. [17] added that desires of researchers and customers don't always dovetail, and therefore invention must be followed by problem identification. Walters et al. highlighted the need of research to be translated between academic and industrial contexts in order to have an impact. The identification of a practical problem and then inventing its solution is therefore a way of making this impact visible. This component was much emphasized by TTO professionals via informal interactions with end users. Therefore, the first component of the LCI is "Problem Identification".

II *Literature Search* For academic research, the problem identification process is supported by literature review to identify a gap and develop a novel idea. Traditionally this is limited to academic literature, but in the LCI, a broader approach is proposed. The second component of the LCI is therefore "Literature Search" with expanded literature including traditional academic sources as well as patents, market reports, regulatory standards, interviews and interactions with stakeholders. This review will help inventors identify gaps in both the academic and practical arena. It will identify not only novelty, but novelty that could potentially solve a real-world problem. Novelty (technology newness, radical/incremental innovation, discontinuous change) is one of the key determinants of technology transfer [49] and can be assessed by existing inventions, patents (granted and licensed) and companies offering solutions. The Literature Search identifies three key sub-components: A—Existing Solutions, B—Market Landscape and C—Novelty. This literature search is also likely to refine the Problem Identification. A comparison of existing solutions, based on their scientific and technological features, can create value for end users to be assessed via a value pyramid. The mapping of existing solutions and their limitations searched via patents and value analysis further assists in strengthening the novel gap.

III *Research Question* Where a Business Model Canvas strives to identify a MVP, the LCI strives to identify the MVRq, and thus it is the central block in the LCI. The literature review is to enable academic inventors to reach this novel research question, its associated objectives and tentative hypotheses. The third component of the canvas is therefore "Research Question".

IV *Research Methodology* The research question then guides the research design and lead towards way of answering the question [56]. Therefore the fourth component is "Research Methodology". A well-thought research methodology covers all stages, each with key deliverables and different methods to accomplish these deliverables. The Research Methodology is supported by three sub-components: D—Key Resources, E—Funding and F—Team Capacities. The key resources may already be available or be provided through proposed funding, how long it will take, and the TRL that can be achieved. Professors normally consider these sub-components when writing research proposals for grants, but students often do not. It will be beneficial for them to consider these aspects, as well. For example, under Team Capacities, they can define the skills they bring to the table or will develop in the course of their studies.

V *Research Outcome* The outcome of the research process is a proposed solution likely still at a relatively low TRL [29, 50]. At the end of research process when novel inventions develop, these get disclosed to TTO professionals where they begin research for patentability and market viability and make calculated decisions. After adoption of the LCI the TTO research can be facilitated with the participation of the inventor(s), who have already done a preliminary review of aspects. Kumar and Jain [24] discussed that the decision to commercialize a technology depends upon the status of technology, market potential of product, patentability and the entrepreneurial experience of the team and its success depend upon product engineering to the market needs. As these components are already considered by academic inventors they can share prior knowledge with TTO professionals during the technology transfer process.

In order to guide academic inventors each of the components have a respective checklist, discussed in online course on LCI, available at University of Utah website. The LCI is for academic inventors to write research proposals with components desired to bridge knowledge asymmetries for successful commercialization. The LCI was evaluated by TTO professionals on a five point Likert-type survey questionnaire, designed for feedback on "Usability" and "Acceptability". The results are in Figs. 3a, b. Figure 3a shows that 16% of the TTO professionals find it "very useful" in easing their challenges, 69% find these "Usable" and 15% find these "Unusable". Figure 3b shows that 23% find these "Very much Acceptable" to be used by them at the time of invention disclosures, 54% find these "Acceptable", and 23% find these "Neither". However, none of them rejected this tool. Figure 4 shows their opinions on whether

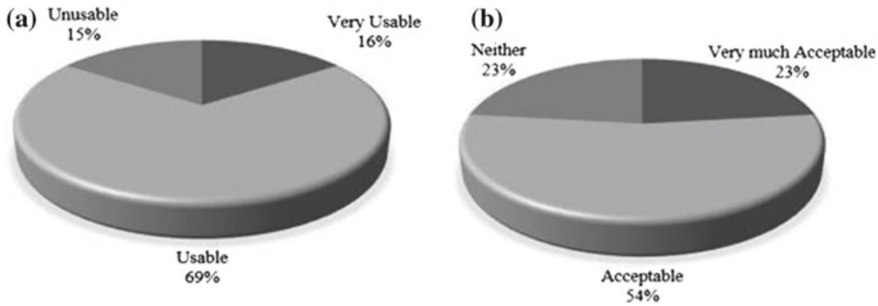

Fig. 3 TTO professionals feedback, **a** Usability of LCI, **b** acceptability of LCI

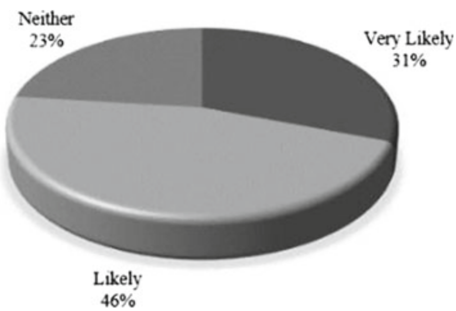

Fig. 4 TTO professionals feedback—using LCI as guidance to academic inventors

this tool can guide academic inventors in developing research proposals along the lines of components required by TTO. In response 31% find these “Very likely”, 46% find these “Likely”, and 23% find these “Neither”. In addition, the TTO directors and managers offered the following benefits of the LCI.

> The greatest benefit of this canvas is that it gets the inventors thinking about the market problems to solve.
>
> This canvas can help the TTO manager understand how commercialization oriented the Principal Investigator is.
>
> This canvas will improve invention disclosure submissions to the TTO
>
> At TTO we can ask all these questions and do our best to answer them. But making the inventor work through this canvas, however, gives us a more contextually accurate place to start.
>
> This canvas eliminates “discoveries” by inventors that are not new, also focuses inventors on real-world needs.

7 Conclusions

The aim of this paper was to explore in-depth the knowledge asymmetries between academic inventors and TTO professionals at the time of invention disclosures and develop a mechanism in order to bridge this gap in an environment of entrepreneurial university. From the in-depth interviews, challenges (*Cn*) were identified and solutions (*Sn*) were proposed. It was found that academic inventors do not identify opportunities at the earlier stage of their research process via stakeholders and they rarely review patents and market reports for their research proposals and mostly develop technologies for the 1–2 TRLs. These prior knowledge limitations of academic inventors create challenges for the TTO professionals when they try to get IP and offer commercialization services. The low motivations and naïve participation of academic inventors in the technology transfer process was found as one of the major problem. Therefore in order to reduce knowledge asymmetries, need of developing a new knowledge structure as a pre-commercialization mechanism for bringing inventors, stakeholders and markets closer was proposed. This need has support of argument that universities must formulate and implement coherent and feasible technology transfer strategies [47] by recreating missing components to bridge knowledge asymmetries [5, 11] and effectively improve the industry science links [10].

Based on Cn and Sn, a tool—LCI was designed with concepts borrowed from business model canvas to assist academic inventors in writing research proposals for future inventions, aligned with the market needs, stakeholders’ problems and IP discoveries. The purpose is to provoke academic inventors at an earlier stage of their research process to address MVR questions and establish prior knowledge to assist TTO professionals at the time of invention disclosures. This research recommends suitability of the LCI mechanism as a first step for reducing distance between invention and commercialization in the death of valley [30].

This paper contributes, first by empirically finding challenges of TTO causing knowledge asymmetries between academic inventors and TTO professionals. Second, a new tool—LCI was designed for academic inventors to meet these challenges. Feedback by TTO professionals supported the usability and acceptability of the LCI for improving the quality of invention disclosures and for aligning the research proposals with their needs for future invention disclosures.

In addition, a course is designed for academic inventors for testing the LCI. This study propose a way towards future adoption of the LCI in multidisciplinary contexts by exploring how LCI can improve the quality of research and invention disclosures. Therefore, it is recommended that the LCI must be adopted as a part of the STEM (Science, Technology, Engineering and Mathematics) curricula for its refinement and evaluation for future inventions. Those who are mature inventors, a short training program on the LCI could be helpful, to gain their viewpoints. The course can utilize experiential learning, a flipped classroom, and immediate feedback to engage STEM students with real-world entrepreneurship. This canvas is expected to help the STEM scholars to think critically and comprehend broad perspectives of diverse stakeholders for their inventions. The training on the LCI is a way of building an entrepreneurial ecosystem and bringing ideas of the STEM graduates to the real business world. The NSF I-Corps program trains graduates on the Business Model Canvas (BMC), but missing out the research process. In future, a more comprehensive course combining the LCI and BMC can be designed for the NSF I-Corps program, where the LCI is used in early stages of research and the BMC later with expectation of helping academic inventors and STEM graduates to discover needs, formalize research proposals and invent solutions with high propensity of commercialization. The course is recommended to be delivered by the NSF I-Corps program, and help in creating prior knowledge by storing and sharing more ideas discussed between research teams and diverse stakeholders for future inventions.

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Role of Entrepreneurial Universities, Research Centers and Economic Zones in Driving Entrepreneurship and Innovation in Cluster Ecosystems

Azam Pasha

Abstract Economic zones are recognized as contributors of entrepreneurship and innovation and key elements of national development strategy. This paper empirically evaluates and answers questions like—is there an impact of entrepreneurial universities and research centers on the performance of clusters? Why and how this happens? Do economic zones affect cluster outputs to the host economy? Can there be enhancement of entrepreneurship and innovation in clusters if economic zones are bundled along with entrepreneurial universities and research centers? This study builds up on the dataset of top-100 clusters of innovation, presented by World Intellectual Property Organization (WIPO), refining it and adding five socio-economic output indicators, testing for three independent variables (entrepreneurial universities, research centers and economic zones) to reveal, quantify the relationships and evaluate the impact of these variables on cluster performance. The results show there is a strong effect of all three independent variables but with varying degrees on different socio-economic output indicators, implying that a hybrid or collaborative model with entrepreneurial universities, research centers and economic zones will be the most emphatic alliance to deliver the socio-economic benefits expected out of clusters.

Keywords Entrepreneurial university · Economic zones · Economic development

Abbreviations

FDI	Foreign direct investment
GDP	Gross domestic product
GVA	Gross value added
PCT	Patent co-operation treaty
PPP	Purchase price parity

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VIF Variance inflation factor
WIPO World intellectual property organization

1 Introduction

Entrepreneurial universities are a mix of academic, research and economic interests coming together with an intent to create and deliver *novel research* that can be commercialized. This novel research is secured through patents and licenses and sold or extended to start-ups thereby creating direct commercial value for recipients. The commercial application of academic research provides direct or indirect academic and economic benefits to entrepreneurial universities, solutions to consumers and socio-economic benefits to the hosting country. Research coming out from universities has contributed significantly to development of all industry sectors, with some to more while others to a lesser degree. The presence of universities within countries and clusters have been referred to be significant drivers of entrepreneurship and innovation. The effect of entrepreneurial universities on countries and clusters has been studied and theoretically explained but nothing conclusive so far has been done to evaluate these effects empirically.

Entrepreneurship focusses on utilizing the cluster resources to efficiently produce products and services, which in turn deliver the outputs of the cluster. Similarly, innovation involves increasing the efficiency or enhancing the value of economic activity by improvising or creating new products, services, or processes. Innovation provides opportunities for clusters to open-up, create and develop new markets, charge higher premium, efficiently manage and mitigate risk for its stakeholders and overall enhance value of cluster. The key driver for innovation is *intellectual capital* where 'Intellectual capital' is of three types [3]: (1) *human capital* comes from knowledge, skill and expertise of employees of a company, (2) *structural capital* comes from intellectual assets of the company which are patents, licenses and trademarks/copyrights and physical assets like office, units and spaces, (3) *relational capital* comes from company's formal and informal relationships with customers e.g. customers, vendors and other players in the ecosystem. It has been highlighted by Edvinssons in categorization of capital of how intellectual capital relates to and delivers organizational value [9], this in one way monetization of intellectual assets through commercial enterprises. There exists a 'positive correlation between the existing intellectual capital within the organization and its innovation performance' [24]. Entrepreneurial universities supply intellectual capital that results in enhancing socio-economic impact of the cluster (which acts like an organization) on the host economy or region. Silicon Valley is one of the best examples of clusters that shows *what kind of success can be achieved (impact), where it can be achieved (location) and how it can be achieved (by utilizing inputs or resources)*. One of the perspectives shared by Kominers [14] in their paper is that success of Silicon Valley has been built on bringing two elements together—*technology spillover* and *human capital*. Key

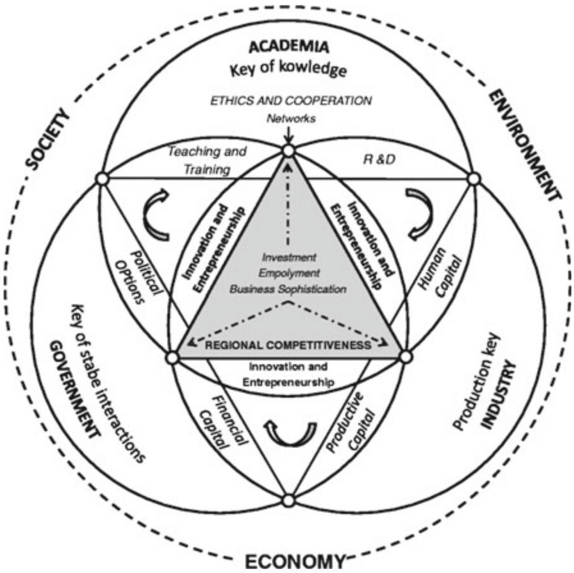

Fig. 1 Triple helix interactions with the three elements of entrepreneurship and innovation ecosystem [17]

source of both these elements are entrepreneurial universities that are found within the cluster or sometimes the economic zone. The interactions, as illustrated by the Triple Helix structure, between the entrepreneurial universities, public institutions and private industry show how entrepreneurship and innovation ecosystem functions and contributes to competitiveness and overall regional development (Fig. 1).

The knowledge transfer between the academic and research centers in the triple helix is highly dynamic and a multi-way process which allows these academic and research centers to work symbiotically to enhance the overall value of the entrepreneurial ecosystem. Even though, the triple helix structure has been used to understand, explain, and design entrepreneurial ecosystems at country level, its effects are more inclusive and pronounced when looked at a city and cluster level. Co-operation between the universities and industries involve two activities which are that the (1) teaching and training and (2) research. They have looked at evolving a theoretical basis that shows—'there are different areas in which universities contribute to cluster growth. Universities with strong technical competencies have often been the starting point for cluster initiatives. Bidirectional university-industry interactions such as consulting, joint research and contract research enable the conduct of tacit and explicit knowledge transfer, benefiting universities, the industry and the cluster' [22]. An interesting study by Athreye [1] mentions that significant proportion of founders in Cambridge come from local firm and universities, re-iterating that universities have played a critical role in success of strong innovation clusters like Cambridge and Silicon Valley, the study mentions that 'interesting aspect of new firm formation revealed by the CBR survey is that more than one third of these new firms were spin-offs from other firms and the University'. It also solidifies the role of university as a major source of knowledge transfer to firm for enhancing innovation capabilities for firms in Cambridge. A paper by Koh [13] mentions that the major reason for success of clusters like Silicon Valley, Cambridge and Hsinchu Science Park (in Taiwan) have been access to talent (by developing networks from research centers to private industry), agglomeration and then the linkages with the private sectors and global networks that have helped forge cluster growth. It has been revealed [16] that in Sweden, companies located within the science cluster or park had more linkages with local universities than companies located outside. The universities have evolved to the stage where they need to amplify the 'third mission' as proposed by Iacobucci [11], which involves activities that enable valorization of research results so that these results can maximize the impact on economies and societies. This third mission has three dimensions which are—*Knowledge Transfer and Innovation, Continuing Education and Lifelong Learning, Social Engagement* [5].

It is a known that to determine the level of innovation (inventiveness) in an economy an indicator called Patent Co-operation Treaty ('PCT') filings are taken into account. It was learnt that 'for some clusters—in particular, Baltimore, Daejeon, Grenoble, Kuala Lumpur, and Singapore—universities and PROs account for more than one-third of PCT filings. In many others, inventive activity occurs in companies, with academic institutions accounting for negligible filing shares. Interestingly, many clusters featuring medical technology or pharmaceuticals as their top field have relatively high university and PRO shares, underlining the importance of science linkages in these two fields' [2]. This opens up a strong possibility to elevate work in universities on applied research, whereby not only research output moves to industry, but also human capital can be shared with industry for successful implementation of research propositions. It has been also suggested that in the triple-helix model the researchers can enter into entrepreneurship and develop new businesses, and on other hand entrepreneurs can collaborate on research to help develop and deliver start-ups as joint ventures [12]. Furthermore, it has been mentioned that 'universities act as a source for knowledge, technology, and skilled employees' which are detrimental for growth of any cluster or economy [6]. All the review infers that presence and density of the entrepreneurial universities and research centers allows availability, renewal and flow of intellectual capital between the participants in the cluster.

Another aspect of that is of importance to clusters is the relevance of economic zones—which are strong contributors to entrepreneurial and innovation ecosystem. Economic zones have now been mapped, latest data shows that there are 3581 zones and spread across 124 countries and they continue to be at forefront of economic development agenda achieving considerable success in boosting entrepreneurship and innovation in some developing and advanced economies [19, 20]). It is mentioned across literature that there is a strong element of knowledge that is shared within the cluster through formal (buyers and suppliers, institutions) and informal relationships (social networks) found inside the cluster. These networks allow fast flow of information within the cluster and the cluster connection with external environment allow the information to flow across the national economy and the surrounding region. It is worth noting that 'clusters that are externally, rather than regionally, organized and oriented may even facilitate the diffusion of university-derived benefits outside the region. The university can produce the seeds of new firms and industries, but the region must offer a fertile climate for them to flourish. The key factors related to the industry cluster are its pattern of organization, market trends, and the life cycle stage of the industry or technology' [8]. Economic zones provide strong impetus to enhance employment and population in a region—two important elements that can be instrumental to diffuse intellectual capital created by universities in a cluster. It is understood that the major input provider for supplying all forms of intellectual capital to a cluster are entrepreneurial universities (or simply universities), while research center provide structural capital, and economic zones provide with the necessary catalyst to boost the population and trade (structural and relational capital) which enhance intellectual wealth or innovation economy of the cluster. It has been established that economic zones have strong potential to enhance trade to foreign markets [19, 20]. It is not known that economic zones help cluster performance or help in raising their socio-economic output? Hence in this paper we explore, analyze, and understand the relationships, and determine the 'real' role played by the entrepreneurial universities, research centers and economic zones, on cluster impact metrics.

2 Approach and Methodology

The literature review does not provide information on a resilient model or studies to understand the role of entrepreneurial universities, research centers and economic zones in enhancing the output or impact of clusters. Hence, the approach taken in this paper involved two steps:

a. to **evolve a model** to evaluate the impact of entrepreneurial universities, research centers and economic zones on top-100 most inventive cluster and
b. to **test this model** on credible sample of top-100 most inventive clusters or cities

The proposed theoretical model is shown in Fig. 2, that illustrates the overall relationships and linkages between the input and output sides. In this model, cluster is considered to function like an organization that creates, processes and delivers value (impact) by utilizing the inputs from an entrepreneurial university, research centers and economic zones (referred to as 'input providers'). The model suggests that the inputs that are received from different input providers include intellectual capital but in varying degrees e.g. the entrepreneurial university provides all forms of *intellectual capital*, research centers provide more of *structural capital* in form of product innovation in varying intensities depending on research center's orientation and type (e.g. pharmaceuticals, semi-conductors, etc.), and economic zones provide a mix of *structural and relational capital* benefits (like commercial spaces) to specialized policy incentive-based inputs (like industry specific export or import tariffs that allow inflow of investment and outflow of product and services in form of trade to foreign markets or customers).

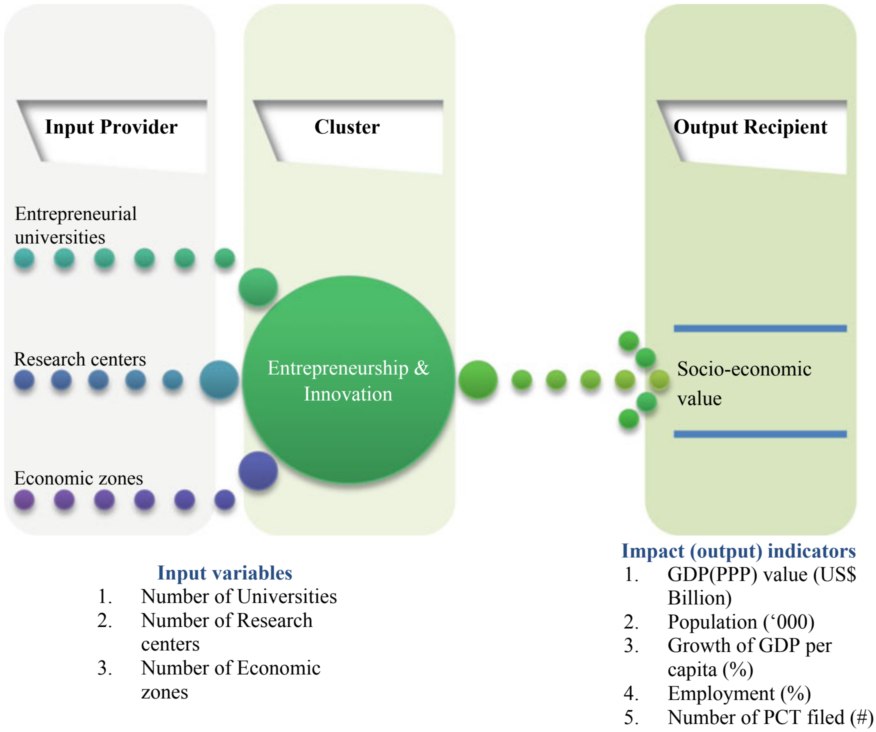

Fig. 2 Theoretical model for relationship between entrepreneurial universities, research centers and economic zones, with clusters (*Source* Author)

The output recipient is the national economy and the other way of expressing this cluster output is referred to as 'cluster contribution to host economy.' The output or the impact generated by the cluster to the national economy is measured by five critical socio-economic impact indicators (dependent variables): *GDP (PPP), population, growth of GDP per capita, employment in the cluster and number of PCT filed by cluster*. The inputs providers or input variables (independent variables) to cluster include—the *number of universities, number of research centers and number of economic zones* in a cluster. The proposed theoretical model was tested on real data which entailed below steps:

1. **numerating the value of dependent and independent variables** for the top-100 clusters extracted from the Global Innovation Index rankings of world's most inventive clusters or cities [23].
2. measure the **presence and intensity of relationships** of five impact (output) indicators with three input variables.
3. **show if alliances will be effective** between entrepreneurial universities, research centers and economic zones.

Table 1 Hypotheses for testing

Increase in IVs results in increase of DV#1/2/3/4/5	GDP (PPP) value (DV1)	Population (DV2)	Growth of GDP per capita (DV3)	Employment (DV4)	Number of PCT filed (DV5)
Number of universities, research centers and economic zones	H1	H2	H3	H4	H5

The dataset for this paper is derived from the study [2] and involves ranking of top-100 clusters based on the number of PCT filed (operated by WIPO) by these clusters between years 2011–2015, where geo-coding was done to identify the clusters from where these PCTs originated. The PCT filed by the cluster were taken as one dependent variables and other dependent variables which were added to this data are (each of these are for the clusters among top-100 most inventive clusters by WIPO are actually metropolitan cities)—GDP (PPP) values for year 2016, Population was taken for year 2016, Growth GDP per capita was taken as average between 2014 and 2016 and Employment data (in %) was taken for 2016. The three independent variables included were—number of universities, number of research centers and number of economic zones was for the year 2016. All this data was collected through different databases and sanitized by cross-checks before being incorporated into the dataset for testing.

The hypothesis that are tested in this paper are centered around the main idea which was—if the number of universities, research centers and economic zones **increase** in a cluster it results in an **increase** of GDP (PPP) value, population, growth in GDP per capita, employment and number of PCT filed by the cluster? (Table 1).

3 Results and Inferences

The dataset of ranking of top-100 clusters blended with value of eight variables (five dependent and three independent) that define impact and performance of clusters were analyzed in 3-steps employing STATA software application.

The **first-step** involved running summary statistics of the complete dataset and understanding how data explains the phenomenon, this is shown in Table 2.

The summary statistics provide following insights, where they are looked from two perspectives—the output perspective and input perspective (Table 3):

1. Output perspective—involves understanding the data to determine how much contribution happens to the host economies from the five DVs:

Table 2 Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
DV1GDPPPPU~e	100	220.8365	267.3452	1.038293	1617
DV2Popul~0 0 0	100	2868.549	4656.112	29.836	24180
DV3Growtho~a	100	0.0200588	0.0208999	−0.029	0.09
DV4Employm~r	100	95.1033	2.782545	82.2	99.9697
DV5Numfoero~u	100	5773.41	11433.13	956	94,079
IV1NoofUni~s	100	23.37	31.822	1	184
IV2NoofRCc~r	100	14.47	26.56703	1	202
IV3NoEcono~e	100	2.05	5.805562	0	51

Table 3 Description of variables

1. **DV1GDPPPPU~e**: GDP (PPP) in US$ Billions of the cluster	2. **DV2Popul~000**: cluster population in ‘000	3. **DV3Growtho~a**: growth in GDP per capita of cluster between 2014 and 2016
4. **DV4Employm~r**: employment in % of a cluster	5. **DV5Numbero~u**: number of PCT filed between 2011 and 2015	6. **IV2NoofUni~s**: number of universities in cluster
7. **IV2NoofRCc~r**: number of research centers in cluster	8. **IV3NoEcono~e**: number of economic zones in cluster	

1.1. GDP (PPP) value—The clusters deliver an average of US$221 Billion in GDP (PPP) value which translates into 10% of the average GDP (PPP) value of their host countries. The contribution of cluster GDP (PPP) value to the host country GDP (PPP) in case of some clusters like Singapore is 100% of the national GDP (PPP) value while in others like Plano in US or Nuremberg in Germany is less than 1% of the national GDP (PPP). The clusters are meant to provide a localized affect rather than a national impact, but as found their role in national socio-economic development is undeniable and significant.

1.2. The average population of a cluster was 2.88 Million. The total population of top-100 clusters sums to 286 Million people over a total host country population on 3.87 Billion, which translates into 7% of the host country population based in clusters.

1.3. The average growth in GDP per capita for clusters was found to be 2%. If viewed in comparison to the growth of GDP per capita of the country it was seen that clusters perform better by around 20% better than their host countries (average growth of GDP per capita for the host countries was 1.7%). An explanation maybe that clusters deploy highly skilled labor force (provided from academic or entrepreneurial universities) and deliver innovation which in turns drives higher growth of GDP per capita in clusters. Furthermore, high entrepreneurial activity in cluster attracts not only more human capital but also finance and investments that fuel comparatively higher growth in cluster GDP.

1.4. Average employment in clusters was 95.1% compared with 94.8% in countries that host these clusters. Clusters shows an average 0.35% of improved employment over the host country average employment levels. It was detected that 72% of clusters have higher employment levels than their host countries, in some clusters like in Lyon employment is 6.9% points higher than host country followed by Madrid at 5.3% and Barcelona at 4.7%. Can it be assumed that countries that have low employment seem to gain by clusters more than countries with high employment?

1.5. It was observed that clusters have filed an average of 5585 PCTs in the 5 year period, which is almost 1500 PCTs per year, and this constitutes an average contribution of 12% to the total PCT issued by the host countries. The range is from a low contribution (of PCT filed by cluster to its host country) of 3% in Chicago and Seattle, to very high contribution of 74% (of PCT filed by cluster to its host country) in Tel Aviv. If the PCT are compared on a per capita basis between the cluster and host economy, it was seen that the clusters deliver double the number of patents per capita than the host country. This shows that clusters are extremely powerful tool to generate innovation in economies. Some clusters like San Jose–San Francisco generate 0.039 PCT per capita (over national PCT per capita of 0.001) while others like Washington generate very low PCT per capita. Out of the sample of 100 clusters 76% of the clusters produce more PCT per capita than their host countries.

2. Input perspective—involves analyzing the data to see how the three IVs are distributed across clusters and understand their effects, if any:

   2.1. The presence of universities in clusters indicates the relevance accrued to universities for providing the key ingredients of developing entrepreneurship and innovation in clusters. On an average 6% of the universities in the host country are present in clusters. A significant 45.6% of the universities in the host country are present within cluster in case of Stockholm cluster followed by 42.7% in Brussels and 36.7% in Vienna clusters. It was observed that there are around 2336 universities located in top-100 clusters of the world (these are 15% of the total of 15,291 universities located in countries hosting these top-100 clusters). With 15% of the academic or entrepreneurial universities present in clusters and high contribution of PCT filings from clusters it is clear that cluster play a strong role in enhancing local and national innovation.

   2.2. There an average of 14 research centers in each cluster varying between 1 and 202, with the highest being in Paris and lowest in mostly Japan and parts of Europe.

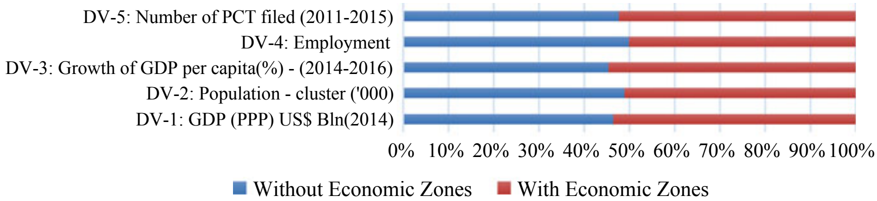

Fig. 3 Effect of absence or presence of economic zones among top-100 clusters on the DV values (based on average values) (*Source* Author)

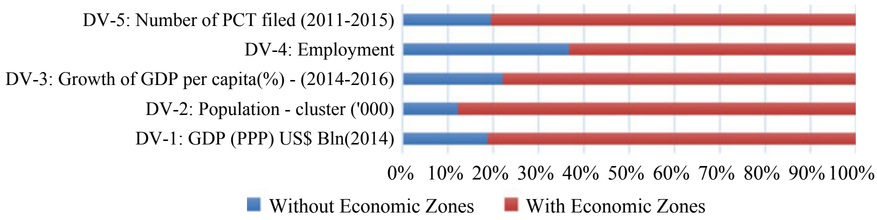

Fig. 4 Effect of absence or presence of economic zones among top-100 on the DV values (based on total values) (*Source* Author)

2.3. There was a presence of economic zones in clusters, and in some cases, clusters act like economic zones (e.g. Singapore, Shenzhen and Hong Kong). It was detected that in top-100 clusters an average 8% of economic zones are present in the host country.
2.4. Furthermore, it was noticed that 100% of the sample (top-100 clusters) had entrepreneurial universities and research centers while only 63% of the sample had entrepreneurial universities, research centers and economic zones all together. This presence and absence of economic zones showed following effect on performance of cluster outputs (performance and impact) (Figs. 3 and 4).

These results show remarkable differences in performance and impact of cluster due to absence or presence of economic zones (along with entrepreneurial universities and research centers) within the cluster.

The **second step** in this analysis was to look at a correlation matrix between different variables and find those variables where significant correlation exists for understanding the interactions between these variables (Table 4).

The interrelationships between the variables can be understood by looking at the correlation values between the five **dependent variables** (DV1-DV5) and the three **independent variables** (IV1-IV3) which result in following interpretations:

1. Strong correlation exists between of number of universities (IV1) and the GDP (PPP) value (Corr. +0.7628) and number of PCT filed (Corr. +0.6716) and a notable relationship with employment (Corr. +0.1169) in the cluster, suggesting

Table 4 Correlation between variables

	DV1GDP~e	DV2P~000	DV3Gro~a	DV4Emp~r	DV5Num~u	IV1Noo~s	IV2Noo~r	IV3NoE~e
DV1GDPPPPU~e	1.0000							
DV2Popul~000	0.4976	1.0000						
DV3Growtho~a	−0.0069	0.5129	1.0000					
DV4Employm~r	0.0854	0.2148	0.1300	1.0000				
DV5Numbero~u	0.6652	0.2689	0.0059	0.1764	1.0000			
IV1NoofUni~s	0.7628	0.3868	−0.0047	0.1169	0.6716	1.0000		
IV2NoofRCc~r	0.3454	0.1742	−0.1529	−0.1768	0.2048	0.5466	1.0000	
IV3NoEcono~e	0.1839	0.6791	0.5012	0.1571	0.0603	0.0813	0.0239	1.0000

Table 5 Consolidated linear regression of impact (output) variables and independent (input) variables

	Model 1 DV~e	Model 2 DV~n	Model 3 Gr~a	Model 4 DV~t	Model 5 DV~d
	b/se	b/se	b/se	b/se	b/se
IV-1: No. of Unive~r	6.779***	51.581***	0.000	0.025*	286.693***
	(0.65)	(11.70)	(0.00)	(0.01)	(31.42)
IV-2: No. of RC − ~r	−0.992	−5.973	−0.000	−0.036**	−99.569**
	(0.77)	(13.97)	(0.00)	(0.01)	(37.52)
IV-3: No. Economic ~r	5.559	522.290***	0.002***	0.068	1.909
	(2.97)	(53.70)	(0.00)	(0.05)	(144.26)
Constant	65.368**	678.835	0.018***	94.884***	510.232
	(22.05)	(398.78)	(0.00)	(0.34)	(1071.22)
R-sqr	0.604	0.573	0.281	0.116	0.489
dfres	96	96	96	96	96
BIC	1326.4	1905.4	−505.4	493.5	2103.0

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

that relationship of universities with economic impact indicators seems instrumental in effecting the value of goods and services produced and the enhancing innovation within the cluster, and to smaller degree in affecting the employment within the cluster.

2. There were strong positive correlations between number of research centers (IV2) with GDP (PPP) value (Corr. +0.3454) and number of PCT filed by cluster (Corr. +0.2048) and a notable negative relationship with employment (Corr. −0.1768). These imply that the increase in number of research centers ('RC') boosts the GDP (PPP) value and number of PCT filed but it was surprising to see the increase in RC results in a decrease in employment and decrease in growth of GDP per capita. Why does number of research centers positively relate to some economic variable while negatively relates with other economic variables?
3. Significant positive correlation was observed between number of economic zones (IV3) and population (Corr. +0.6315) and growth in GDP per capita (Corr. + 0.5012), and weaker but notable relationship with GDP (PPP) value (Corr. + 0.1839). These imply that the economic zones have very different relationship with the clusters' economic impact indicators than the other two IVs, they affect population and growth in GDP per capita which was not seen in other IVs. Population was a very important DV that has interactions with all the other dependent variables, and it has been seen to enhance the impact of clusters significantly.

The **third-step** was to interpret this data applying linear regression on these variables and see which model best applies to this dataset to accept or reject the proposed *hypotheses*.

The model in Table 5: Consolidated linear regression of impact (output) variables and independent (input) variables, clearly shows high R-sqr values in all the models except model-4. Multi-collinearity (by undertaking VIF test) was checked to see if the variables are inflated in the regressed dataset and it was found to be at mean value of 1.29 and all variables within range of 1.01–1.44. Evaluating each of the models it was deduced that:

1. In model-1, where R-sqr value is of 0.604, DV1 has high significance (p-value <0.001) and positive coefficient of 6.77 with IV-1, implying that the GDP (PPP) value was strong positively influenced by number of universities. This allows good insight why the universities need to be increased with a cluster to enhance its GDP output.
2. In model-2, has R-sqr value of 0.573, DV2 has a high significance (p-value <0.001) and positive coefficient of 51.581 with IV-1 and a high significance (p-value <0.001) and positive coefficient of 522.29 with IV-3, implying that the change in number of universities and number of economic zones in a cluster positively affects population of the cluster. It can be implied that economic zones have strong capacity to attract population in areas which are under-developed by drawing FDI and trade into the region or cluster, and this is one of the key objectives for administering the economic zone programs under national development strategy.
3. In model-3, has R-sqr value of 0.281, DV3 has a high significance (p-value < 0.001) and positive coefficient of 0.002 with IV-3, implying that the change in number of economic zones in a cluster positively affects growth in GDP per capita of the cluster. This relationship shows that as the number of economic zones increases the growth in GDP per capita increase for the cluster.
4. In model-4, has R-sqr value of 0.116, DV4 has notably high significance with IV-2 (p-value <0.01), negative coefficient of 0.036, notable significance with IV-1 (p-value <0.05) and positive coefficient of 0.025, implying that the change in number of research center and universities in a cluster affects employment of the cluster. This relationship shows that as the number of research center increases employment decreases which is a very surprising effect of RCs. The contrasting relationship and effect seen in this research shows the impact of research centers in a different form than in conventional literature. This raises a few questions—Can this anomaly be answered by incorporating another dependent variable such as the number of companies in the cluster and evaluating the effect on number of companies by change in number of research centers within the cluster? *It seems that negative effect of research centers on employment was more pronounced than the positive effect of entrepreneurial universities on employment*. The effect of universities on employment and subsequently on other economic variables like GDP (PPP) value and attracting population, seen in this research, is understandable and is in line with conventional academic research—it has been mentioned that in between a period of fifty years between 1940 and 1990 a 10% increase in college residents' results in 0.8% of employment growth in the region [21]. Since employment growth was positively correlated with the economic growth it can

be assumed that rise in college resident should support economic growth in any region based on Okun's Law which illustrates the relationship between unemployment and real GDP and substantiated in work done on relating economic output to employment [4].

5. In model-5, has R-sqr value of 0.489, DV5 has highly significant impact resulting from changes IV-1 (p-value <0.001) with a positive coefficient of 286.693, notably high significance with IV-2 (p-value <0.01) and negative coefficient of 99.569, implying that the change in number of universities and number of research centers affects number of PCT filed from the cluster. Surprisingly, the negative coefficient for RC infers that increase in number of RCs reduces the number of PCT filed by the cluster (this surprising discovery was seen across all the models - the coefficients are negatives on number of research center across all five models). Is this due to limitations in data capture due to unavailability of complete public data on RCs? research center data is highly inconsistent as many of the research centers continue to be housed, acquired or merged with entrepreneurial universities, government institutions or private industry (corporates). Is it possible that within clusters due to high agglomeration the research centers lose their individuality (this might result in lower number of PCT filings from individual RC and more PCT filings accrued from RC hosting entities like entrepreneurial universities, government institutions or private companies)? This needs to be explored and researched more in detail before any conclusions can be drawn.

Overall, the results mentioned in this paper, give clear indication to accept H1, H2, H3 and H5 (with high R-sqr values), while there is not much substantiation to accept model-4 (employment effected by IVs) due to low R-sqr value, low coefficient values and negative relationship of significance between IV2 and DV4. This facet of relationship between employment and the number of universities, research centers and economic zones, needs to be investigated in greater detail by incorporating other variables and expanding the extent of the RC database. But it is clears from these results that cluster deliver strong impact and entrepreneurial universities, research centers and economic zones have a very crucial role to play in enhancing this cluster impact on the host national economy.

4 Inferences

Entrepreneurial universities have capacity and expertise to build—tools, methodologies and technologies on one hand, and create networks on the other, both these deliver strong value to companies or industry [18]. It has been highlighted in a paper that 'Cambridge has also developed an array of institutions, university-industry links and local technology venture capital that have favored and sought to nurture entrepreneurship in science-based industries. In these institutional developments, Cambridge is unique of all the other IT clusters that followed in the wake of Silicon Valley's success. No other European region has shown the same scale of entrepreneurial activity in science-based sectors as Cambridge or can boast the emergence of similar institutions without any state intervention. Furthermore, the University of Cambridge has been a key player in these institutional developments. These qualitative features of the growth of Cambridge have prompted several comparisons with Silicon Valley' [1]. The deviation in success of same formula of cluster development along with universities have led different results—but it has now accepted that universities have resulted in a significant impact on delivery of macro-economic output from these clusters. It has been shown in the same paper that results of interview showed overwhelming number of firms where based in Cambridge because either their founders where based in the city or had studied at Cambridge. This geographical affinity can be seen as playing a major role for start-ups to be founded in same city or area where their university was based, in a way showing that universities also act as large incubators churning both entrepreneurship and innovation. The research undertaken in this paper has highlighted the relevance of universities and pointed out that a collaborative model that involves entrepreneurial universities, research center and economic zones, would be the right model for development of highly emphatic clusters.

5 Limitations

Even though, the results in this paper give a sense of direction and help in understanding the overall structure and role of entrepreneurial universities, research centers and economic zones still there is need to conduct a larger research exercise to deduce the role of entrepreneurial universities and research centers in overall functioning of entrepreneurial ecosystem. Entrepreneurship universities have not been successful as a rule in development of economic development, and examples of this success are limited. It goes to the extent of proclaiming that even university driven research has neither produced the expected returns but has been able to deliver economic benefits that might be envisaged from these research and academic activities [15]. Furthermore, it has been voiced that the 'Universities also play an important role in entrepreneurial ecosystems, but not the re-eminent role that is often attributed to them' [7]. Accordingly, the results of this paper can be further augmented by undertaking further tests:

a. on the output side, *incorporating other DVs* like number of companies, skill level of employees, start-ups, etc., identified as output indicators [10]
b. on the input side there needs to be further *incorporation of other input variables* of importance that may impact the output of cluster
c. *increasing the sample size of around 300 clusters* to come up with a more conclusive model
d. *incorporating time* to see the effect of time, as number of entrepreneurial universities, research centers and economic zones grow inside the cluster

6 Conclusions

It can be concluded after reviewing the literature and undertaking the research exercise as cited in the paper that the linkages between the entrepreneurial universities, research center and economics are strong, crucial and valuable. It was remarkable to see the effect of economic zones to complement the delivery of cluster objectives along with the flow of intellectual capital from the entrepreneurial universities and research expertise from research centers. It has also been interesting to note that most of the clusters identified that are able to deliver significant value on impact indicators are located across Asia, US and Europe. This provides a new insight into what other countries can learn and develop, e.g. Africa, Middle East and Latin America (where the cluster development and economic zone development have been a key area for investments, employment and economic growth objectives) and emulate to create similar successful cluster development programs integrating entrepreneurial universities, research centers and economic zones as ingredients for local, national and regional development.

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Evaluating the Success of Companies at University Science Parks: Key Performance and Innovation Indicators

Claudia Olvera, Josep M. Piqué, Ulises Cortés and Mario Nemirovsky

Abstract Science and Technology Parks (STPs) facilitate the flow of knowledge and technology among universities, R&D institutions, companies and markets, and foster the creation and growth of innovation-based companies. Among the diversity of STPs, it is possible to identify two types: Science Parks (SPs), which involves university shareholding and Technology Parks (TPs), which are not owned by universities. This study will take into account just SPs due they are closely linked to the university, and they are the bridge between University and companies in the process of Knowledge and Technology Transfer (KTT). The evaluation of the firm's performance in SPs results in determinant to identify the needs of the companies and the feasibility of the University-Business Collaboration (UBC). Firm's real needs also are of interest of Universities, since they face the challenge of designing strategies that best help them to transfer the knowledge more effectively. While previous studies have been focused on tenants' innovation performance on-Park and off-Park, very little research has taken into account the Parks heterogeneity that may affect the firm's performance. This research focuses on SPs in Spain and México due to data availability. This paper (1) aims to identify the Key Performance Indicators (KPI's) used by Companies co-located at SPs, and (2) explore the performance measure and critical success factors of SPs. For this study, data was collected through 71 online company surveys in Spain and 19 online company surveys in México. This empirical

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analysis uses ten semi-structured interviews to explore (KPI's) and success factors of SPs in both countries.

Keywords University business collaboration · Open innovation · Evaluation metrics · Key performance indicators (KPIs) · Science parks

1 Introduction

Knowledge is widely acknowledged to be one of the primary sources for the economic and social development of a country [19, 20]. Universities and research centres, both public and private, are key actors in the generation and disseminating of knowledge [14, 27]. Through the research mission, they generate cutting-edge discoveries, expanding the boundaries of science, while the third mission implies the dissemination and exploitation of this knowledge, contributing to social growth and economic development [2, 11, 29]. Moreover, knowledge spillovers stimulate other research institutions to commercialize their research findings resulting in the acceleration of economic growth. The establishment of University-Business Collaborations (UBC) is therefore central to this process in order to facilitate this knowledge flow from academia to industry [9]. Aiming at narrowing the gap between science and industry, many universities have created specific units and designed specific programs to assist in this endeavour. Technology Transfer Offices (TTOs) and Science and Technology Parks (STPs) are two clear examples. Acting as knowledge brokers, they also bring together academics, businesses and venture capitalists. They seek to facilitate the transfer of knowledge from academia to the industry while infusing an entrepreneurial culture of research [7].

The STPs play a crucial role in the knowledge and technology transfer process because they have the function of contributing to the regional economic development, promoting the culture of innovation. To achieve this objective, a "*Science and Technology Park (STPs) stimulates the flow of knowledge and technology between Universities, research institutions, companies and markets and facilitates the creation and growth of companies based on innovation through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities*" [21]. Among the diversity of STPs, it is possible to identify two types: Science Parks (SPs), which involves university shareholding and Technology Parks (TPs), which are not owned by universities [4]. Regarding the types of Science and Technology Parks, this study will take into account just Science Parks due they are closely linked to the university, and they are the bridge between University and companies in the process of Knowledge and Technology Transfer (KTT).

Friedman and Silberman [17], define KTT, as the process by which the invention or intellectual property (IP) resulting from academic research is licensed or transferred through rights of use to an entity with the intention of profit and eventually led to its commercialization or exploitation. It is important to emphasize that to the extent that knowledge and technology are transferred to companies, they improve their production processes, services or business models and have a positive impact on the process of adapting to new situations and demands of the market in which they compete. One of the best ways to achieve this growth is to increase its innovative capacity. Companies with greater strengths in the field of innovation will be better prepared to extend its presence both regionally and in international markets and be able to face and adapt to an environment of global competition.

According to Oslo Manual [25], Innovation is defined as: "*The implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations*". The Oslo Manual also considers R&D activity as innovation activity even though it is not directly related to the development of a specific innovation.

2 Related Studies

Given the importance of the STPs in the innovation process, several authors have been interested in investigating these organizations from different perspectives. The most representative studies are focus on firm's innovation performance on-Park and off Park location and very little research has taken into account the Parks heterogeneity that may affect the firm's performance [4]. Regarding studies in Spain about firm's innovation performance, Vásquez-Urriago et al. [34] show a positive effect on innovation outputs of firms collocated in Spanish STPs, and, in most recent studies, Vásquez-Urriago et al. [35] also demonstrated the increase in the probability of cooperation for innovation in companies co-located in STPs. Similarly, Díez-Vial and Montoro-Sánchez [13] present a case study of Madrid Science Park showing that the innovative capacity increases when the firms have formal collaboration with the university and go on to show that when firms focus on internal knowledge networks, there is an increase in the innovative outputs. On the other hand, Albahari et al. [3] finds that the more involved of the university in the STPs, the firms have a negative impact on innovations outputs but a positive effect on the number of patent applications. Similar studies in other countries compare the effects of park location on firms. For example, Colombo and Delmastro [10] (Italy, 45-on and 45-off Park), the study showed no significant effect on patents; The results from Siegel et al. [31], (UK, 89-on and 88-off Park) showed positive effects on new products and patents; Squicciarini [32] (Finland, 48-on and 72-off park) found a positive effect on patents; Fukuwaga [18] (Japan, 74-on and 138-off Park) found positive impact on collaborative research with universities; Yang and Lee [37] (Taiwan, 57-on and 190-off Park) also found a positive effect on R&D productivity and finally Ferguson and Olofsson [15] (Sweden, 30-on and 36-off Park) found a positive effect on survival rate, but no significant effect on growth.

With regard to the economic and social implications that have the STPs, in the knowledge and technology transfer and innovation process, the present study aims to identify the evaluation metrics, Key Performance Indicators, (KPIs) in UBC used by Companies collocated at SPs and explore the critical success factors of them and the Science Parks as well. The evaluation of the firm's performance in Science Parks results in determinant to identify the needs of the companies and the feasibility of this University Business Collaboration. Firm's real needs also are of interest of universities, because they face the challenge of designing strategies that best help them to transfer the knowledge more effectively.

The KPIs in UBC used in this research are based on the most representative studies on metrics in UBC: Barnes et al. [6], Seppo and Lilles [30], Perkmann et al. [26], Langford et al. [23], Iqbal et al. [22], Tijssen et al. [33]. The aim of this study is to cover the main activities of technology transfer between the University and industry with their respective KPI's. This technology transfer between universities and industry occurs through a variety of mechanisms [11], these range from the hiring of university graduates, to exchanges of personnel, university joint research-company, research contracts, consulting, patents and publications, licenses, spin-off companies, and laboratories financed by industry and other physical facilities, also includes informal contacts such as meetings and conferences. In this way, companies can collaborate with universities in a wide range of possibilities. Additionally, according to Davey et al. [12] define 7 Activities that ease this collaboration (1) Joint Curriculum design and delivery, CDD, (2) Lifelong learning, LLL, (3) Student mobility, SM (4) Professional mobility PM (5) Joint research R&D, (6) Joint marketing R&D, (Commercialization of joint R&D, COM) (7) Entrepreneurship. All these activities are classified within the three primary missions of the Universities: Education, Research and Valorisation.

The remainder of the paper is organized as follows. We first describe the methodology. The next section, presents the Key Performance Indicators used by companies collocated at Science Parks according with the online survey results. Additionally, we present the qualitative analysis of semi-structured interviews. The paper ends with some concluding remarks alongside indicators for future works.

3 Methodology

3.1 Mixed Methodology (Qualitative and Quantitative)

The study used both a qualitative and quantitative research approach. Regarding qualitative research, it was conducted through semi-structured interviews with the directors of Science Parks in Spain and Mexico. The interview was designed according to three main categories: (1) Target audience, (2) Value proposition and (3) the main KPIs of the Science Parks. The information was coded according to the three main categories. A total of ten interviews were conducted. The interview is a directed conversation [24] and a useful tool for interpretative research, as it allows a more in-depth exploration on a particular topic [8]. The study used content analysis to analyse the data [5], the interpretive data was done according to the qualitative research process [36]. The interviews were designed according to the IASP Strategigram Questionnaire [28] which examines different strategic approaches and creates a profile for each science park that concerning such strategic issues as the target markets, target companies and the degree of specialization. Experts on the board of International Association of Science Parks (IASP), validated the questionnaire.

3.2 Quantitative Analysis

Regarding quantitative research, a comparative approach was used between Spain and Mexico. Data was taken from 90 online surveys, 78.89% online surveys in Spain and 21.11% online surveys in Mexico. The survey was designed with the objective of identifying the main KPI's in the University-Business Collaboration (UBC). For this purpose, a literature review of the most representative studies on this topic was carried out. Additionally, collaborative work was done from September 2017 to March 2018 with CA Technologies Company, which had been co-located at the Polytechnic University of Catalonia, Spain for eight years. This collaborative work is a result of the Science2Society project, which has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement N° 693651. In addition to designing and validating the online survey, two frameworks were designed with the main KPIs of both the university and the company. These university-company frameworks show the objectives, strategies and long-term KPIs, as well as process KPIs, and they are a useful guide to evaluate the accomplishments and alignment of goals in UBC, (see Figs. 1 and 2). The online Surveymonkey platform was utilised to send the survey and collect the data. Regarding the Statistical Method, the Principal Components Analysis (PCA) technique was applied for the data analysis, using the SPSS statistical software. The PCA technique serves for data reduction by finding homogeneous groups of variables and highlighting their correlation between each other [1, 16].

4 Results

According to the online survey, 78.89% of the companies surveyed come from Spain and 21.11% from Mexico. The most representative industrial sector is information and telecommunications 36.36% of the total sample, followed by professional and scientific services 25.00% and other services 19.32% (See Fig. 3). Regarding the type of company 46.23% start-ups, 44.34% consolidated companies and 9.43% spin-offs. Finally, the distribution by size of companies is as follows: 53.51% with 0 to 10 employees; 35.09% with 10 to 49 employees; 7.89% with 50 to 249 employees and just 1.75% big companies with more than 250 employees. On the other hand, a total of 53 variables were analysed; Table 1 lists all variables and their descriptive statistics. The information was standardised to the application of the Principal

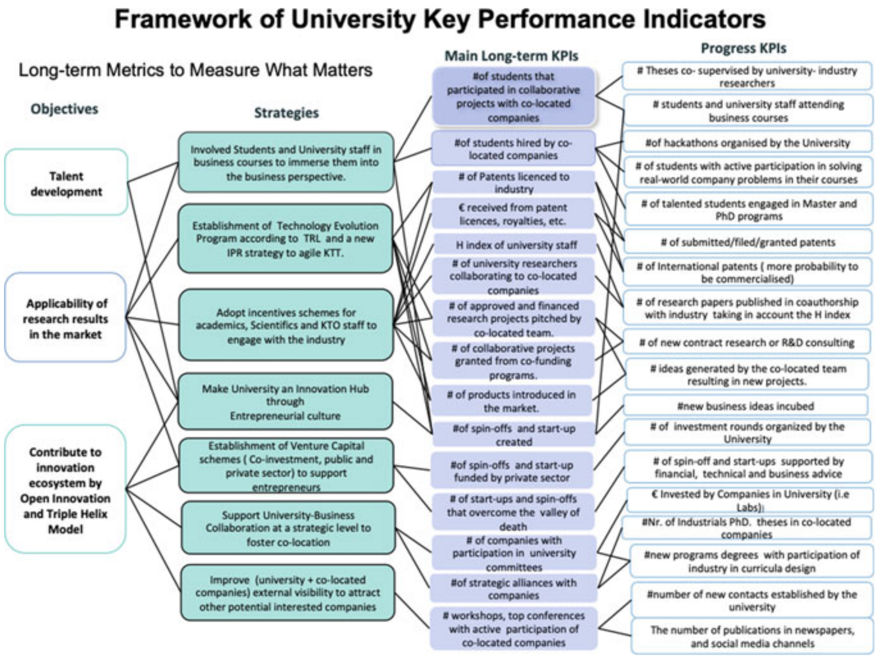

Fig. 1 Framework of university key performance indicators (KPIs). *Source* Elaboration by authors and CA technologies team

Components Analysis (PCA), and five main components were extracted according to the correlation between them. These components were classified as follows: Impact KPIs in UBC, (1), Effectiveness and Funding Support (Private and Public (2)), University-Business Support (3), Industrial Sector (4) and, Firms Characteristics (5) (see Table 2). After application of the Principal Components Analysis (PCA), the variables were reduced from 53 to 26. These twenty-six KPIs in UBC indicators were classified into the five components mentioned above. From the firm perspective, we can note the importance to collaborate with the University both in the short and long-term, as well as to have a favourable legal framework for the transfer of knowledge and technology (IP). Also noteworthy are the indicators with strong links to the university such as mobility of academics and students, courses developed in conjunction with the university, and co-supervised theses. In economic terms, they care about cost reduction and an increase in sales by innovations in products, processes and services and timesaving in product development, among others. Regarding university counselling, highlight topics such as business plan, funding, and technology assessment; however, according to the negative results obtained, universities are not supporting companies in these needs. From Science Park's perspective, the qualitative study shows that the KPIs and success factors perceived by the interviewees focused on economic terms, sustainability and occupation of spaces.

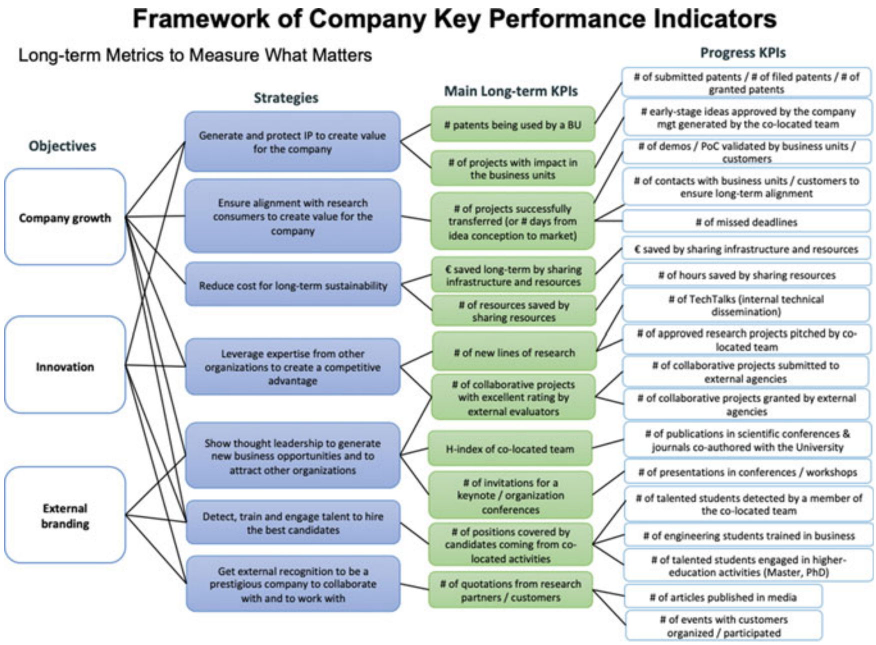

Fig. 2 Framework of company key performance indicators (KPIs). *Source* Elaboration by authors and CA technologies team

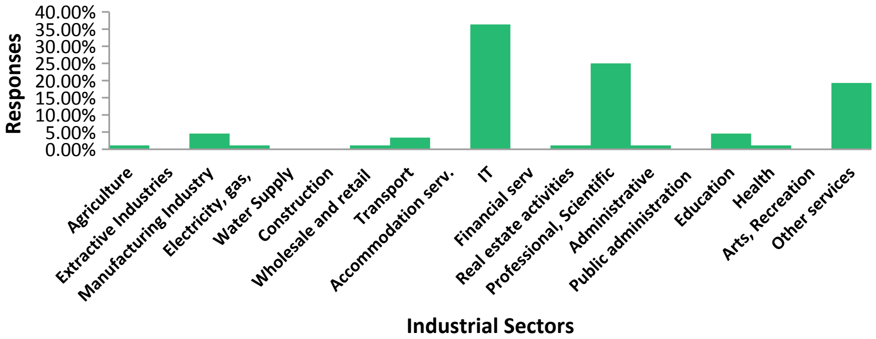

Fig. 3 The most representative industrial sectors (according to data set)

5 Conclusions

There is a diversity of indicators that measure the collaboration between university and company; however, the firm's decision to do a partnership with the university will depend mainly in two of them (a) their short and long-term business objectives and (b) the industrial sector to which they belong. Thus without knowing the sector, it

Table 1 Descriptive statistics for all variables used in the factor analysis, (53 variables)

	Descriptive statistics			
Demographic variables	Variables	N	Mean	Std. Devi
	Company location (Spain/México)	90	1.21	0.410
	Industrial sector	88	12.32	4.354
	Size of your company	88	1.55	0.741
	Market (national/international)	80	2.43	0.652
	Type of company (start-up, spin-off. etc.)	81	1.65	0.616
	Position within the company	89	2.55	2.148
Variables of motivation to establish in SP	Familiarity	79	2.75	1.160
	University location	79	3.08	0.997
	Ecosystem of innovation offered by the University	79	3.00	0.961
	Excellence (top ranking)	79	2.59	1.225
	Favourable legal framework (regarding intellectual property rights)	79	2.39	1.192
	University with an entrepreneurial culture	79	2.85	1.099
Variables of company objectives	R&D: technology development (long term)	73	2.85	1.139
	Consultancy services, research contract (short term)	74	2.73	1.089
	Acquisition of university licenses and patents	74	2.05	1.058
	Investment in start-ups (corporate venturing)	74	2.39	1.004
	Hire talent	73	3.12	0.942
	Advertising (presence in university/prestigious Science Park)	74	2.68	0.967
	Use of university-park infrastructure and services (cost-benefit)	74	3.19	0.961
Variables of company key performance indicators (KPIs)	Number of patents (presented/granted)	62	1.85	1.480
	Number of patent citations and/or articles in university-company co-authorship	4	2.00	0.000

(continued)

Table 1 (continued)

	Descriptive statistics			
	Number of patents and university licenses being used by your company	52	1.25	1.281
	Number of new university start-ups integrated into your company's business units	55	2.16	1.411
	Number of new collaborative projects	62	2.81	1.212
	Number of new consultancy contracts	55	2.44	1.167
	Number of new research contracts	59	2.41	1.233
	Number of new research lines	54	2.44	1.313
	Number of patent citations and/or articles in university-company co-authorship	57	2.16	1.347
	Number of projects completed on time (from idea to market)	60	2.95	1.268
	Time-saving in product development	59	2.98	1.137
	Cost-reduction through shared infrastructure and resources	61	3.30	0.919
	Cost-reduction due to innovations (products, processes or services)	60	3.12	1.043
	Increase in sales due to innovations in products, processes or services	50	2.82	1.320
	Number of talented students detected by your company	62	3.32	0.937
	Number of students, doctoral students and academics hired by your company	53	2.74	1.163
	Number of positions filled by candidates coming from activities such as: hackathons, internships, etc.	62	2.63	1.440
	Number of university-company exchanges (mobility of academics/students)	53	2.43	1.323

(continued)

Table 1 (continued)

	Descriptive statistics			
	Number of co-supervised masters and PhD Theses (university-company)	52	2.17	1.216
	Number of courses/graduates/MBA, received by your company's staff	51	2.24	1.350
	Number of conferences, seminars, meetings, workshops, networking Activities (university-company)	59	2.95	1.105
	Number of new courses developed by university-company	60	2.45	1.333
	Number of publications in newspapers, magazines, social networks, etc.	60	2.65	1.147
Satisfaction variables	Within the last 3 years, were your objectives/expectations fulfilled when you established your company at SP?	57	1.23	0.423
Funding variables	Public funds local or regional government (tax deductions, subsidies, credits)	49	0.55	0.503
	Public funds government national level (Innovation Programs)	49	0.41	0.497
	(Spain Grants) European Union Public Funds (Participation in EU 7 Framework, Horizon 2020)	49	0.27	0.446
	Private funds (venture capital, Angel Investors)	50	0.30	0.463
	Bank credits	48	0.31	0.468
Satisfaction variables	The university evaluates the commercial value of technology	61	2.00	1.017
	The university provides a suitable legal environment for the transfer of knowledge and technology (IP).	61	2.38	0.934
	The university advises on the development of business or marketing plans	61	2.28	1.082
	The university advises on access to bank loans, Angel Investors and venture capital.	61	2.07	0.910

(continued)

Table 1 (continued)

	Descriptive statistics			
	In general, are you satisfied or dissatisfied with your experience in this University Science Park?	53	2.08	0.895
	N valid (according to list)	0		

Table 2 Main key performance indicators in UBC, according survey results

	Components matrix					
	Variables	Principal components				
		1	2	3	4	5
Impact key performance indicators in UBC (1)	Number of new research contracts	*0.808*	−0.026	0.379	0.031	0.146
	Number of new collaborative projects	*0.770*	−0.137	0.253	−0.018	−0.019
	Number of courses/graduates/MBA, received by your staff	*0.746*	−0.432	0.005	0.062	0.085
	The university provides a suitable legal environment for the transfer of knowledge and Technology (IP)	*0.731*	0.218	−0.444	0.129	0.048
	Number of new consultancy contracts	*0.717*	−0.148	0.292	0.021	−0.033
	Increase in sales due to innovations in products, processes or services	*0.714*	−0.411	−0.064	0.185	−0.008
	Number of new research lines	*0.705*	−0.012	0.471	−0.030	0.095
	Number of university-enterprise exchanges (mobility of academics/students)	*0.697*	−0.164	0.308	−0.160	−0.025
	Cost-reduction due to innovations in products, processes or services	*0.694*	−0.396	−0.032	−0.030	0.120
	University with an entrepreneurial culture	*0.666*	0.069	−0.267	−0.270	−0.210

(continued)

Table 2 (continued)

	Components matrix					
	Variables	Principal components				
		1	2	3	4	5
	Number of new university courses developed by university-company	*0.663*	−0.265	−0.029	0.240	−0.141
	Number of positions filled by candidates coming from activities such as: hackathons, internships, etc.	*0.662*	−0.240	0.179	0.069	−0.144
	Favourable legal framework (regarding intellectual property rights)	*0.637*	0.151	−0.286	−0.107	−0.157
	Number of students, doctoral students and academics hired by your company	*0.637*	−0.135	0.390	−0.242	0.126
	Number of co-supervised masters and Ph.D. theses (university-company)	*0.634*	0.073	0.477	0.196	−0.151
	Number of new university start-ups integrated into your company's business units	*0.632*	0.142	−0.058	−0.120	0.120
	Ecosystem of innovation offered by the university	*0.603*	0.114	−0.057	−0.434	−0.096
	Number of talented students detected by your company	*0.596*	−0.084	0.116	−0.317	0.223
	Number of publications in newspapers, magazines, social networks, etc.	*0.594*	−0.489	−0.032	0.328	0.053
	Number of patents and university licenses being used by your company	*0.591*	0.499	0.291	−0.026	0.153
	Excellence (top ranking)	*0.547*	0.447	−0.044	−0.237	−0.059
	Cost-reduction through shared infrastructure and resources	*0.521*	−0.367	0.034	−0.396	0.220

(continued)

Table 2 (continued)

	Components matrix					
	Variables	Principal components				
		1	2	3	4	5
	Number of patent citations and/or articles in university-company co-authorship	*0.515*	0.132	0.403	0.114	−0.092
	Company location (Spain/Mexico)	*0.489*	0.283	−0.169	0.007	−0.273
	Number of projects completed on time (From Idea to Market)	*0.476*	−0.353	0.029	0.255	−0.203
	Hire talent	*0.459*	−0.192	0.068	−0.338	−0.380
Effectiveness and funding support (2)	Acquisition of university licenses and patents	0.321	*0.704*	−0.106	0.225	−0.251
	Time-saving in product development	0.465	*−0.657*	−0.154	0.081	0.095
	Number of patents (presented/granted)	0.446	*0.643*	0.123	0.063	0.119
	Public funds, Government or national level (innovation programs)	0.173	*0.579*	0.428	0.035	0.159
	R&D: technology development (long term)	0.491	*0.542*	0.037	0.093	−0.233
	Bank credits	0.096	*0.516*	0.195	0.079	0.265
	Private funds (venture capital, angel investors)	0.057	*0.400*	0.158	0.177	0.357
University-business support (3)	The university advises on the development of business or marketing plans	0.434	0.108	*−0.729*	0.253	0.180
	The university advises on access to bank loans, angel investors and venture capital	0.376	0.206	*−0.716*	0.048	0.229
	The university evaluates the commercial value of technology	0.536	0.208	*−0.599*	0.086	0.204

(continued)

Table 2 (continued)

	Components matrix					
	Variables	Principal components				
		1	2	3	4	5
	In general, are you satisfied or dissatisfied with your experience in this University Science Park?	−0.391	−0.189	*0.594*	0.359	−0.033
Industrial sector (4)	Industrial sector	0.026	−0.046	−0.060	*0.630*	0.057
Firms characteristics (5)	Advertising (presence in university/prestigious science park)—level of importance	0.338	−0.247	−0.278	0.370	0.193
	Type of company	−0.012	0.140	0.033	−0.037	*0.649*
	Size of your company	−0.121	0.419	0.267	0.002	*−0.501*
	Public funds local or regional government (tax deductions, subsidies, credits)	0.266	0.303	0.237	0.209	*0.457*

Note Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalization

will be complicated to distinguish which indicators are more relevant. It is important to note that in this study the most representative industrial sectors were IT, Scientific activities and other services. Therefore, it would be convenient to classify the above indicators presented, according to the governmental policies of each country and, the economic and social impact they present. On the other hand, this study shows the lack of universities assistance in business advice, commercial technology evaluation and funding. The results of this study fill an important gap in the literature because they took into account the companies and the Science Parks point of view, which is decisive, in order to know and aligned the objectives of the primary stakeholders in the process of transfer of knowledge and technology.

The limitations from this study are from the side of the University because the data was taken into account partially; thus, there is a need also to design a survey about university KPIs and compare the results with the analysis of the companies KPIs showed in this study. Also, there is a need to extend this study to larger samples and to include the political, economic, legal and technological characteristics of each country. Therefore, in future research, it would be appropriate to integrate these factors.

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Powering Synergies Between Innovation Policy and Regional Development Frameworks: The Case of Smart Specialisation

Dimitri Corpakis

Abstract The case study refers in principle to the whole of the European Union, since it addresses synergies between two critical policies with strong potential for Triple Helix interactions. It focuses on the importance of increased coordination between two significant European Union policy frameworks, namely the one on Research and Innovation and the other on Regional Development (Cohesion Policy funding through the European Structural and Investment Funds). This is illustrated through the policy background of the current programming period (2014–2020) that placed Smart Specialisation as a key ex-ante conditionality for the deployment of regional innovation plans to be funded through Cohesion Policy. Research and Innovation Strategies for Smart Specialisation, (RIS3) have emerged as key enabler for an effective coordination between the two policy frameworks. To make this process a success, national and regional governments, universities and businesses had to engage at national and local level through the so-called Entrepreneurial Discovery Process (EDP), a key step for prioritising investment. EDP lends itself to a real Triple Helix structural component and its success is heavily dependent on an efficient articulation of all layers and stakeholders involved. The case study addresses these issues in detail and identifies the critical determinants for success through specific real-world examples located primarily in the European Union.

Keywords Knowledge-based economies · Innovation and entrepreneurship · Funding strategies and priority identifications

1 EU Policies for Research and Innovation

The European Union is a unique political experiment. Brought out of the ashes of World War II, as an initial coalition of neighbouring countries designed to prevent further production and proliferation of deadly weapons, it developed into a powerhouse of economic development, bringing peace and prosperity to its members, at large. Its success is underlined by its successive enlargements that made it a Union of 28

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countries as well as a powerful and desirable partner in the world markets (despite the fact that one of the current members, namely the United Kingdom, decided through a referendum to leave the bloc by 2019). Widespread economic growth is due to many structural factors, among which its fundamental principles on the so-called four freedoms, namely the freedom of circulation for individuals, the liberty of establishment, the freedom of trading goods and services as well as the freedom of capital circulation (which jointly establish one of the greatest achievements of the Union, its Internal Market (the Single Market), a unified space for living, working and trading inside the Union).

The gradual establishment of the Single Market came with challenges too, namely the potential reinforcement of inequalities. To counterbalance these, the Union introduced specific policies with strong socio-economic objectives: the European Structural and Investment Funds' (ESIF) goal is to reduce economic disparities, with a strong focus on regional (sub-national) ones and to promote a balanced and sustainable economic growth.

In addition and to keep the EU as competitive as possible, additional policies have been deployed: promotion of quality education and training with a strong emphasis on evolving skills in adaptation to technological change and support of high quality research and innovation activities. The latter is being supported through two specific policy frameworks that together make two of the biggest parts of the Union's spending budget: the Framework Programme for Research and Innovation (Horizon 2020 in its current implementation) and the European Structural and Investment Funds (ESIF or else Cohesion Policy). Both policies are strongly underpinned by the concept of the Triple Helix with different connotations and intensity.

In this paper we will examine the funding principles that govern the two frameworks supporting research and innovation in the EU. We will compare similarities and differences and will determine how the regions (sub-national entities) and the Member States can make the most out of them, increasing the synergies between seemingly diverse activities. We will show that the single best factor for achieving the maximum of synergies was the introduction of the principle of Smart Specialisation in the course of the latest programming period (2014–20) and we will illustrate the ways that this can be effectively achieved. Finally we will bring examples of real-world cases that illustrate the synergies that can be achieved.

2 The Framework Programme

2.1 Treaties and History

The first glimpses of the European Union's involvement with Research and Innovation policy, date back to the first European Steel and Coal Community Treaty, established in 1952. It was not however at the time the centrepiece of the political priorities of the founding fathers of the EU, since the ESC focused primarily on limiting the powers of some Member States for developing and producing lethal weapons. Despite this, a fist embryonic research activity saw the light with the ESC Treaty: article 55 of the ESC Treaty included a small programme of R&D to: "… encourage technical and economic research concerning the production and the development of consumption of coal and steel, as well as labour safety in these industries".

While the Rome Treaty on the European Community remained silent about research, it was the Single European Act (1986) and the Maastricht Treaty (1992) that defined and strengthened the legal bases of the EU action on Research and Innovation. With the Single European Act (SEA) the aim of the Union's RTD policy was defined as "… strengthen the scientific and technological basis of European industry and to encourage it to become more competitive at international level". Today, the Lisbon Treaty defines the EU action on Research and Innovation with Articles 179 to 190 of the so-called Treaty on the Functioning of the European Union (TFEU). In particular and in the spirit of an 'ever closer Union' article 179 of the TFEU specifies that 'the Union shall have the objective of strengthening its scientific and technological bases by achieving a European Research Area (ERA) in which researchers, scientific knowledge and technology circulate freely'. Thus the concept of a broader unified space for European Research is introduced by providing a strong message of unity and cooperation of scientists and innovators under the sign of the European Union.

2.2 The Concept of the FP

The EU's Framework programme for Research and Technological Development is the largest funding instrument for science, technology and innovation at world level. It brings together universities, research organisations (public and private), businesses (big and small) as well as individual researchers, in a multi-purpose programming activity that focuses primarily on strengthening the competitiveness of the Union by pushing the frontiers of knowledge and by creating the framework conditions that will allow knowledge-intensive technological breakthroughs. This objective was significantly specialised over the years to include important support for scientific excellence, as well as using science and research to address big societal challenges like environmental protection, climate change, health, sustainable transport etc. As a concept it is fully defined in the EU Treaties (see box). It is important also to note that most of the activities have to be carried out in a transnational cooperation mode, thus favouring, on the one hand, the broader European Integration process but at the same time, opening up the frontiers of the Union to world-wide peaceful and productive cooperation.

Article 180
(ex Article 164 TEC)
In pursuing these objectives, the Union shall carry out the following activities, complementing the activities carried out in the Member States:

(a) *implementation of research, technological development and demonstration programmes, by promoting cooperation with and between undertakings, research centres and universities;*
(b) *promotion of cooperation in the field of Union research, technological development and demonstration with third countries and international organisations;*
(c) *dissemination and optimisation of the results of activities in Union research, technological development and demonstration;*
(d) *stimulation of the training and mobility of researchers in the Union.*

The Framework Programme is now in its current (8th) edition (2014–20) with a budget circa EUR 80 billion (bn), having started operations in a quite more modest format, in the early '80s (1984). A new (9th) version is in the making with an even bigger budget for the next programming period (2021–27, Horizon Europe; projected budget circa EUR 100 bn). The FP is centrally managed by the Commission services in Brussels with the help of a number of Commission Executive Agencies that are entrusted with contract management and the day-to-day administrative and financial operations. The Commission services are in charge of strategy, policy and coordination.

2.3 Main Actions and Beneficiaries of the FP

The *aim* of the EU's Framework Programme (at the moment Horizon 2020, Regulation EU No. 1291/2013) has been defined by the legislator in these terms: "*to build a society and a world-leading economy based on knowledge and innovation across the whole European Union, while contributing to sustainable development*".

This overall target is broken down to three 'mutually reinforcing actions' focused on: *(a) excellent science; (b) industrial leadership; (c) societal challenges*. Each of these "priorities" have a number of particular objectives, that is:

– *Priority I excellent science: reinforcing and extending the EU science base excellence, and consolidating the ERA (European Research Area, a unified space for researchers), to enhance the competitiveness of the EU research and innovation system on a global scale;*
– *Priority II industrial leadership: focusing on accelerating the development and deployment of technological innovations that will be able to scale-up the innovative European SMEs;*

– *Priority III societal challenges: addressing the policy priorities and societal challenges, identified in the Europe 2020 strategy that require common research and innovation actions, since no Member State can afford to address them alone (like health, sustainable development, energy and the environment* etc.*).*

The ways and methods of designing and delivering the Framework Programme have developed substantially throughout the few decades of its history: there has been a clear evolution to more strategic programming that takes into account not only the declared strategic priorities of the European Commission's Work Programme but equally the views of the numerous stakeholders coming from all parts of society (universities, public and private research organisations, big industry but also Small and Medium Size Enterprises, Professional associations, civic society, etc.). The programme is now designed following open public consultations that use heavily the Internet and most recently Social Media, together of course with the formal consultation and co-decision process with the Council (EU Member States) and the European Parliament. Increased publicity is given to the forthcoming work programmes and Calls for proposals that have been heavily rationalised and rendered fully electronic, through an entirely online proposal submission system.

It is important to note that while there are different classes of actions under the Framework Programme, in principle the basic structure is shaped on the basis of typical Triple Helix partnerships with several variations. From the full-blown helix of academia–industry–government, the typology ranges from public–private, to private–private, public–public partnerships. Another factor that shapes the type of the partnership is content: thus, for example, there are several different types of actions used under Horizon 2020: collaborative R&I projects [most specifically Research and Innovation Actions (RIAs) Innovation Actions (IAs)], support to individual applicants for fundamental research under the European Research Council, Future and Emerging Technologies (FET) schemes, Marie Sklodowska-Curie mobility and training Actions for researchers (MSCA) as well as support to disruptive innovation under the so-called SME Instrument. Other types of actions include the procurement of innovative solutions (Pre-commercial procurement for innovation (PCP), Public Procurement of Innovative solutions (PPI)), P2P (including ERANET Co-funds, Article 185), Public–Private Partnerships (including Joint Technology Initiatives (JTIs), contractual public–private partnerships), inducement prizes and financial instruments. Finally the so-called "Coordination, support and other actions" are used for studies, expert groups, conferences, as well as for disseminating and exploiting results.

The first and most visible impact of the Framework programme is its funding to beneficiaries researchers, research teams and partnering institutions. On a total budget which stands at present at EUR 74.8 bn and on the basis of January 2017 statistics, EUR 20.4 bn has been allocated to 11,108 (eleven thousand one hundred eight) signed grants. Of these, EUR 7.5 bn was allocated to Pillar 1: excellent science (36.8%); EUR 4.5 bn to Pillar 2: industrial leadership; EUR 7.4 bn to Pillar 3: societal challenges; and EUR 944.1 million to additional priorities [6]. Most of this money was allocated through the so-called Research and Innovation Actions (39.3% of total funding), followed by fundamental research grants awarded by the

European Research Council (19.0%). Again, it has to be stressed that such funding has an immediate and lasting impact on the research communities of the Member and Associated States since it allows the creation of new knowledge as well as important synergies and breakthroughs within cooperation industries and small businesses.

However, while the Framework Programme promotes the creation and the advancement of knowledge, it does not pay any attention on where and how such advancement will result into meaningful gains for the hosting communities/places. **As such it falls in the category of "location-blind" policies, in stark contrast with EU's Cohesion Policy which is place-based**. This has resulted over the years in significant asymmetries on the ground, with little or no corrective action (until Horizon 2020 introduces the important actions on "Spreading excellence and Widening Participation" with promising results).

There are strong arguments in favour of a "location-blind" approach (as well as against): first and foremost the main reason is the unconditional quest for scientific excellence that cannot afford to be "contaminated" with other criteria types. Even if this is not entirely true for the majority of the actions of the FP (where, in addition to the excellence criterion, there are two others at play, namely, impact and efficient use of resources) the nature of the partnerships which are almost always trans-national, renders very difficult every attempt for effective localisation of any funded R&D project: partners are dispersed all over Europe, with no particular geographic base, even if the coordinating entity could play a role in this process. On the other hand, the declared objective for funded projects, is the significant advancement of knowledge and innovation for humanity at large (and of course for the benefit of Europe), with the expectation that the overall impact will eventually override any kind of localised perspective. **Thus the local dimension is difficult to capture in the context of the FP**.

This said, there is of course an important regional dimension of the FP funded projects that materialise over a number of research institutions across Europe, mobilising several research teams in different socio-economic and geographical contexts. For the majority of FP funded projects, research teams follow a typical Triple Helix pattern, linking together universities, research organisations and businesses. In the context of the FP, the government role is mostly represented by the European Commission that sets the stage and manages the projects as they go along; this however does not exclude the occasional involvement of local or national authorities in significant projects: in these cases the involvement is either through a provision of facilities, training of researchers or technical staff or support on diffusion and commercialisation of results. However there is currently no way for a proposal to involve the local or regional dimension argument to be taken seriously in the context of the FP.

Despite the fact that the Framework Programme represents the biggest source of funding at EU level for Research and Innovation, **it is not the only one that matters: Cohesion Policy (the European Structural and Investment Funds)** is the second biggest research and innovation funder in the same context, and its role is greatly increasing over time. From a modest percentage of 4% of its budget devoted to R&D and Innovation (RDI) in the early 90s, the European Regional Development Fund

(ERDF) has climbed to almost 30% in the last programming period (2014–20). In concrete figures this represents more than EUR 40 bn for all kinds of support to RDI with funding rates that can go from 40 to 80% of the total expenditure (The FP in comparison provides the 100% of the total expenditure for public bodies while it goes up to 70% for companies). Thus in absolute numbers, the ERDF expenditure on RDI is almost half of the total one of the FP.

There is however an important difference between the two frameworks: while the FP follows a totally competitive approach for allocating grants, the ERDF (and the rest of the European Structural and Investment Funds, ESIF) work(s) in partnership with the Member States' Managing Authorities, allocating money to the national governments in a non-competitive approach, based on specific economic and population indicators and on a number of jointly agreed strategic programmes. In the case of Research and Innovation Policy, this difference creates a number of tensions on the ground, as on the one hand there is one single common objective at Union level (advancement of the Knowledge Economy and strengthening of competitiveness and growth) pursued by both policies; on the other however the ways actions and beneficiaries are selected differ profoundly and lead to questionable results when seen from an efficiency perspective [17].

Such results tend to favour, over time, strong institutions as they lead to an increased networking concentration among the-best-in-class (forming competitive partnerships coming out of the strongest places and communities in terms of resources but also of institutional thickness). **The question thus is how to re-conciliate the seemingly contradictory policy frameworks by increasing positive synergies, interactions and coordination while respecting their respective philosophies and rationale (as both policies are fully justified in their own arguments)**.

3 Support for Research and Innovation in the Context of EU's Cohesion Policy and the Need for Increased Synergies with the Framework Programme

3.1 EU's Cohesion Policy as a Power Funder for Research and Innovation

The birth of Cohesion Policy preceded the EU's actions on Research and Innovation as the latter are still perceived as shared competence between the Union and its Member States. The European Community Rome Treaty (1957), has put emphasis on the concept of "promotion of 'harmonious development of economic activities'", somehow pre-announcing a policy for sustainability and balanced development. However it is far later (in 1972) and following the first enlargement (IRL, DK, UK) and the adoption of the objective for achieving an Economic and Monetary Union, that the European Regional Development Fund (ERDF) is created, based on art. 235 of the

Treaty (now art. 308), while the first ERDF Regulation is adopted in 1974, allowing it to become operational on the ground.

According to the Treaty, the main aim of Cohesion policy is to reduce regional disparities across the EU. Article 174 of the Treaty on the Functioning of the European Union (TFEU) stipulates that: '*In order to promote its overall harmonious development, the Union shall develop and pursue its actions leading to the strengthening of its economic, social and territorial cohesion. In particular, the Union shall aim at reducing disparities between the levels of development of the various regions and the backwardness of the least favoured regions*'.

Cohesion policy forms a substantial part of the EU budget [6] since it is roughly around 30% of the total (current amount for Cohesion budget stands at about EUR 454 bn). Factoring-in national/regional and private money, this figure goes up to some EUR 638 bn. In practical terms, five (5) funds are operational of which the biggest and most significant is the European Regional Development Fund (ERDF) [the others being the European Social Fund (ESF), the Cohesion Fund (CF), the European Agricultural Fund for Rural Development (EAFRD) and the European Maritime and Fisheries Fund (EMFF)]. Applying specific pre-allocation criteria, the 'less developed regions' (whose GDP per capita is lower than 75% of the EU average) get the lion's share, while the so-called 'transition regions' having a GDP per capita between 75 and 90% of the EU average get the rest.

During its long history the objectives of the ERDF have been remarkably steady, but during the two last programming exercises they have been significantly broadened to reflect the commitment of the reformed Cohesion policy to the Lisbon strategy (and its successor policy, Europe 2020) **towards a knowledge economy and society**. Consequently we have witnessed a major turn towards innovation and intangible investments favouring R&D, the Union's Digital Agenda, the Sustainable Development Goals and the strengthening and modernisation of SMEs. It has also to be noted that over the years, the component of efficient partnership of the Triple Helix partners on the ground has played an important role on conceiving and designing local and regional strategies. This culminated in the use of the Entrepreneurial Discovery Process a participatory exercise to identify the unique growth drivers of a country/region in the context of Smart Specialisation Strategies (S3). **It was indeed the introduction of the concept of Smart Specialisation as a compulsory approach to the programming of the Structural Funds that provided the strongest opportunity for efficient synergies with the Framework Programme in the field of innovation**.

3.2 The Advent of Smart Specialisation

Smart specialisation strategy here means the *national or regional innovation strategies which set priorities in order to build competitive advantage by developing and matching research and innovation own strengths to business needs in order to address emerging opportunities and market developments in a coherent manner, while avoiding duplication and fragmentation of efforts; a smart specialisation strategy may* *take the form of, or be included in, a national or regional research and innovation (R&I) strategic policy framework. The development of smart specialisation strategies through involving national or regional authorities and stakeholders such as universities and other higher education institutions, industry and social partners in an entrepreneurial discovery process is compulsory for the regions and Member States that wish to invest resources from the ERDF into research and innovation. Smart specialisation strategies have to include upstream and downstream actions with the Framework Programme (i.e. Horizon 2020).*

The concept of Smart Specialisation was born in the context of a High Level Experts Group of the European Commission set up by former Research Commissioner Janez Potocnik (Knowledge for Growth). Coming out from earlier work of innovation economists the concept originated out of examining the causes of the persistent productivity gap between Europe and the USA, a gap blamed primarily to fragmentation of innovation programmes and efforts in Europe and lack of capacity in exploiting better the so-called General Purpose Technologies [1, 11, 13]. The expert group then advised in a working paper to "*encourage investment in programs that will complement the country's other productive assets to create future domestic capability and interregional comparative advantage*" [12, 19].

In the run-up to the next Multi-Annual Financial Framework of 2014–2020, the **concept of Smart Specialisation reached unexpectedly the heights of the European Council (the Heads of State and Government)**. With such a strong backing it found itself as an Ex-Ante Conditionality in the Regulations laid down by the Council of Ministers and the European Parliament for the new Cohesion Policy (2014–20), advocating for Smart, Sustainable and Inclusive Growth. Doing this, it marked a new ground in making a link between a renovated 'Smart' Regional Policy and the Research and Innovation Policy of the Union, energising more Triple Helix links in the process and mobilising new kinds of stakeholders for a new place-based Innovation Policy.

Smart Specialisation is indeed about specialisation but is at the same time a departure [18] of a simplistic specialisation logic that can lead to economic lock-ins and sometimes blatant failures (for example after a mega-failure of a given sector due to endogenous or exogenous factors or an unexpected withdrawal of a key investor—e.g. the steel sector in Belgium). It describes rather "a strategic approach to economic development focusing on targeted support for research and innovation" [2], and addresses issues as "smart diversification", focusing on the real growth drivers of the future for a given location, based on knowledge assets. Because of this Cohesion policy regulations adopted the term "*Research and Innovation Strategies for Smart Specialisation (RIS3)*"[1] to identify the relevant Ex-Ante Conditionality for all investments in research and innovation to be supported under the Structural Funds. In their own words the experts that conceived the concept urge policy makers to set

[1]RIS3 Guide: http://s3platform.jrc.ec.europa.eu/s3pguide See http://ec.europa.eu/regional_policy/thefunds/fin_inst/pdf/fi_esif_2014_2020.pdf and http://ec.europa.eu/regional_policy/thefunds/fin_inst/index_en.cfm (an update of the "Practical guide to EU funding opportunities for research and innovation").

priorities [3] in certain domains "*in order to realize the potential for scale, scope and spillovers in knowledge production and use, as these are important drivers of productivity in the domain of R&D and other innovation-related activities*" [13].

In the current programming period, more than 120 Smart Specialisation Strategies, focusing on Research and Innovation priorities as significant growth drivers and investment orientation choices, helped the 28 Member States who are all ERDF beneficiaries, albeit with differences, commit money from the Fund on RTDI. Starting from a huge EUR 10 bn commitment on RDI from Poland to the smaller commitments of Luxembourg, Cyprus and Malta (that are performing however very well if account is taken for their population, and their researchers' community) it is clear to establish that MS take now the Research and Innovation structural investments very seriously. **This puts however on the table the question of the best possible achievement of meaningful synergies and coordination between the ESIF action on RTDI and the one launched by the Framework Programme**.

To achieve this, it is crucial, first, to align strategies and implementation modalities and complement existing and future roadmaps. However, translating this new reality is largely a learning process, given that ESIF implementation is under Member States' shared management rules while FP support is allocated at EU level (directly or indirectly by the Commission). **A first effort lies in making strategic choices and planning on the side of the regions and Member States, i.e. to foster excellence in the smart specialisation areas**. For Framework Programme proposers this means taking fully into account the Smart Specialisation Strategies of their region/country to align their proposal if this is indeed feasible (this is by no means compulsory). On a broader approach, authorities should try harder to raise awareness for universities and companies trying to enter the Framework Programme on the existence and content of these strategies. This may look as a bureaucratic process but it is very important in order for maximising synergies between the two frameworks on the ground.

It is useful to concentrate here on the concept of Synergies: in a relatively detailed guidance document (2014) [8] the Commission services identified "*synergies between the different Union funds as amplifying the research and innovation investments and their impact, combining different forms of innovation and competitiveness support, or carrying innovative ideas further along the innovation cycle or value chain to bring them to the market. Synergies are thus about obtaining more impacts on competitiveness, jobs and growth in the EU by combining ESIF, Horizon 2020 and other EU instruments in a strategic and also cohesion-oriented manner.*"

Among the practical ways available for achieving better synergies, is to focus at project level: here participants have been strongly advised to examine how money from the two frameworks can be put to work for the same project, or for a combination of projects that build on each other (through an intelligent road-mapping). **The common breeding ground of this effort then is the relevant, localised, Smart Specialisation Strategy**.

4 Smart Specialisation as a Breeding Ground for Synergies: Illustrating Specific Synergy Cases

The particular characteristics of establishing and running a Smart Specialisation Strategy provide for a fertile ground for developing synergies between Cohesion policy and the Research and Innovation Framework Programme. It has to be understood that what is actually sought after here is the **maximisation/optimisation of the impact of relevant activities on Research and Innovation, irrespectively of the funding programme that underpins them**. Considering that ESIF related actions are actually broadly planned by the national or regional authorities (albeit in theory at least, through a participatory process where the private sector is normally present) but actually carried out by the regional Triple Helix stakeholders (universities, companies and sometimes non-profits) on the ground; considering also that broadly a similar pattern is followed by the Framework Programme but mostly on a transnational basis and following a centrally designed and delivered competitive selection process, it is clear from the outset that a **thematic approach can form the common starting ground for synergies**. Thus, through the S3 process, crucial choices [4, 5, 7, 10] will have to be made on the orientation of investment and then on the accompanying measures that will support it including on actions on R&D that will normally give it an edge over competitors in the global value chains where ideally it will be integrated on successful outcomes.

This fundamentally constructive role of Smart Specialisation can function as a **real accelerator for investments on research and innovation**, especially by allowing them to find **transnational partners** and construct a more sophisticated endeavour, on the basis of the growth drivers/priorities that happen to coincide with some of these found simultaneously in their RIS3 and the Framework Programme. However t*his kind of organisation requires particular know-how in the area of priority setting* [14, 15, 16].

Because of the complexity of the operations, it is clear that organisations and partnerships with thick institutional structure and capabilities will be more successful in designing, seeking and building synergies, across the two frameworks.

A particularly interesting example [9] **is the case of Bio-Based Industries Joint Undertaking (BBI JU)**, a relatively new EUR 3.7 bn Public–Private Partnership between the EU (Horizon 2020) and the **Bio-based Industries Consortium (BIC)**, an industry group. The BBI JU has devised a particular Vision and Strategic Innovation and Research Agenda developed by industry, mobilising EUR 975 million of EU funds and EUR 2.7 bn of private investments, a financial set-up that creates a sound basis for attracting additional investment from regional authorities (that can use for this purpose Structural Funds to include it in their Smart Specialisation Strategies). BBI JU has an ambitious objective of developing new bio-refining technologies to transform renewable natural resources into bio-based products, materials and fuels and thus create new value chains. This is a particularly promising sector for Europe, especially in the context of sustainability but also growth, targeting new and expanding markets.

Another good example of **multi-stakeholder Triple Helix like initiative is the Joint marine and maritime research and innovation initiative BLUEMED for jobs and growth in the Mediterranean Sea**. BLUEMED[2] is an initiative jointly launched by the participating Member States (Cyprus, Croatia, France, Greece, Italy, Malta, Portugal, Slovenia and Spain) and funded by the European Commission. Launched in 2014, the project focuses on research and innovation activities in the maritime sector with a special focus on the Mediterranean Sea, its ecosystems and the potential benefits that can be derived by the sustainable optimal exploitation of its natural resources, while caring for social and environmental protection. The Triple Helix dimension is strongly present in the partnership and aims at strengthening the positive effects from a harmonious collaboration between policy makers, business leaders and research institutions over the long term. The initiative provides a good model for a synergetic approach of multi-instrument funding, clustered around a key specialisation area.

A final telling example of a large multi-stakeholder initiative is the case of the **MicroTec Südwest consortium (MTSW)**, consisting of about 200 companies and universities and research institutions, specialised in knowledge advancement, industrial production processes, marketing and exploitation activities in the field of microsystems technologies (MST), an important localised cluster in Baden-Württemberg (BW), Germany. The cluster is a good example of a Triple Helix initiative with heavy involvement from industry and the authorities, that managed to systematise and expand its activities and better integrate the global value chains in its domain, by improving, codifying and prioritising its activities to anticipate and match the dominant global market trends, making it one of the global leaders in its field.

5 Instead of Conclusions

This paper tried to focus on the issue of synchronisation between two different large programmatic initiatives of the European Union, namely the multi-annual Research and Innovation Framework Programme and the European Structural and Investment Funds (Cohesion Policy). Largely driven by top-down policies, they both leave the ability of bottom-up initiatives for synchronisation options. This is now greatly facilitated by a programmatic component in the Structural Funds, namely Smart Specialisation Strategies. By providing a clear priority-setting procedure for identifying future growth drivers for a given location (region, country), Smart Specialisation reinforces the ability of the local or national research and innovation stakeholders to focus on their real competence and target their real research and innovation priorities inside the highly competitive Calls for proposals of the Framework Programme. In addition, the strategy allows for a better local preparation for investments that strengthen the innovation capabilities of the stakeholders (infrastructure, smart

[2]Bluemed https://www.researchitaly.it/uploads/12471/BLUEMED_Vision.pdf.

intermediaries, networks, and exploitation and diffusion policies). **Triple Helix is a major enabler here, providing the basis for a smart mobilisation of stakeholders and their interactions**.

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The Success of Innovation Projects in Public/Government Sector

Eman Alhosani and Khalid Al Marri

Abstract Innovation encourages the organization to provide smart and unique services or products to users and customers to meet their needs and satisfaction. Success criteria and factors helps the organization to improve the possibility of having successful innovation project. This research will examine the influence of innovation criteria and factors on innovation project's outcome. It clarify the effects of selected factors and criteria of innovation project. The researcher in this paper examine the relationship between factors and criteria. Quantitative method implemented to assess the proposed hypotheses and evaluate the impact of the selected criteria and factors on the innovation project's outcome in term of success and failure over three federal entities in UAE. The outputs promote the idea that the government spends time and money to develop the innovation strategy to deliver the product/service on the specified time to meet the project objectives, customers, end-users and project stakeholders satisfaction. In addition, the support of top management to all department and team members will increase their satisfactions, which will lead to the successes of innovation projects. Also sharing the knowledge will strengthen the relationship between the team members and will cut-off the barriers which will reduce the time and cost spend to transfer the knowledge between project stockholders.

Keywords Innovation project · Project Success Factors (PSF) · Project Suceess Criteria (PSC) · Top management support · Innovative strategy · Knowledge management

1 Introduction

Nowadays innovation and development are considered the most important function in organization management, especially government organizations that are considered a service provider to public in a high competitive advantage. The innovation becomes

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a part of major activities in government sector, however still they need to implement some improvement to reach private sector level and meet the competitive advantages [1]. Generally, the public sector has developed their innovation process and used the method of create, produce, check and then implement the innovation project to ensure meeting the project objective and have success implementation. Those developments aim to enhance the project outcomes quality and efficiency. Also they help to achieve the organization objectives. This idea shows that innovation establishes the idea of ensuring the continuance of improving actions [2]. Furthermore, innovation defined as creating new idea or producing new things or doing things in new way [3]. Referring to this concept of innovation, mostly the innovations are the outcomes of studies and research, which is part of organizational plan. So the innovation management plan should be aligned with organization plan. However, Dispensa [4] views the innovation is the of way finding solution, or enhancing the current solution or using latest technology to provide new services. Furthermore, previous knowledge and knowledge management enhance research efforts to achieve new development for the organization [4].

1.1 Research Problem

The federal cabinet in UAE encourages the government sector to adapt innovation in their services and product by establishing a numbers of initiatives such as smart government award, such as Ebtikar award, and services criteria awards and so on. Also they called 2015 the year of the innovation [5]. Al-Khouri [6] mentioned that the strategy of UAE government aim to offer an innovative service that concentrates on developing smart services with high level of quality through different channels such as mobile, online, call center, etc. This means the number of innovation project will increase and the top management will face a huge challenge to succesfully manage and implement those projects [7].

According to the importance of the innovation projects and the required time and cost spend on research and developing new idea in any organization, this research developed to examine the impact of innovation management criteria and factors on the project success. It used the literature research to define the most important factors and criteria. Then an evaluation of those factors and criteria will be done to find out the most effective factors and criteria in innovation projects management.

1.2 Research Questions

The research question will reflect the aim and objectives of this paper. It will help in provide the road map of the research and define the research process. The research will study and verify the contribution of effective success factors and criteria's by answering two main question:

What are the effective innovation success project criteria?
What are the effective innovation success project factors?

2 Literature Review

> Investment in long term innovation and support of UAE national innovators are key pillar for the work of future government, with a key objective to make innovation a culture and a way of life. H. H Sheikh Mohamed Bin Rashid

Nowadays, innovation has become one of the most interesting subjects in academic and economic researches and events [8]. Many researchers and developers focus on studying and discussing the innovation from different aspects and consider it as the engine of competitiveness among the organizations and sustainability mechanism in all the fields [9].

Schumpeter [10] view was that: defined vision, great leadership style and strong teamwork are the elements of possible treatments for innovation. Schumpeter anticipated that with broadening fields and integrated products containing all kinds of technology, requests for collaboration would naturally help a company grow. He explained the innovation model as creating new product or providing new services, using new internal methods to process the internal activities, create new needs to the users or develop new market. Also, he divided the process of innovation into 3 main stages; the first stage "invention": where the idea will be generated and defined. Then, "innovation" phase: where the idea is developed and the work is executed. Finally, "diffusion" phase: it is the time of implementing the idea and announcement of the new product or services [11].

Basically, the innovation is identified as the development of a new idea or the improvement of a current product/service. It can be also defined as the new way of doing things by changing the process, or using new technique or method to bring new business practice [12]. Damanpour [13] explained the innovation as a process of transforming new idea to new product, service, process, technology, structure, or approach [14]. While, Rogers and Kin [15] defined the innovation as the implementation of anything new thing to one or group of people such as: "idea, practice or object" [16]. Also, Dadfar [17] added that aligning the sustainable of competitive advantage with using the innovation concept as a key of business improvement [12].

Moreover, innovation is a driving force of competitive advantage in market development and economic growth. It can be used as a tool in which it helps the organization to lead the market by increasing customer satisfaction and demand through new concept, idea, product or services which meet customer need or build new demand in the market [9].

2.1 The Success of Innovative Projects

The nature of innovation project needs more caring while implementation and launching because of its new concept. According to Theodore Levitt definition “creativity is thinking up new thing, innovation is doing new things” [16]. Also based on Joseph Schumpeter (1930s) explanation: the innovation process includes 3 steps starting with idea generation and ending by implementation. That means the implementation of innovation and success of innovation projects’ is more important than idea itself [11].

Recently, many researches studied the innovation projects’ success and project success criteria to find out the effective success factors and parameters. Studies have shown different results from different concepts and objectives that have been used.

2.2 Project Success Criteria and Factors

A number of researchers advised that it is better to select the Project Criteria Success (PCS) for each project separately. The project’s stakeholders can define the PCS at the begging of the project. The Criteria Success Factors (CSF) defined as the most important elements that support meeting and delivering the PCS. Also, it can be explained as the group of conditions, factors or activities that have great impact on the project outcome. In addition, the PSC used to evaluate the project success, however the CSF are the factors that support the achievement of the project. Nowadays, the description of project success mainly is evaluated by achieving the project objectives and satisfaction of customer, end user, project owner and stakeholders [18].

2.2.1 SF 1: Top Management Support

The first element of PSF is “top Management support” as it is obvious that it helps the advancement of the project. The top administration ability to follow-up projects is a necessity, particularly on following the real progression of the project, to beat the boundaries and inflexibility that regularly exist in organizations. For instance, individuals focused on one territory of generation may oppose moves to new territories. The best way is that the management encourages such moves. Recently, many researchers agree that the responsibility of top management support and motivation is playing a great role in project success [19]. The traditional management approach; which considered the team efficiency, user contribution, and effective plan as the major success factors, changed to the new method; which align and agree with the roles of top management support as it can strongly contributes to the success of projects and solve most of causes of project failures [20].

2.2.2 SF 2: Innovative Strategy

The second factor of PSF is the significance of having the innovation strategy, which ensure the long-term technique and competitiveness. Innovation strategy provides the guides for the organization to ensure the effectiveness of the outcome and meeting the organization objectives. The importance of having an innovation strategy to set up the clear direction of how to deal and manage the innovation projects in the right way as well as it helps to align the innovation with organization objectives and goals. Also, innovation strategy lets the organization know how to deal with uncertain cases in the market and leading the market competition. For example, if there is a new technology launch in the market which got a great acceptance from the customer, in this scenario the organization can use the innovation strategy to develop new service or product on time and align it with their goals and budget to attract the customers and improve their satisfaction level. Moreover, having clear vision and strategy improve the opportunity of the success and effectiveness on the work and increase satisfaction level of customers, employees and stakeholders by controlling and managing new type of project, supporting the new idea and continuous development of the services and products [19].

2.2.3 SF 3: Knowledge Management

The third element of PSF is Knowledge management within the organization. With a specific end goal to be successful and accomplish prevalent execution, every organization must build their internal knowledge base accessed by organization members to find out all their requirements [19]. Also sharing knowledge strengthens the level of the relationship between the team members and cut off the barriers which reduce the time and cost spend to transfer the knowledge between project stakeholders

3 Conceptual Framework

According to the literature, many researchers and expert discussed the innovation management success and they defined its criteria and factors as two main elements in innovation management success. The innovation management success criteria is a dependent variable where it is used to measure the level of project success. However, the innovation management success factors are the independent variables that have great impact on innovation projects' outcome and success. This means: the criteria helps the organization on evaluating the level of innovation success, where the factors help on controlling the outcome results. So being aware of the contributed factors of innovation management will improve the possibility of achieving innovation management criteria and meeting innovation projects objective by having successful innovation project.

In this paper the conceptual framework present the literature outcome and previous feedback related to the different innovation management success criteria and innovation management success factors. Mainly the research will study the relation between selected innovation management success criteria and some of innovation management success factors to achieve the research objective, define the most impact of innovation management success criteria and factors, and evaluate its contribution on the project's outcome and success.

The above conceptual framework (Fig. 1) presents the innovation management success and project success. It selects three main variables related to innovation management success criteria and three variables from innovation management success factors to find out the relationship between its impacts on project's success.

There are three basic variables, which are hypothesized to increase the likelihoods of innovation management success:

- Reducing time and effort of producing the services or products
- Meeting stockholder's satisfaction/happiness
- Adding value to the organization and meet the competitive advantages

Other three variables that determine how to measure the innovation management success factors are Innovation strategy, Top management support and Knowledge management. Furthermore, the purpose of this part of the research is to discuss the hypotheses, explain how those hypotheses will meet the research objective and defined the impact of each selected variable on innovation project success and find out the link between innovation management success criteria and innovation management success factors.

First hypotheses is innovation strategy: it is the variable related to innovation success management factors. This variable specifies the different approaches which

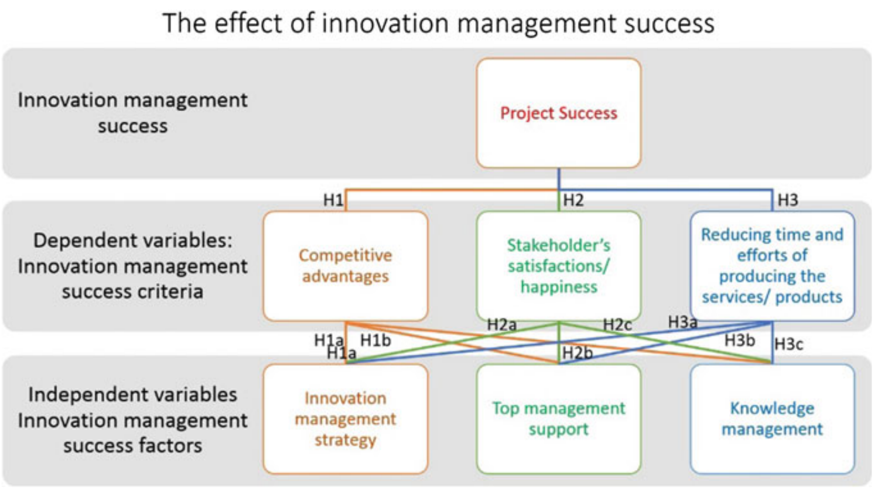

Fig. 1 Conceptual framework: innovation management success and project success

are used internally in the organization to manage the innovation, and their alignment with the organization objectives and strategy. Each organization or entity develop it's own innovation strategy related to the internal process and procedures to ensure the used of best innovation management strategy and meeting project aim, achieving competitive advantages, meeting stakeholder's satisfaction, and reducing time and effort which lead to have success innovation project management and project success.

- H1: The innovation strategy factor has a positive relationship with innovative project success
  - H1a: The innovation strategy factor has a positive relationship with competitive advantages variable
  - H1b: The innovation strategy factor has a positive relationship with reducing time and efforts of producing the services/products variable
  - H1c: The innovation strategy factor has a positive relationship with meeting stakeholder's satisfaction/happiness variable

Second hypotheses, Top management support: it is one of innovation success management factors. This variable shows the importance of top management support on having a success innovation projects. It defines the responsibility of top management in providing the encouraging work environment and providing all requirements and needs to ensure the implementation of innovation projects according innovation strategy. Also, it includes taking responsibility to confirm the alignment between the innovation strategy and organization objectives, processes, producers and so on. Moreover, the main role of top management support is to motivate the team work and support it's needs to bring and implement the innovation projects.

- H2: The top management support factor has a positive relationship with innovative project success
  - H2a: The top management support factor has a positive relationship with competitive advantages variable
  - H2b: The top management support factor has a positive relationship with reducing time and efforts of producing the services/products variable
  - H2c: The top management support factor has a positive relationship with meeting stakeholder's satisfaction/happiness variable

Third hypotheses, knowledge management: it is one of innovation success management factors. This variable improves the knowledge share and learning methodology between the team members in innovation atmosphere. The innovation research team play great role to support innovation knowledge share and learning methodology among the organization to achieve innovation management success. For example, using project time to share the knowledge and activity learning methodology will increase the team knowledge level, and motivate team members to participate in decision making will increase the innovation level in the projects and improve the possibility of having success innovation management and project success [21].

- H2: The knowledge management factor has a positive relationship with innovative project success
  - H2a: The knowledge management factor has a positive relationship with competitive advantages variable
  - H2b: The knowledge management factor has a positive relationship with reducing time and efforts of producing the services/products variable
  - H2c: The knowledge management factor has a positive relationship with meeting stakeholder's satisfaction/happiness variable

4 Methodology

The main objective of this research is to study the impact of innovation management criteria and innovation management factors on innovation projects' success, and to find out the relationship between selected criteria and factors with innovation projects' success. Based on the literature the study developed three main hypotheses which will be tested and evaluated by using a quantitative method; the descriptive technique used to verify the impact of innovation management criteria and innovation management factors in implementing innovation projects successfully. The study focus on collecting and highlighting opinions and feedbacks from the federal government organization in UAE. The following parts of the research will explain the research process and questionnaire design.

4.1 Research Process

An online questionnaire was distributed electronically among three federal government organization in UAE. The contact was done over different hierarchy level such as; top management, managerial level, supervision level, technical and administrative level. The survey targeted about 50 participators; where the respondents were covered 50% by 25 participators. Moreover, the study targeted the people who have experiences with innovation projects, direct or indirect. However, the data was analyzed through M S Excel to evaluate the significant of success innovation management criteria; competitive advantages, reducing time and efforts of producing the services/products and meeting stakeholder's satisfaction/happiness, with success innovation management factors; innovation strategy, top management support and knowledge management. Also to test and verify the impact of selected criteria and factors on innovation project success.

4.2 Questionnaire Design

According to the innovation management project criteria and factors which was mentioned in the literature, the survey questionnaire was prepared, participators were asked to evaluate the impact of each innovation management projects' criteria and factors based on their experiences and opinions.

The survey depended on scale technique to capture the participators feedback in innovative management projects. The questionnaire contained a number of questions to know the previous experience. Two main questions were divided to sub-questions. In the first part, the questions aimed to collect demographic data and general information about the respondents, such as the number of years of experience. The second part: a two-digit section of the criteria and a section of the factors including sub-questions in each section. The replies assess the influence of each variable in managing innovation project and meet project success. The scale question was from; 1 for strongly agree, to 5 for strongly disagree.

The survey showed many differences were taken into consideration in the personal experiences of all respondents, as some of them had prior knowledge and experience in the field of innovation management, some of whom were not.

5 Data Analysis

5.1 Destructive Analysis

The survey responded by 25 out of 50. The first demographic question was "Years of Experience" and it was on a scale of (1) less than 1 years of experiences, (2): between 2 and 5 years of experiences, (3): between 6 an 10 years of experiences, (4): between 11 and 15 years of experiences years, (5): more than 16 years of experiences.

From the total responded we found that 32% of the total participators were more than 16 years of experiences, and another 32% of the participators were between 11 and 15 years of experiences, and 20% of the total participators were between 6 and 10 years of experiences, however the rest (16%) were less than 5 years of experiences.

The second demographic question was to evaluate the experiences of participators in innovation projects. The results show that 100% of the participators were having experiences in innovation projects.

The third demographic question was to evaluate the success of innovation projects in the federal government. The results show that 96% of the projects have been successes, while only 4% of innovation projects failed (Fig. 2).

This paper developed to study the effect of innovation management success criteria and factors in innovation project success. Based on correlation analysis, we found that there was a positive strong significant correlation (with average of $r = 0.7$) between the three of innovation management success criteria and innovation

Fig. 2 The results of correlation analysis

project success, in term of meeting the competitive advantages, meeting stockholders' satisfaction/happiness, and reducing time and effort of producing the services or products. However, by evaluation the significant of innovation management success criteria and factors we found that the relationship between the three success factors and the three success criteria was strongly significant except between SF 3 "Knowledge management" and SC 3 "reducing time and efforts of producing the services/products or managing the project" it was moderate with $r = 0.47$.

6 Discussion

The purpose of this part is to study and test the proposed hypotheses by using MS Excel software. First, the descriptive statistics show analysis of participators response in the 2nd section of the questionnaire, assess the innovation management project success factors with innovation project success. However, 3rd section of the survey test the innovation management project success criteria with innovation project success. Second, a correlation check evaluates the relation between success criteria and factors. In examining the research hypotheses, the elements of innovation management success factors show a significant relationship with innovation management success criteria and this result aligned with the outcome of the literature review section and previous researches, as it explained below:

- Innovation strategy has a positive strong relationship with innovation management success criteria such as; adding value to the organization and meeting the competitive advantage, meeting stockholder's satisfactions/happiness and reducing project time and effort.

- Top management support has strongly significant with the innovation managing success criteria such as; adding value to the organization and meeting the competitive advantage, meeting stockholder's satisfactions/happiness and reducing project time and effort.
- Knowledge management has a positive relationship with innovation management success criteria. Where it was strongly significant with; adding value to the organization and meeting the competitive advantage, meeting stockholder's satisfactions/happiness, however it has a moderate relationship with reducing project time and effort.

7 Conclusions and Recommendations

In conclusions, innovation encourages the organization to provide smart and unique services or products to users and customers to meet their needs and satisfaction. Success criteria and factors help the organization to improve the possibility of having successful innovation project. Moreover, the innovation in UAE has become one of the most important subject to all type of organization especially government organization because it is one of the most important assessment of the excellence. The federal cabinet keep monitoring and encouraging the government organization to adapt innovation in their services and product by number of established initiatives.

In addition, referring to the research question the aim and objectives of this paper was to verify the contribution of effective success factors and criteria. Also the research found that the innovation management success factors; innovation strategy, top management support and knowledge management show a significant with innovation management success criteria; adding value to the organization and meeting the competitive advantage, meeting stockholder's satisfactions/happiness and reducing project time and effort.

From the research outcome, we list some recommendation that may help the organization in having better implemention of innovation projects, such as:

- Use modern methods to support and develop business and provide innovative solutions as means of solving problems and providing adequate support to the teams of development and innovation.
- Ensure the alignment of the innovation strategy and organization strategy and it will be great if the innovation strategy cover the knowledge management parts.
- Make sure that the organization structure and top management are support the needs and requirements of implementing the innovation projects.

Finally, the research has succeeded in achieving its objectives, but there are unavoidable limitations related to distribution of the questionnaire on the internet to government departments without interviewing employees. More research can be done among the public users and communities can focus more heavily on evaluating the success criteria of innovative projects management because they are an important part of evaluating the success of innovation project management.

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The Global Innovation Index as a Measure of Triple Helix Engagement

Emanuela Todeva

Abstract This paper reviews the leading scoring systems for measuring innovation capabilities on a global scale providing comparability across developed and developing countries. Each Index is introduced with its background, methodology, and how it reflects on different Triple Helix constituencies. The first OECD framework developed a methodology for measuring business-led innovation, justified with the mid-twentieth century scientific believe, that universities merely supply labour markets, and government is performing a regulatory role, influencing the environment. The World Bank framework on measuring the knowledge Economy brings in a stronger system view with the role of institutions and late 20th century believes. The EU Innovation Scoreboard, while using the OECD methodology and measures for R&D intensity, expands in the direction of enablers from the university education, public sector research, direct and indirect financial support, and the accumulation of broader economic effects from the innovation process. The Global Innovation Index adds little to this portfolio, but offers a simplified version of innovation inputs, outputs and intensity measure, enabling to extend the comparability across countries. Overall the evolution of innovation indexing is moving towards a recognition of the complex and dynamic realities of interactions between university science, business innovation and government investment in system-level policies and projects, but the measurement remains focused on individual helices.

Keywords Global innovation index · Triple helix framework · Knowledge economy · EU innovation scoreboard · Competitiveness

1 Introduction

The global innovation index was created at the time of economic growth and prosperity. The measures of innovation were designed to measure the speed to prosperity and were not directly linked to global challenges or worldwide megatrends. There are many issues and questions that emerge in relation to this gap. For example, is

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innovation helping to address global challenges? Can innovation help to tamper the impact of global demographic changes? How innovation can help in our capabilities to address health and inequality and well-being challenges? How innovation can contribute to accelerate the global efforts of humanity to address climate change and environmental catastrophe? Can innovation society gain enhanced decision making powers how to protect natural resources and energy? How innovation can help to improve and enhance the role of government, the state of the economy and jobs, or the scale of globalisation? Is the global innovation index helping to address the global challenges and megatrends?

There are many technologies for the future that are seen as driving growth and prosperity. Are the digital technologies for example shaped to drive change towards sustainable development? Are biotechnologies designed to enhance health, or to plug-in gaps in biopharmaceutical profitability? Are technologies such as electric vehicles and drones and biofuels directly mobilising productive assets to address environmental sustainability? Are nanomaterials and nanodevices designed to enhance human capacity, or they are planted in defence value chains? Who are the societal actors that have the decision-making power and capacity to match technology solutions to global challenges? (Fig. 1).

Science, technology and innovation policies worldwide are focused on driving growth and prosperity. Most of them are focused on the technology side and prescribe insufficiently who are the leading actors and what are the linkages that can deliver on these policies. Innovation is about flow of information and resources, spillover effects and positive externalities that emerge from collective and creative efforts.

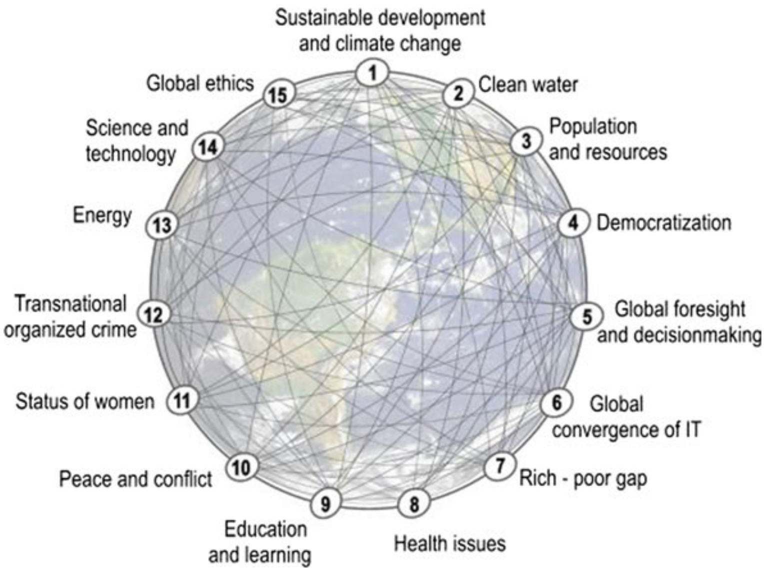

Fig. 1 Global challenges and megatrends. *Note* Adopted from The Millennium Project [25]

Among the strategic sectors in UAE, education and technology appears separated [24]. Investment in technology and in education appear to have separate pathways. Can we separate education, innovation and technology developments without hindering the societal impact of innovation? Can we separate biotechnology and genomics from public health and disease management? What are the consequences of this separation for the fairness of distribution of technology outcomes to those members of society where they're mostly needed?

The questions about the links between education, science, technology and society are at multiple levels. Some of the methodological questions about the relationship between inputs and outputs are addressed within separate spheres of education, industry and government, where each sphere has a prescribed role. Universities carry the responsibility of knowledge creation and dissemination, while industry takes the responsibility of translation of this knowledge into commercial technological solutions. Government supervises this process of transfer, by supervising the regulatory environment that governs activities in industries and in universities.

The global Innovation Index launched in 2008 by INSEAD covers 143 economies around the world and is using 81 indicators. Although its methodology does not represent an innovation in itself, its reach to policy makers around the world is profound. Through harnessing the sponsorship of established global agencies such as the World Intellectual Property Organisation (WIPO), PwC Strategy Network, and major institutions in India, Brazil and USA, it is promoting a consistent platform for index-driven policy evaluation across all participating countries.

2 Global Indexing of Innovation—History and Current State of Affairs

Most indices capture either innovation inputs or outputs. Although there are indices about the behaviour of actors that translate inputs into outputs, currently there are no direct measures to reflect on the knowledge transfer process, or the impact of university-industry collaborations.

The first innovation metrics used since the 60s are: Research & Development (R&D) expenditure, Science & Technology (S&T) personnel employed, Capital invested, and Technological Intensity—as a measure of the relationship between inputs and outputs of R&D activity [16]. Four new measures were created in the 70s—to capture innovation outputs: patents, publications, new products introduced to the market and new quality enhanced processed introduced within firms. The 90s brought the awareness that innovation capacity is deeper than these input and output indicators, and requires some qualitative measures collected with innovation surveys. During the same period, innovation management theory introduced a number of tools and techniques for innovation indexing, benchmarking and measuring innovation capacity. All of these tools and techniques continue to be used at present—both at firm level and at the level of national innovation systems.

During this period and as one of the first efforts to establish a robust methodology that measures innovation and provides a framework for comparisons is the OECD publication of the Frascati Manual [17, 21] which enlists innovation indicators with clear definitions—how to obtain them. This manual, as well as its latest update [22] pose still a challenge for statistical authorities around the world.

At the turn of the 90s The World Bank launched its Knowledge Economy Index, which essentially built a measurement framework around four pillars: economic and institutional regime, education and skills, information and communication infrastructure and the innovation system as a whole [18]. There were three measurements of the global economy—in 1995, in 2008 and 2012, and the most recent effort covers 83 structural and qualitative variables, applied to 140 countries, including 100 developing nations [30]. In this framework, there is a much stronger place for Government as the "Gardener of Innovation", and a very clear position for education establishments, providing education and skills [27]. The three comparisons of the world economy have identified a dynamic picture of some countries rapidly advancing their position through the index and across a significant number of normalised indicators.

Among the newest developments in innovation metrics are the fourth generation of measures and 'process indicators' that were introduced at the turn of the 21st century, interrogating system-level environmental dimensions such as: business clusters and networks, knowledge and intangible assets of firms, the effect of market demand and ratios such as risks to returns, the critical impact of effective management techniques and the scale and scope of system dynamics [16]. All these concepts have proven difficult to integrate into established innovation indices, such as the Global Innovation Index and the European Innovation Scoreboard.

3 The OECD Framework

The OECD framework puts a heavy weight on the industry, enlisting indicators under 4 categories: Business capabilities for innovation; Business innovation activities (including Acquisition of technology, Acquisition of knowledge and Training and development); Business innovation and knowledge flows (measuring innovation adoption, diffusion, absorptive capacity and flow across firm boundaries through innovation surveys), and Objectives and outcomes of business innovation (mixing qualitative measures of innovation objectives and quantitative measure of innovation outcomes at firm level {markets, production, delivery, business organisation} and the level of economy, society and the environment {gender, health, quality of life, social inclusion}). All context specific factors, that relate to the activities of the knowledge sector (universities) and the policy and regulatory environment (government) are enlisted under External factors influencing innovation in firms (activities of customers, competitors and suppliers; labour market, legal, regulatory, competitive and economic conditions; and the supply of technological and other types of knowledge) [12].

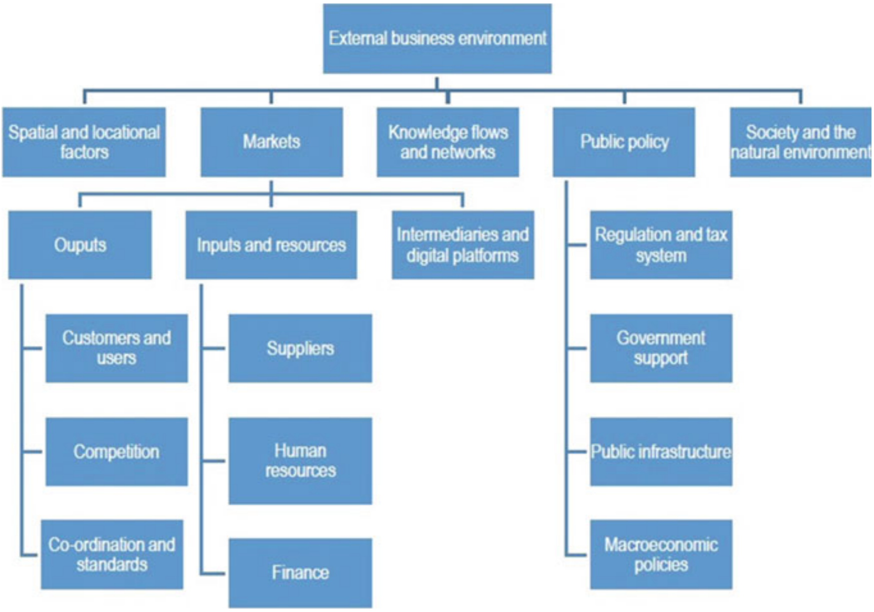

Fig. 2 Main elements of the external environment for business innovation. *Note* Adopted from OECD/Eurostat Oslo Manual [22], Fig. 7.1

Figure 2 describes the very broad scoping of the environment that influences the innovation activities and capacity of firms and indicates clearly that universities and education are not seen as deeply integrated into this process.

The OECD model put a heavy weight on industry and markets, where innovation is seen mainly driven by commercial establishments. The role of government is framed in terms of 5 categories—public policy, macroeconomic policies, regulation and tax incentives, direct and indirect government support and public infrastructure—all of which are framed as enables for the commercial sector. The university presence is disguised behind the spatial and location factors—as generic knowledge provider. Although knowledge flows and networks are considered, they are mainly viewed in terms of knowledge and technology transfer from Universities to industry, or across firms.

There is no reflection on how the 'government value' is deployed and distributed, or how education and innovation policies can contribute beyond enabling the business sector. Although this model envisages contributions from all Triple Helix actors, it does not provide sufficient guidance on what types of interactions between government policies, market forces and knowledge creation are best suited to drive innovation for sustainable growth.

The new dimension of knowledge flows and knowledge networks aims to introduce some new categories, such as: the rate and scale of diffusion of innovation (measured by product/service adoption), the type of actors and the type of knowledge (i.e. existing, vs. prospective), inbound and outbound knowledge flows in open innovation, co-operation, collaboration and co-innovation. It even engages with the concept of knowledge capabilities but leaves short of acknowledging that dynamic capabilities involve learning, and absorptive capacity, which are beyond domestic and foreign inflows and outflows. The categories used in this dimension do not even address the complex interactions between universities, government and industry (or Triple Helix interactions) that trigger such flows, or the governance issues that emerge within knowledge networks [26].

In addition, the latest edition of the OECD Manual acknowledges that innovation occurs not only in the private sector, but also in the public sector, in non-governmental organisations and even if family households. The innovation, however, is still perceived as new products and services, and does not even question the innovation in processes, and system-level innovations, or what is acknowledged as 'innovation-in-innovation' [9].

4 The World Bank Framework

The World Bank Knowledge Economy Index has proven that there are very insightful comparisons that can be made across developing and developed nations in terms of economic and institutional regimes, systems for deployment of education and skills, the outreach of communication and information infrastructure, and the overall elements of innovation systems.

The World Bank Knowledge Assessment Methodology (KAM) employed a range of robust indicators that demonstrate long-term trajectories underlying knowledge growth [3]. Since 1995, the World Bank programme on Knowledge for Development has promoted that Government is a "Gardener of Innovation", managing both the university and the industry parts of the innovation system. The measurement methodology includes a number of indicators that capture government impact and education outputs [32]. The economic performance indicators introduced as a fifth pillar are used as an ultimate measure for growth. The index itself has evolved from basic performance indicators (i.e. average annual GDP growth (%) and Human Development Index), to a sophisticated portfolio of measures that capture how countries address their wider societal challenges, such as poverty and unemployment.

The systemic view of the knowledge economy also has evolved—from the three basic measures of patents, publications and royalty payments—to a complex measurement of foreign capital flows (as % of GDP), science and engineering enrolment of graduates, Ph.D. researchers employed in R&D, research collaborations between universities and industry, technology clusters and private sector spending for R&D. Such a broad systemic picture of the science and innovation systems enables to investigate the direct relationship between innovation inputs from government, industry and university actors—into innovation outputs (Fig. 3).

Pillar	*Indicator*
Economic and institutional regime	• Tariff and non-tariff barriers • Regulatory quality • Rule of law
Education and skill of population	• Adult literacy rate • Gross secondary enrollment rate • Gross tertiary enrollment rate
Information infrastructure	• Telephones per 1,000 people • Computers per 1,000 people • Internet users per 1.000 people
Innovation system	• Royalty payments and receipts, US$ per person • Technical journal articles per million people • Patents granted to nationals by the U.S. Patent and Trademark Office per million people

Fig. 3 Pillars and indicators of the knowledge economy. *Note* Adopted from World Bank Knowledge for Development Programme [31]

Although this is one of the most comprehensive frameworks for comparisons across the world, it is still short of determining the policy instruments that can enhance the innovation position of a country breaking from path-dependency and accelerating economic growth through all stakeholder mobilisation. World Bank recommendations spread across all comprehensive policy mixes of: economic reforms, investments in 'entry points' such as sectors and cities, removing obstacles for business development, managing the business environment (trade, finance, regulations), strengthening cluster policies, strengthening institutions and instruments of innovation policy, enhancing research and technology infrastructure, developing export sector policies, enhanced and holistic information and communication technology (ICT) policy, upgrading education, and overall putting the knowledge economy at the heart of development policies [27]. The World Bank view adopts the old static Triple Helix model, envisaging Government as orchestrator of innovation transformations in the economy and society, driving innovation through the public and the private sector [10]. In the entire portfolio of policy recommendations, the World Bank maintains this economic view of the supremacy of government. The only other force that rivals the role of government is the ICT revolution, and the profound impact of the internet and ICT technologies on bringing transformational changes to the society and the economy [1, 23].

5 EU Innovation Union Scoreboard

The EU Innovation Union (IU) Scoreboard was launched to support the European 2020 Strategy, 'Innovation for Growth'. The 2011 marked the first edition of the European Innovation Scoreboard, which has been strongly influenced by the OECD methodology, including the OECD measure for R&D intensity [Gross Domestic Expenditure on R&D (GERD) as % of Gross Domestic Product (GDP)] [11]. The IU Scoreboard offers over 10 years comparison of the innovation inputs and performance of all member states, using one of the most advanced resources for comparable metrics—the Eurostat.

The methodology of the EU Innovation scoreboard mixes the inputs and outputs in three distinctive categories—enablers, firm activities, and innovation outputs (see Fig. 4). The unique category of enablers combines measures of both public and private sector, including all institutions and actors that support the development of human capital, open and excellent research system, and finance and support. The role of government in this category of enables is reduced to public sector financing, and this leading role is shared with education establishments and venture capital [28].

The second group of indicators is focused on the industry and in particular—firm activities directed towards innovation, such as Firm's investment in R&D, Linkages and entrepreneurship, and Intellectual assets of firms. Specific indicators in this category are the R&D expenditure of firms, contributions from the small and medium size firms, and intellectual assets, including community designs and trademarks, usually attributed to various social enterprises and not-for-profit organisations [28].

The final group of indicators refers to innovation outputs, where a strong emphasis is put on the agency of innovators and the economic effects, including entrepreneurship effects, growth of employment for innovators, and internationalisation of knowledge intensive services (Fig. 4). Using essentially similar to the OECD methodology, the EU Innovation scoreboard produces a substantially different picture, attributing much stronger role for universities and education providers, as well as small entrepreneurial firms and social enterprises.

The index, however, remains short of measuring the impact of specific policy initiatives, or the interactions between government policies, university and industry contributions. Overall, the Triple Helix actors are included in the index, but their dynamic interactions that lead to specific outcomes remain hidden, and hence the explanatory power of the index is limited to a normalised score. The main advantage of this index is the quality of indicators used, which enables to explain individual country cases and their position in one of the four groups: innovation leaders, followers, moderate and modest innovators. Neither the scores and the position of individual countries, nor the contextual explanation of individual variables enables a substantive analysis of the strengths and weaknesses in each unique innovation system. What is visible from the country comparisons is that the weaknesses and strengths are usually across the board of all variables, or they capture a systemic strength or weakness.

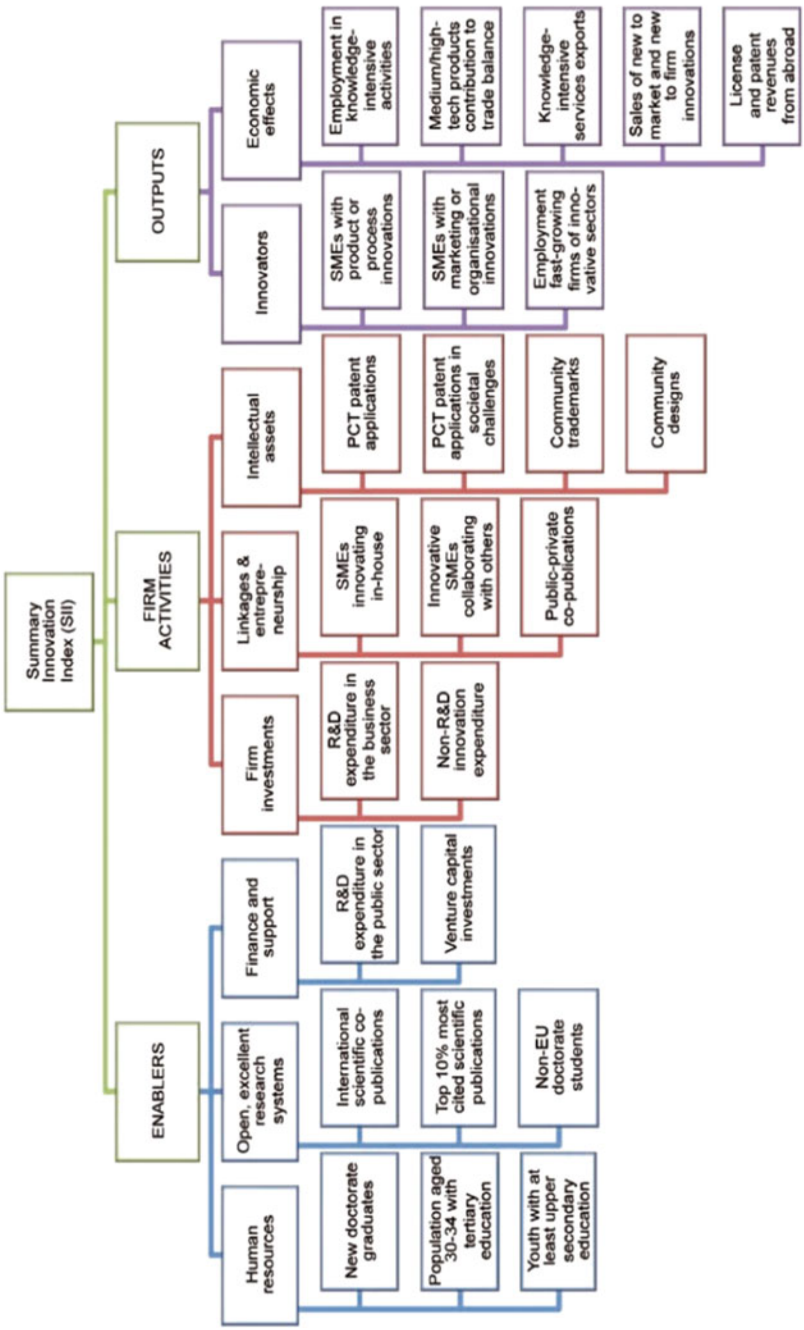

Fig. 4 European Innovation Union Scoreboard indicators. *Note* Adopted from EC report on Research and Innovation Performance in the EU (2014)

6 The Global Innovation Index (GII)

One of the great strengths of the GII is the structural simplification of measurement procedures. The index constitutes of two sub-indices for innovation input and innovation output. The Innovation Inputs sub-index combines the scores for all enablers: (1) Institutions, (2) Human capital and research, (3) Infrastructure, (4) Market sophistication, and (5) Business sophistication. The Innovation Outputs sub-index combines the scores for (6) Knowledge and technology outputs and (7) Creative outputs. The Innovation Efficiency Ratio—is calculated for each country as the ratio of the Output Sub-Index over the Input Sub-Index. It shows how much innovation output a given country is getting for its inputs [14].

This methodological approach enables cross-country comparability at multiple levels—the level of the overall ranking, the level of sub-indices, the level of input and output categories, and the level of individual indicators (Fig. 5). The first group of enablers (Institutions) broadly reflects on the activities of government in terms of political stability and shaping the regulatory and business environment for firms. The second enabler (Human capital and research) broadly represents activities of universities and the education providers, as well as public sector research and technology organisations (RTOs). The third group of enablers adopts the World Bank measures on ICT and infrastructure, with some modifications towards ecological sustainability.

The next two enablers represent the industry and are significant developments separating macro-economic measures of credit, investment, trade and competition (bundled as market sophistication) from micro-economic measures of firm level innovation (described as business sophistication). The business sophistication group comprises both static and dynamic variables, such as knowledge workers, innovation linkages and knowledge absorption [5–7].

Although the input sub-index contains measures of all three of the helices—government, industry and university, there are no dynamic measures that reflect on the positive engagement between university-industry and government. Measuring individual helices remains a dominant position.

There is also a confused grouping of indicators in the output sub-index—discriminating between knowledge and technology outputs (i.e. from Universities), such as knowledge creation, impact and diffusion, and creative outputs from industry (intangible assets, firm capabilities, creative goods and services and on-line creativity). Conceptually, this distinction is incorrect, although at aggregate level both groups give an emergent picture of innovation outputs.

There are also insufficient indicators to capture knowledge flows across the helices, as well as activities from positive overlaps between university, industry and government. The Triple Helix literature has been very clear about the distinction between positive overlap of helices (through mutual engagement and sharing), versus negative overlaps (through boundaries and lack of trust) [15].

Although the Global Innovation Index is a very authoritative publication and does not receive much criticism, it can be observed that it is not moving along with the wave of recognition that there is a fundamental need for government, industry and

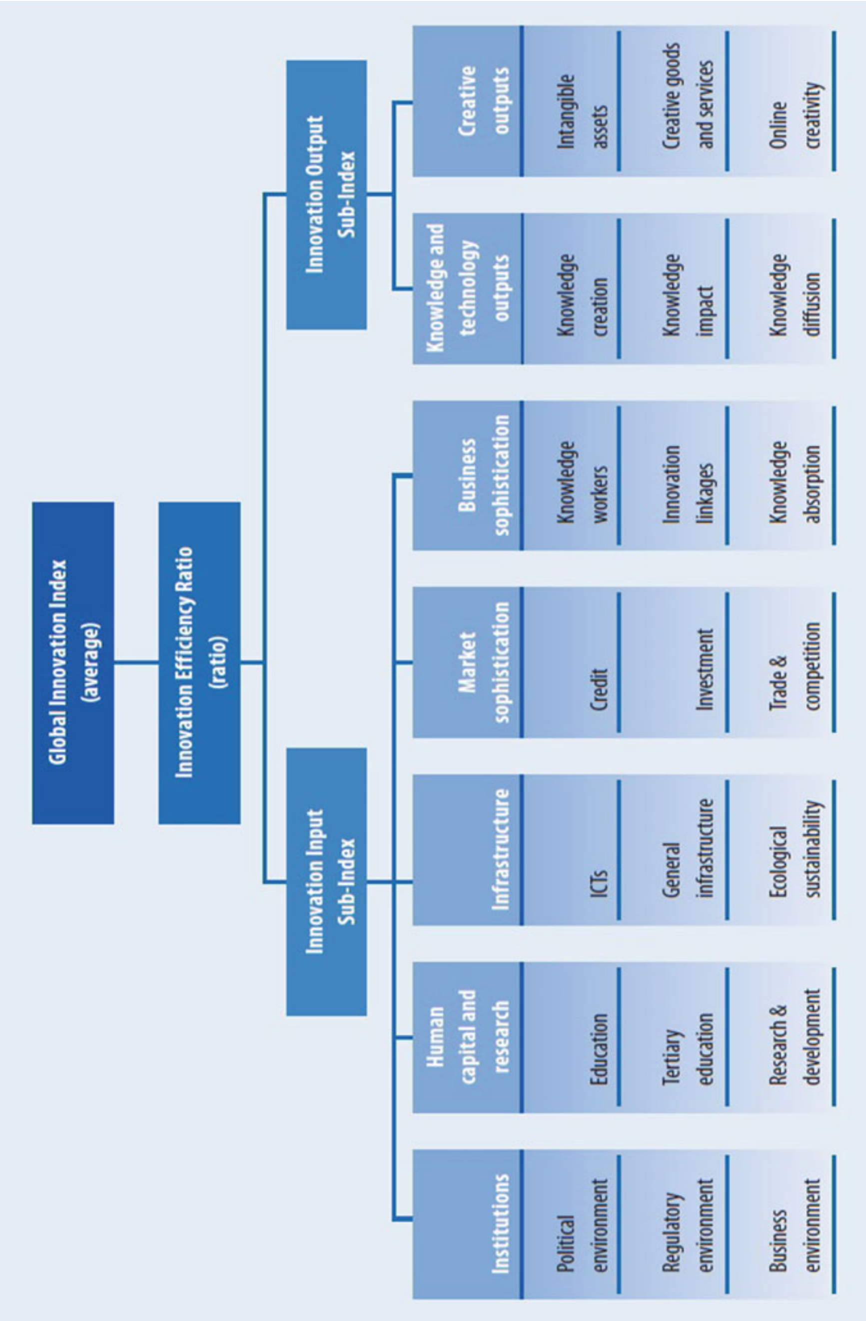

Fig. 5 INSEAD Global Innovation Index. *Note* Adopted from Global Innovation Index [4]

university to create a shared space of translated meaning into action and of mutually shared directions for innovation. Many global events, such as the World Economic Forum and the INSEAD Global Business Leaders Conference drive a new agenda for a stronger engagement between the government, the industry sector and the knowledge providers, as collective driving force for innovation and growth.

7 Other International Institutions and Forums

The World Economic Forum has been established since 1971 as an international organisation for public-private cooperation, annually bringing together political and business leaders to discuss global challenges and to envisage solutions. For its existence over 48 year it has generated a wide range of institutionalised cooperation platforms and initiatives focused on innovation and metrics. Among these are: the Global Future Council (GFC) on New Metrics and the GFC on Innovation Ecosystems. The GFC on New Metrics is working to expand the availability of accepted actionable data from traditional and new data providers and analytic methodologies. The GFC on Innovation Ecosystems, on the other hand, is working on models for effective collaboration between startups, corporations, owners of private capital, governments, and academia.

A key map from the Mapping Global Transformations initiative indicated that the pivotal role of Innovation is played by System level design, the Role of Government, the Role of Science and Technology, Business Model Innovation, as well as Innovation for Social Benefit. Interestingly, this map, generated by the top world leaders does not reference any of the innovation metrics, which shows the information gap between the data providers and its users [29]. It looks like for the majority of world leaders, innovation metrics is not critical for shaping policy initiatives.

8 Conclusions and Recommendations

The discussions on the Knowledge Economy continue to expand both the theoretical foundations and the empirical observations of our knowledge capacity and flows. The metrics, however, continue to expand with a focus on firms. Distinctions are made between existing and prospective knowledge, embedded and disembedded, material and intrinsic, generic and commercial knowledge—all of which is associated with commercial entities. The Universities remain at the periphery of this process, and knowledge transfer is not taken into account. Knowledge management is mostly seen in the context of enterprise activities, and even the creativity indicators are measuring firm outputs, largely ignoring University contributions to knowledge.

One of the main reasons for this state of affairs is the dominant paradigm that R&D is nested in the industry sector, and it feeds on investment capital and labour, while universities are merely ‘servants’ of the labour markets. The change in position of the 'ivory towers' of University knowledge has not happened yet, in spite of the accelerating discourse on entrepreneurial universities, and the impact of knowledge in general.

Knowledge flows are interpreted mainly as knowledge sourcing by firms and are discussed in 5 categories: product and client-oriented R&D; collaborative inter-firm R&D; science-based embedded knowledge sourcing (such as contract research); open process modernising (such as management innovations in firms); and wider innovations in the society (such as social entrepreneurship and community innovation) [19, 20]. All University-based innovations are measured in terms of publications and number of graduates, and entrepreneurial university metrics are still a voluntary self-assessment.

Although there is a theoretical understanding of the mechanisms behind knowledge exchange, there is a lack of a comprehensive policy framework in place that can enhance knowledge flows through effective disembodiment of knowledge, which occur in commercial transactions around intellectual property (IP), licencing, franchising, know-how contracts and non-disclosure agreements. Innovation policies cannot create direct incentives for embedded knowledge transactions, sourcing solutions, or co-development agreements—beyond transaction costs. This leaves the direction of innovation skewed towards firm performance, and very far away from altruistic and philanthropic innovations that address societal and economic challenges.

Innovation is in the Ninth Sustainable Development Goal (SDG) and it is bundled with Industry and infrastructure—driving development through resilient infrastructure and the promotion of inclusive and sustainable industrialization.

One of the most insightful metrics of the innovation indices is the calculation of the R&D Intensity as a ratio between innovation inputs and outputs. The new proposals are that R&D Intensity considers innovation outputs, based on four components chosen for their policy relevance, data quality, international availability, cross-country comparability and robustness of results. These output components are (1) technological innovation; (2) employment in knowledge-intensive activities (KIA); (3) competitiveness of knowledge-intensive goods and services; (4) employment in fast-growing firms of innovative sectors [22].

Based on the systematic collection of data across all European Union member states, the conclusions from the policy evaluation on innovation-driven growth and the impact of Horizon 2020, emphasises policy mixes that invest in people, in markets for the future, in high-growth firms, in solution-driven clusters, alliances and networks, and in lifting visible and invisible barriers for free movement of the factors of production within the Single Market [8]. This policy evaluation suggests that innovation performance is very much driven by context factors, rather than by direct policy measures, as it requires a complex mix and co-alignment of policy instruments in order to generate substantial effects.

In concurrence with this position, the UAE chapter of the Global Innovation Index for 2014 develops a clear framework for building a comprehensive innovation ecosystem. It highlights that under the Government Leadership, the country should enhance simultaneously the human capita, the technological capital, and the financial capital [2]. This is linked to the accelerated government spending for education as well as increased R&D expenditure [13]. Among the specific recommendations are to invest in innovation culture and in entrepreneurial mentorship.

Dubai Future Accelerators Program is clearly a strategic response in this direction—to create a collaborative environment for public and private stakeholders to engage in knowledge transfer, harnessing key challenges and opportunities for the 21st century. Observations of the first three cohorts show that participants from the government and the private sector are at the front line of engagement. The omission of university actors in the programme is an important fact that exhibits a weakness at a system level. University actors are essential players—not only to bring critical thinking, but to ensure sustainable knowledge flows across the public and the private domain.

The policy recommendations from the Abu Dhabi Innovation Index clearly point in this direction that the foundations of the knowledge economy require a broad range of knowledge capabilities for knowledge creation, accessing, anchoring, diffusion and exploitation [33]. Universities are critical players that drive the knowledge process and engagement with university actors is essential for the success of system level innovation.

It is at the university level, where knowledge and technology are intertwined—in a pre-commercial design and a post-commercial critical reflection and learning. Knowledge and technology exhibit complex pathways of mutual enhancement and acceleration that starts at a university level before it flows into the economy. Acquisition and implementation of technology cannot be a substitute to a comprehensive knowledge linkages and spill over effects across the socio-economic sphere.

The University axis of the Triple Helix is essential to balance the system towards a sustainable growth through critical and reflexive evaluation of alternative scenarios and impacts. Moreover, the universities are the 'glue' in the Triple Helix system with the impartiality of knowledge and the future thinking of blue-sky research. It is not accidental that the countries that are among the highest in innovation performance have the strongest higher education sectors, whereby universities are critical strategic players in regional development [26].

Harnessing effective Triple Helix interactions is a guarantor for sustainability and strategic coalignment between the public and private sector. Multi-stakeholder solutions and collaborations are becoming best-practice cases, where observations and measurement of the process of collaboration can enhance both the process and the innovation outcomes. Comprehensive mapping of the actors within the Triple Helix, the linkages between then, the knowledge flows and sharing and the spill over effects from interactions can show the real value creation for the society and the economy.

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Factors Affecting Expert Systems Implementation by UAE Government

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Abstract Expert systems have been widely used in the last forty years to have less dependence on human experts to resolve certain problems and enhance decision-making process by using computers. These systems are used by many industries and governmental sectors. The aim of this research is to focus on the pros and cons of implementing expert systems in general, and identifying the factors affecting its successful implementation in particular. Furthermore, the identified factors were used to evaluate the differences in implementing the expert systems in four out of the eight sectors specified by the UAE Strategy for Artificial Intelligence, namely; education, health, transportation and traffic, and environment. The methodology adopted in this study is detailed content analysis. Ten general factors affecting the implementation of the expert systems were identified. In addition, specific factors affecting the implementation of expert systems as part of the wide implementation of the UAE Strategy for Artificial Intelligence were also defined. Moreover, this study highlighted the difficulty in identifying special factors affecting the implementation of expert systems for any specified sector.

Keywords Expert system · UAE government · Artificial intelligence · Knowledge management

1 Introduction

1.1 Background

Knowledge management has played a vital role to enhance the ability of leveraging the management of data and information into new prospective of complex decision

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making. New emerging concepts of big data, internet of things, artificial intelligence, expert systems, Wikis, industry 4.0, cybersecurity, machine learning, etc. are reshaping the future into a new era where knowledge management is becoming the bread and butter for every individual, organization, and country to excel in the new challenging world. Moreover, technological changes as part of knowledge management will have the ability to reshape the future jobs as highlighted by Frey [1].

One developed tool of Knowledge management is the Expert Systems (ES) which can be defined as specific computer programs that mimic human problem-solving expertise [2, 3]. This tool is critical for knowledge management as it enables knowledge discovery, capturing, representation, sharing and application through an elicitation procedure where rules are being elicited by a developer from an expert in a specific field to design an application that can be used through a user interface to find solution (s) to a related problem [4]. The rule patterns used by expert systems are utilized for machine learning that can be used in the "machines replacing humans" concept to find solutions to problems usually addressed by human experts [5–8].

The expert systems are a subset of Artificial Intelligence [9–15] while the former is focusing on defining set of rules through an inference engine extracted from a human expert the latter is a wider concept that depends not only on experts as an input but also on the wide range of data and information processing, and technologies to come up with intelligent solutions [16–19].

Due to the special nature for implementing expert systems compared to other IT systems implementation [3] the general factors affecting Expert Systems implementation should be assessed in depth to define the pros and cons of implementing expert systems at in general [4, 20, 21]. Moreover, in the literature there is a massive research in the field of expert systems implementation to resolve certain problems [22, 23] or using expert systems in a specific field or domain [20, 24]. However, more emphasis should be given to address the implementation of expert systems at national level or by a specific governmental sector [41], especially with the introduction of the first ministry in the world for Artificial Intelligence by UAE government in October, 2017 [25].

Proceeding the announcement of the first ministry for the Artificial Intelligence, a UAE strategy for artificial intelligence was announced aiming to "speed up government's performance and create conducive creative environment with high productivity" [26]. The strategy includes nine main sectors to focus on, namely; transport, health, space, renewable energy, water, technology, education, environment and traffic. Each of these sectors has a specific key performance indicator to achieve [27].

1.2 Overview of the Study

As been highlighted in the previous section, the literature is highly rich with in-depth researches of expert systems. These researches focus mainly on using expert systems to resolve a certain problem in a specific field or by a specific organization and lack studying the general factors associated with implementing expert systems at a national level or by a specific sector. In this study, a more literature review search will be done to try to build an understanding of the general factors associated with Expert Systems implementation and the specific factors associated with implementing expert systems for four selected sectors addressed by the UAE National Artificial Intelligence Strategy [27]. Based on the defined general factors affecting expert systems implementation and the specific factors at the four identified sectors an understanding will be derived for the success factors associated with implementing expert systems as part of implementing artificial strategy at UAE National level.

1.3 Methodology and Research Limitations

The methodology used in this study will be a detailed content analysis in order to capture as many details as possible to define the themes of the general factors and the themes of the specific factors associated with expert systems implementation within the scope of this study [19].

Limitations of this study reside in the limitation of earlier researches done on expert systems implementation at national level in general and at UAE level in particular. To overcome this limitation, the first assumption was made that general factors affecting the implementation of expert systems by organizations or by a specific field can be projected on the national level but with considering the implementation scale factor. The second assumption in this paper is that the literature review study is sufficient to the methodology used in this research to validate the derived conclusions.

2 Concepts Overview

In this section, two concepts are discussed in details: the expert systems, and the UAE National Strategy for Artificial Intelligence:

2.1 Expert Systems Overview

The literature for the expert systems topic is highly active since the last forty years. There are too many definitions highlighting what is an expert systems, but they all agree in a simple concept that is: “applications or computer programs that mimic human-problem solving expertise in a special area” [2, 28]. The expert systems are part of the artificial intelligence [11, 29] were a knowledge is being elicited [9, 30, 31] from an expert and process it through different types of rules [11] to develop an application that can be used by a normal user to reach to a decision or conclusion that is equivalent to the expert human judgement in similar scenario [31, 32].

Expert systems architecture has the following three key components [11, 17]: knowledge base, inference engine, and user interface. Some researchers add a fourth component which is the explanation module [3]. Below is a description of each component of an expert system with examples of the types associated with each one of them:

1. Knowledge base [5, 33]: Contains the knowledge required by the expert system under development that includes all the facts and rules elicited from the expert. The knowledge base usually includes: rough "rules of thumb", a strict if-then sequence of rules, and rules obtained by statistical techniques, fuzzy logic, or neural network modelling".
2. Inference engine [11, 33]: is the reasoning part to supervise the knowledge in the expert system to ensure coming up with similar conclusions by the automated system based on the knowledge base provided by the expert. The inference engine usually includes: rule based "if-then", chaining "forward or backward", confidence factors, real-time adaptation, and learning capability.
3. User interface [17, 33]: offering interaction with the non-expert users. The user interfaces in the expert systems are usually of two forms: intuitive and self-explanatory.
4. Explanation Module or facility [3, 33]: Examines how the expert system is reliable. It examines how the rules were derived and applied, and the confidence levels that can be attached to the results.

There are two main terminologies associated with expert systems: knowledge engineering and knowledge elicitation; the former is methodologies to build, maintain and develop expert systems everywhere and when necessary [7], while the later is the techniques used for knowledge acquisition from the expert [9]. This makes knowledge elicitation a major research field within expert systems development and implementation [30].

2.1.1 Pros and Cons for Expert Systems

When discussing the pros and cons of expert systems, most researchers focus on listing the benefits of expert systems and they discussed in a less context the drawbacks. Table 1 summarizes the identified characteristics of expert systems versus human experts as been highlighted by Ghunaim [2].

Although it seems that the trends for expert systems implementation are growing [3, 34], the legal liability for the expert systems failure is still under question [35]. The other factors associated with expert systems are their ability to learn; Aly et al. argued that the merge between expert systems and machine learning will enhance the ability of expert systems to learn [5]. Meanwhile, innovation through expert systems still need more evaluation as till know there is no clear evidence in the literature that expert systems can really come up with innovative solutions.

To summarize the section for expert systems overview: Expert systems are widely used by too many organizations, sectors, and business fields. They are "applications

Table 1 Characteristics of expert systems versus human experts

Comparison factor	Expert systems	Human experts
Reliability	More reliable	Less reliable
Duplication	Can be duplicated	Can't be duplicated
Availability	Available anywhere, any place	Available only where expert is located, and now with internet technology the level of availability is improved
Consistent performance	Consistent performance	Varying performance due to stress and other human factors
Working hours	24/7/365	Limited working hours
Break or vacation requirements	Do not need break or holiday	Needs break or holiday
Knowledge depth and breadth	More knowledge depth or breadth	Less knowledge depth or breadth
Cost	Less expensive	More expensive
Commonsense	Lack of commonsense	Have commonsense
Innovation	Only stick to the programed rules	More creative

or computer programs that mimic human-problem solving expertise in a special area" [2, 28]. They composed of four main components; knowledge base, inference engine, user interface, and explanation facility. The main aim of the expert system is to elicit the knowledge acquired by an expert through a facilitator or developer to design an IT platform that can be used by a user to reach similar conclusion or decision to a certain problem that the human expert can conclude. Studying expert systems is usually performed for a certain field or problem, which makes it difficult to assess the factors of implementing expert systems at a national level.

The general factors affecting the implementation of expert systems will be thoroughly discussed in section number 3, while the coming section will focus on UAE strategy for artificial intelligence and the sectors addressed by the strategy.

3 Factors Influencing Expert Systems Implementation

The concepts and components of expert systems and the UAE artificial intelligence strategy were discussed in details in the previous section. In the following two subsections a content analysis from the literature will be performed to assess the general factors associated with implementing expert systems and the specific factors associated with expert systems implementation for the fours sectors selected in the UAE national strategy for artificial intelligence.

3.1 *General Factors Associated with Implementing Expert Systems*

The factors associated with expert systems implementation usually follows the life cycle of expert system development process [21]. Any expert system starts with the knowledge acquisition process and before initiating this process a very important factor can be identified which is identifying the right expert [36] and overcoming the resistance of the expert to provide the required information [9]. In the knowledge acquisition process there is another important step for knowledge elicitation from the expert that is done by the knowledge engineer [31]. After knowledge acquisition it is important to do a proper knowledge representation in the knowledge base where the knowledge engineer is ensuring that the expert is seeing his/her problem solving method during the design of the expert system [21]. The user interface should be user friendly [13] and proper mechanisms should be put in place to overcome the resistance from the users to use the new expert system fearing of losing their jobs [3, 31]. Guimaraes examined nine factors crucial to the successful implementation of expert systems and concluded that seven factors are significant, namely; problem importance, knowledge engineer characteristics, end-user characteristics, expert systems impact on end-users' jobs, shell characteristics (interactive user interface), user involvement, and system usage [4]. He also examined most of the critical factors concluded that there are other factors affecting the successful implementation of expert systems such as problem difficulty, domain expert quality, and management support [3].

Subramanian et al. followed the three phases for the expert systems development process (initial phase, core development, and expert system deployment) to evaluate the effectiveness of the expert systems [21]. All three phases can be utilized to categorize the previously described factors associated with expert systems implementation as shown in Table 2.

Table 2 Categorizing the general factors associated with expert systems implementation based on the expert systems life cycle

Initial phase	Expert systems core development	Deployment phase
Problem importance	Knowledge elicitation	Overcome the resistance from the end users to use the new expert system
Problem difficulty	Knowledge representation	End user characteristics
Identifying the right expert	User interface	System usage
Overcoming resistance from the expert to provide the required information	Knowledge engineer characteristics	
Domain expert quality	Shell characteristics	
Management support	User involvement	

The general factors associated with expert systems implementation at the initial phase can be re-categorized into three main sub-categorize; the problem to be addressed by the expert system, the expert(s) to be selected to have their inputs to resolve the problem through developing a system, and management support. The problem addressed to be resolved by the expert systems should be directly linked to the achievement of the strategic objectives of the organization [4] and it should be difficult enough to see the value of the expert system by the end user [3]. Moreover, selection of the expert and ensuring the provision of the required information while maintaining the quality of this information is a critical factor in any expert system success. Furthermore, defining the required skills attained by the expert plays a major role in having a proper input to the expert system [36]. The final sub-category in the initial phase is (management support) as it is proved to be of a high importance to ensure the success of any knowledge management implementation initiative [37].

For the expert systems core development phase, the general factors associated with expert system implementation can be re-categorized into four main sub-categorize; knowledge elicitation and representation, knowledge engineer characteristics, user interface, and end user involvement in the system development. The knowledge elicitation and representation process depends on the expert who possess the knowledge and needs to be "elicited" by the knowledge engineer to represent the knowledge in a way that can be read by the developed system (Usually through a set of defined rules) [9]. Knowledge engineer characteristics represents the skills attained by the developer to develop the expert system [4], this also includes the proper definition and practice of the knowledge engineer roles and responsibilities [7]. For the user interface, it is the main engine for the expert system and should be user friendly [11]. Moreover, it should be interactive in a way that encourages the active interaction of the end user with the expert system [2]. The end user involvement in the design of the expert system is critical to its success as they should be engaged in defining the goals of the expert system in the verification and validation phases [3].

In the expert system deployment phase the general factors associated with its implementation can be re-categorized into two main sub-categorize; the end user and the system usage; the end user should have the opportunity to configure and test the system [13] also he/she should be provided with the appropriate trainings in order to facilitate the proper deployment and effectiveness of the expert system [4]. System usage is associated with the degree to which the system is used by the end user, and his/her satisfaction with the system, and the ability of the expert system to improve the quality of the job assigned to the end user [4].

To summarize the above points, the effective expert system implementation is influenced by the following general factors; **management commitment** towards the implementation of the expert systems, **type of problem** to be resolved by the expert system itself, the **human factor** of resisting to provide the required information by the expert or resistance to use the expert system by the end user fearing of losing their jobs in the future, the **knowledge elicitation** process that should be planned and performed in an efficient and effective method, the **knowledge engineer** who should be playing his/her role efficiently and effectively, and the **expert system itself** which should be fulfilling the requirements of the end user, being user friendly, and to be designed in the proper reasoning and structured process.

The defined general factors affecting the implementation of expert systems can be put in a positive context by having the proper tools and techniques to: enhance management commitment [18, 38], proper definition of the problem to be addressed by the expert system [3], improve the engagement of the expert and the end user [37, 39, 40], perform an effective and efficient knowledge elicitation process (16, 30), enhance the skills of the knowledge engineer [9, 20, 31], and improve the features of the expert system [13, 15].

3.2 Specific Factors Associated with Expert Systems Implementation at the Selected Four Sectors

To evaluate if there are specific factors associated with expert system implementation in specific sectors, four sectors out of the eight sectors (as highlighted earlier transport was combined with traffic) specified in the UAE national strategy for artificial intelligence were selected, namely; education, health, transportation and traffic and environment. Literature review of papers addressed the expert system implementation of each one of these four sectors was performed to investigate if there are specific factors associated with implementing the expert systems per sector other than the general factors identified in the previous section or not. The methodology used in the review is the content analysis methodology and the outcome is as follows:

1. Education sector: Khanna et al. studied expert systems advances in the education sector, their main argument for expanding the implementation of expert system in education sector is to have proper documentation and enhance research capabilities in this field [41]. The same finding was also concluded by Monish and Ashwini [42] and they both agreed that expert systems have great potential to change the learning techniques by less dependance on a physical teacher. On the other hand, Sora et al. emphasized that the bond between the teacher and student should be physically and not virtually maintained especially for elementary students [43]. This brings a specific factor for implementing expert systems in the education sector which is using expert systems as facilitation to the learning process and **not eliminating main component of the process** (the physical teacher) as this will negatively impact the learning outcome of students.
2. Health (including medical) sector: In the health sector expert systems were widely used in medical diagnosis [6, 11, 19], and expert systems were proved to have up to 100% accuracy in some studies to have the right diagnosis [29]. The main factor affecting expert system implementation in the health sector is the **liability factor** as it is very difficult to assign responsibility of having wrong diagnosis if the system fails to provide the right answer [35].
3. Transportation and Traffic sector: As been highlighted by Wagner et al., transportation sector is among the lowest sectors that implemented expert systems in

the last thirty years [19]. Three research papers for implementing expert systems in the transport and traffic fields were reviewed; the first paper uses expert systems to articulate a strategy for road safety in the Government of the Russian Federation [16], the other two papers depended on regulations in the transport and traffic sectors as the main input to the developed expert systems [17, 28], and this may bring into the discussion table the question of: What is an expert system and what is not?
4. Environmental Sector: Yoram designed an expert system check list based mainly on the environmental regulations [44] and this brings us to our previous discussion in the transportation and traffic sector of what is under the domain of an expert system and what is not. On the other hand, since the environmental sector can be assumed to be part of other industries such as chemical or oil and gas the research of expert system in the environmental sector is not very popular [19].

The identified specific factors resulting from literature review affecting the implementation of expert systems in education and health are applicable to other sectors, so within the limitations of this study, as it is based on content analysis of selected researched papers, it was difficult to distinguish any specific factor affecting the implementation of expert system per sector. On the other hand, and due to not having a clear cut in the UAE artificial intelligence strategy of the domain of each sector (for instance, what should be under the domain of the environmental sector or technological sector) it will be also difficult to base the implementation of expert systems in UAE in relation to the sectors defined in the UAE artificial intelligence strategy.

4 Success Factors Associated with Implementing Expert Systems as Part of Implementing Artificial Intelligence Strategy at UAE Level

Based on the discussions in the previous section, the factors associated with implementing expert systems were identified. These factors were regrouped according to the themes of UAE national strategy for artificial intelligence to define the success factors associated with implementing expert systems as part of implementing artificial strategy at UAE level. Table 3 illustrates the distribution of the general factors affecting expert system implementation against the 5 themes of UAE national strategy for artificial intelligence.

For the successful implementation of expert system within UAE artificial intelligence strategy, the following success factors are identified:

1. Having clear **strategic plan** with defined objectives to implement expert system strategy within UAE artificial intelligence strategy.
2. Building a **national database** for the experts across UAE, within this regards UAE government can partner with companies such as LinkedIn to build and maintain the database.

Table 3 Distribution of factors affecting expert systems against UAE AI strategy themes

Theme 1 AI council	*Theme 2* Knowledge sharing in AI	*Theme 3* Capacity building in AI	*Theme 4* Service provisioning through AI	*Theme 5* Leadership engagement
Not eliminating main components	Knowledge elicitation	Knowledge engineer	The problem	Management commitment
Liability factor		Expert system		Human factor

3. Building the **proper legislations** that supports the implementation of expert systems at national levels and identify the right liability in case of system failure.
4. **Not making radical changes** such as eliminating physical teachers.
5. Defining the most suitable **techniques for knowledge elicitation** that is aligned with UAE culture and train the knowledge engineers on these techniques.
6. Providing the proper training for the developers to become knowledge engineers and to ensure practicing this role, also to introduce the **knowledge engineering function** in the ministries and government bodies.
7. To develop **prioritization criteria** for selecting the problems to be resolved by expert systems or the services to be enhanced.
8. Building trust with experts and internal end users to ensure having **job advancement** and engaging them more in innovation activities.
9. Defining specific **technical platforms** for expert system development and provide the required infrastructure and knowledge transfer capability.
10. Ensuring **leadership engagement** at the higher level and at the organizational level.
11. Due to UAE workforce nature that depends on a great extent on expat experts, it is recommended to have an **incentive and rewarding scheme** for these experts who are willing to provide the required knowledge.

5 Conclusion and Future Prospects

Expert systems are subset of artificial intelligence that have been widely used in the last forty years. The main aim of an expert system is to mimic human problem solving expertise and it has four main components; knowledge base inference engine, user interface, and explanation facility. The expert systems gained their popularity due to the advantages they have of being reliable, can be duplicated, always available, having consistent performance and for their cost effectiveness against the human expert. While these expert systems are lacking the commonsense and they are simply not creative.

The purpose of this paper was to define the general factors associated with expert systems implementation and to define if there are specific factors associated with its implementation within the context of UAE artificial intelligence national strategy. The methodology used in this paper was literature review detailed content analysis.

The general factors identified in this paper that have an impact on expert system implementation are: management commitment towards the implementation of the expert systems, the type of problem to be resolved by the expert system itself, the human factor of resisting to provide the required information by the expert or resistance to use the expert system by the end user fearing of losing their jobs in the future, the knowledge elicitation process that should be planned and performed in an efficient and effective method, the knowledge engineer who should be playing his/her role efficiently and effectively, the expert system itself (which should be fulfilling the requirements of the end user, being user friendly, and to be designed in the proper reasoning and structured process), not eliminating main component as a result of implementing expert system, and the liability factor to define who is liable if the expert system fails. On the other hand, and due to the lack of available relevant resources it was difficult to identify specific factors affecting the implementation of expert systems in the selected four sectors part of the eight sectors identified by the UAE national strategy for artificial intelligence.

The additional value to this paper was to build up on the previous findings to conclude the critical success factors to implement expert systems as part of the wide implementation of UAE strategy for artificial intelligence. The defined success factors are: developing a strategic plan for expert system implementation within the UAE national strategy for artificial intelligence, building a UAE national database of experts, putting the proper legislations for implementing expert systems, not making radical changes while implementing expert system strategy, defining the most suitable techniques for knowledge elicitation that are aligned with UAE culture, providing the proper capacity building programs for knowledge engineers and investigate the possibility of having specific functions within their organizations to strengthen their roles, developing national prioritization criteria to the problems to addressed by expert systems, putting job advancement programs for experts and internal end users, defining specific technical platforms for developing expert systems, ensuring leadership engagement at different levels, and having an incentives and rewarding scheme for expat experts.

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The Role of Higher Education in the Maturity of Knowledge Commercialization Ecosystem

Mohsen Sepahi, Ghasem Salimi and Vahid Sohrabpour

Abstract Knowledge commercialization ecosystem is a concept, which considers a high level of convergence, synergy, participation, and innovation based on the interactions between parties involved in the process. In this paper, the knowledge commercialization ecosystem has been regarded as an open system and the role of higher education in the formation and maturity of it has been conceptualized. This study used a qualitative approach to explore the experiences of the knowledge commercialization experts through case studies. Thirty participants from four large universities of Iran participated in this study. The data was analysed through thematic analysis approach. The results showed that according to the experience and perspective of experts, higher education institutions play a vital role in maturity of knowledge commercialization ecosystem alongside the other institutions. Furthermore, this study explored the intellectual and practical barriers, drivers, vital processes and the concerns of knowledge commercialization. Finally, findings showed that by establishing an effective communication between Triple Helix Partners in Iran, the knowledge commercialization process would be facilitated through breaking down barriers and reducing costs.

Keywords Knowledge commercialization · Ecosystem · Higher education · Iran

1 Introduction

In recent years, universities have moved more and more towards using the strategy of creating knowledge-based companies as an effective strategy for utilizing academic innovations (Forte 2017), as a result of the expectations of economic development and internal pressures to create new and sustainable sources of income. Studies have shown that knowledge commercialization is a process that transforms knowledge generated at universities and research centres into products that are affordable in the

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market or in industrial processes. On the other hand, studies have emphasized the importance of knowledge as a driving force for economic growth and a factor in increasing productivity [1].

The fact is that universities are increasingly faced with the increasing commercialization of new research and the reduction of longstanding activities such as teaching and research. The development of commercialization of academic research is a new gateway to scientific advances [2]. Accordingly, the commercialization of knowledge and the creation of fundamental reforms in the mission, structure, process, and culture of organizations that have led to the institutionalization of the commercialization of knowledge has become inevitable and a topic of interest for developed and developing countries [3]. In research organizations, it does not make sense to carry out an unbiased research [4] On the other hand, new perspectives on research and technology development policies, now often referred to as "innovation policy", emphasize the tangible effectiveness of the economic, social impacts of these activities [3, 5].

One of the most important aspects of these policies is the commercialization of research achievements and the development of new technologies [6]. Today, increasing the credibility of universities through the transfer and commercialization of knowledge plays an essential role in increasing the human capital of universities. Realization of this strategy is possible by attracting the most intelligent students from the best colleges [7].

The importance of transferring knowledge and applying research results to decision-makers in developed and developing countries is quite clear. In developed countries, growth centres, science and technology parks, generative companies, and commercialization of humanities research along with engineering are considered in the new generation missions of most universities [8]. Therefore, the main building-block of the competitive advantage and economic development of the regions is the creation and development of knowledge-based businesses.

One of the mechanisms for transferring knowledge is the creation of academic companies. These companies commercialize ideas for highly educated graduates, expand the level of employment, and have economic implications for the development of regions [9]. Thus, noteworthy is that startups are always faced with problems, especially when competing with rivals with a background. Various support systems have been developed to boost these companies in a competitive environment. These supportive systems provide companies with many benefits such as tax breaks, training, and exemptions from statutory regulations [10]. Therefore, to form such a system that is supportive for the growth and maturity of new companies, a network of elements is required. This elemental network can be considered as the commercialization of knowledge in the ecosystem of knowledge.

Knowledge commercialization is a concept that highlights the high level of convergence, synergy, participation, and innovation in the interactions between the parties involved in the process of commercializing knowledge.

In spite of the attention paid to the issue of the ecosystem of the entrepreneurial university ecosystems and ecosystems [11], and the organizations that facilitate science commercialization through entrepreneurship [12], Expanding entrepreneurship education ecosystems [13] and startup ecosystem in Iran [14], so far, little has been done about the role of higher education in the maturity of knowledge commercialization [15].

The main purpose of this article is to explore experiences of knowledge of business expertise through case studies in Iran. This study aims to explore the experiences of the knowledge commercialization experts and the perspectives of them on the role of higher education in the maturity of knowledge commercialization ecosystem through case studies, and therefore, it tries to answer the following question:

– How Iranian experts describe their experiences on higher education role-playing in maturity of knowledge commercialization ecosystem?

2 Theoretical Background

2.1 Knowledge Commercialization

According to Cooper [16], the process of knowledge commercialization consists of conceptualizing, reviewing and screening the basic idea, examining and refining the idea for creating a business, developing ideas, testing and validating them, industrial production, and entering the market for commercialization.

In addition, in the commercialization literature, the following definitions are provided for this process, which indicates the focus of commercialization literature on research and R & D production for technology-specific industry. For example, the commercialization of energy technology commercialization is defined as "the full range of activities necessary to inject a technology, product, or process from its conceptual stage to the market" [17].

Karlsson [18] considers commercialization as the official transfer of explorations and innovations from scientific research conducted at universities and non-profits to the commercial sector for public benefit.

Bandarian [19] defines commercialization as the transformation or transfer of "technology" to a profitable position, which refers to technology, techniques, and processes for the acquisition of patents or other private property, materials, equipment, systems, and the like. Otzkevitz et al. (2000) argue that a gradual relationship between the university and society has created a two-way knowledge-based relationship and universities have been able to play an active role in economic development. It is worth noting that university-industry cooperation enriches the field of theorizing in universities.

On the other hand, researches conducted in the academic sector will not have the quality or context for attracting and receiving from the industry sector until the policies of R&D are in line with the basic needs of the national innovation system (Abdul Latif et al. 2016).

2.2 Knowledge Commercialization Ecosystem

The term biomass means close proximity to the environment and is concerned with the complex relationships between living organisms and their environment and the impact of human activities on these relationships [20]. Biomass is a scientific concept of the study of environmental systems [21].

The first concept of the business biomarker was introduced in 1993 by Moore at Harvard Business Review as a new environment for competition and won of the Makenzie Award of the year [22].

From Acs, Autio and Szerb [23] viewpoint and Feldman, Francis and Bercovitz [24], Eisenberg (2010) and World Economic Forum (2013) and Feld (2012), Hwang and Horowit (2012), according to Spiegel (2015), in popular business literature, biomass is a vital tool for creating flexible economies based on entrepreneurial innovation.

Ecosystems are a set of central cultural views, social networks, financial support, universities, and active business policies that create a supportive environment for a risky business based on innovation (Spiegel 2015). Accordingly, the process of starting a business does not occur in a vacuum, but within the framework of factors including (1) government policies and directives, (2) economic conditions, (3) entrepreneurial and business skills (4) grants, and (5) non-financial assistance. The hidden power of a knowledge economy commercial biomarker lies in its dynamic mechanism that may transform a social network and make it into a value chain [25].

3 Methods

3.1 Methods Research Design, Population, and Sample

In this research, a multiple case study [26] has been used. A multiple case study enables the researcher to explore differences within and between cases. The purpose is to replicate findings across cases [27]. Accordingly, and with regards to the purpose of the study, semi-structured interviews were conducted with the participants. In the qualitative section, the sample was interviewed using a targeted approach. Hence, 30 experts in the field of knowledge commercialization held interviews for 30–60 min after co-ordination and obtaining necessary permissions. In this research, participants were those who: (1) had expertise, experience or nobility in the field of knowledge commercialization; (2) had experience or were already working in direct business in knowledgeable companies, centres of excellence and science and technology parks. Participants in this research were experts in Science and Technology Park of Shiraz, Science and Technology Park of Sharif University of Technology, Centre for Innovation and Entrepreneurship of Amir Kabir University of Technology, and Human Development Center of Allameh Tatababa'i University.

3.2 Data Collection and Analysis

The research data collection criterion was theoretical saturation. In other words, collecting research data continued until no more new information was added to previous information. Subsequently, the data obtained using Maxqda Software 11, which is software for analysing qualitative data, was analysed through thematic analysis technique. Thematic analysis can be used to formulate and analyse the content network. Template networks are web-based images that summarize the main content-related topics [28]. Thematic analysis is a method for identifying, analysing and reporting patterns and themes in the data. This method transforms the data into rich and detailed data. The phases and steps of the method of analysis of the subject may coincide with some phases of the qualitative research methodology similarly, in other words, it is not exclusive to the analysis of the subject [29].

The findings were then categorized and organized in the form of a basic, organizing, and inclusive content network. This was done for each interview, and if there were parts with similar content in the context of the previous interview, the same code was used as a marker. Subsequently, based on all identified themes, a more general categorization of the whole research was conducted that led to the identification of the main theme (the role of higher education in the maturation of knowledge economy commercialization). The results of this process are presented below.

4 Findings

To analyse these data, the theme analysis and content network were used. In the first stage, the data were collected through open-ended and semi-structured questionnaires. Its analysis is one of the most suitable analytical techniques in qualitative research that transforms distributed and diverse data into rich data. Written responses were then studied and reviewed several times and a list of early codes was prepared. At this stage, 182 initial codes were identified. In the next step, the codes obtained in similar groups were organized and the content network was analysed and reviewed several times. Finally, the role of higher education in the maturation of biomedical knowledge commercialization as a universal theme, four types of organizing themes, and sixteen themes were identified and the content network was derived, as shown in Fig. 1.

Based on the results of the research, the role of higher education in maturation of biomaterials in the commercialization of knowledge (comprehensive content) are dimensions such as obstacles to the commercialization of knowledge, the pioneers of knowledge commercialization, and the processes of commercializing knowledge as organizing themes. Each of these cases has dimensions as basic themes.

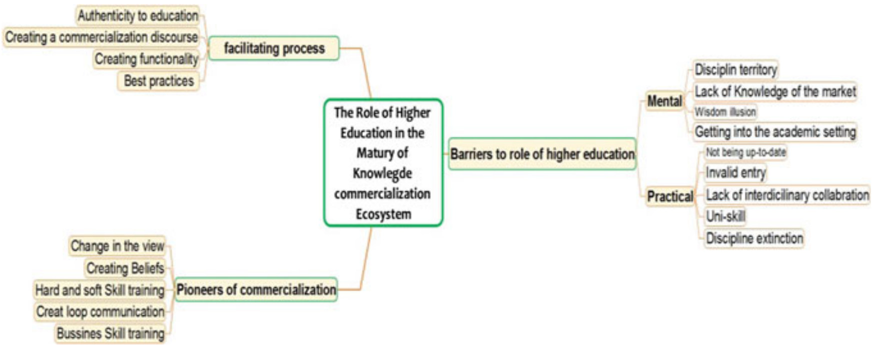

Fig. 1 Network content themes

4.1 How Iranian Experts Describe Their Experiences on Higher Education Role Playing in Maturity of Knowledge Commercialization Ecosystem?

The study revealed three themes on how participants describe their experiences on higher education role-playing in maturity of knowledge commercialization ecosystem. Moreover, from the analysis of the qualitative data, the following sub themes emerged:

Lack of knowledge in market's need, get used to the academic environment, the illusion of knowledge, disciplinary aristocracy, not up-to-date, poor input of some fields of study, Non-interdisciplinary collaboration, Uniformity of university graduates, disciplinary Extinction, Change the view, Creating Beliefs, Hard and soft skills training, Business skills training, Interdisciplinary education, Create loop communication, Authenticity to education, Creating a commercialization discourse, Best practices. These themes are further explained below.

4.2 Barriers to the Role of Higher Education

The findings of the study indicated that participants contributed to higher education barriers. These barriers are divided into two types of mental and practical barriers. The following are the views of the interviewees. Mental constraints include:

4.3 Lack of Knowledge of the Market Needs

> The university claims that the industry does not want to let us know and trust us; the industry believes that the university will not be able to provide its own business and will, at any rate, resolve the industry's challenges, with both sides claiming that the other side is neglecting the other.[1]

O'Shea et al. [22] highlight the need for market knowledge of the success factors in the commercialization of knowledge. Findings of Bandiran's [19] study have identified the lack of information, inadequate human resource capabilities, economic, political and legal barriers, structural and organizational barriers, and lack of understanding of market and customer needs, including barriers to knowledge commercialization.

4.4 Getting into the Academic Setting

> New companies do not have the experience they need. The market is mostly young people who are new to universities, graduation with a good and optimistic vision. There are differences between the academic environment, the scientific environment, the research environment, and the market. It is all about co-operation. We, in the fields of academic sciences, humanities, engineering, basic sciences, etc., can be divided into two categories. Individuals who get into to the academic environment do not feel the need to adapt to it and the business environment is a problem of its own.

In this regard, Sadeghi Shahmirzadi and Adli [30] have shown that there is a positive relationship between the components of the higher education system and the development of entrepreneurial spirit, and if members understand the space of the higher education system as a closed space, they are reluctant to cooperate.

4.5 Wisdom Illusion

> I suppose it is apparent why the illusion of knowledge is more dangerous than ignorance. When one does not know anything, his own task is clear: he does not decide on the basis of uncertainty, and therefore probably less troublesome, but he who does not know and at the same time he thinks he knows, has a dangerous situation: he decides on the basis of information or knowledge that is not correct, and in many cases, it has more consequences than the decision-making process.

[1]The material presented as Quotes is the same statements and phrases used by the contributors, and the use of direct quotes from the interviewees is one of the main tools for conveying their understanding and interpretation of the phenomenon in question [31].

Research studies have also shown that the knowledge gap between industry and university is one of the barriers to higher education's role in the commercialization of knowledge [32].

4.6 Discipline Territory

> There is a concept named discipline territory in the universities. I am an expert on the subject and no one else has the right to enter my territory. This concept must be broken. If this happens and collaborates, further research will be unfolded to the students. It's an example of a student who has published a paper in Europe, whose authors come from a variety of disciplines, but this does not happen in our universities; yet, this interdisciplinary culture can be created.

Structural and disciplinary structures of universities are inefficient. The emergence of interdisciplinary areas is a sign of the gap between the world of life and the higher education system and academic system. In the real world, in the industry and services needed by the community and in the world of professionalism and the labour market, there are emerging issues and demands that cannot be explained to all existing curricula and programs. With traditional disciplines and well-known structures of groups, the university has been repatriated. The concept of "interdisciplinary" has come about to face this problem [33].

In addition to the mental barriers, practical obstacles hamper the role of higher education in knowledge economy commercialization.

4.7 Not Being Up-to-Date

> The next decade is the decade of startup flourishing, like a flood that no one can handle, we need to keep up with the world, be up to date, and adapt to our own peripheral changes. Unfortunately, some outlets for universities are not up-to-date with the needs of society.

Invalid entry of some fields of study

> The humanities were confined to high school, because they were given more importance to other disciplines, and poor people entered the humanities (weak grades, for example), and this is the good example of these disciplines. With the arrival of poorly weakened people these disciplines became even weaker.

According to the World Economic Forum (2013), the number of university graduates has grown exponentially over the past decade. However, the average growth has been very small. A survey of international indicators shows that Iran in terms of labour productivity among 148 countries is ranked as the 130th.

4.8 Lack of Interdisciplinary Collaboration

The topic of interdisciplinary co-operation is the topic that research participants referred to.

> I see from the practice that one of the problems of companies is, for example, assuming that a group is created, which is a very specialized group and they want to produce a product on a subject, but along with their specialty, there is nobody in the realm of the market and economy. Well, naturally, it shows that you did not grow well in the interdisciplinary concept.

For Lynch [34], interdisciplinary collaboration does not mean encompassing multidisciplinary or collaborative work by individuals with different specializations, but in different doctrines for the development of conceptual models, the explanation and conceptualization of results, the application of each other's methods, and the idea of knowledge.

4.9 Uni-Skill of Universities' Graduates

The need for some high-level college graduates is one of the concerns expressed in this study by participants.

> You cannot believe that a master graduate in our field is not able to write a letter in simple text. For example, you say, if you have a request, write it down; write down what you want. It's impossible for him to write it, for there is no general skill let alone the specialty. My experience also shows that one of the main factors of these teams is incapability and one of the items of incapability is being single-skill.

4.10 Discipline Extinction

> We are holding workshops, looking at courses that may have been extinct in the past five years, because they failed to respond to the needs of the community.

A study by Parand et al. [35] showed that the gap between industry and academic education and the lack of conformity with the needs of the labor market is a major problem that has led to a steady increase in the unemployment rate of graduates.

4.11 Knowledge Commercialization Pioneers

According to the participants, the drivers that contribute to the effective role of higher education in maturation of the commercialization of knowledge are:

- Change in the view

> In the past few years, tourism has been a subject of debate and the view has changed. It is really from tourism that founding knowledge societies have established and tourism has shown this potential.

Etzkowitz [36] believes that today the mission of universities has shifted from education to research and education, and has focused on economic development.

4.12 Creating Beliefs

"I do not have this belief in Iran. There is no basis for this belief in Iran, and this is necessary to be taught through education that you can create a business."

Luthans, Stajckovic, and Ibrayeva [37] argue that self-efficacy in entrepreneurship is one of the essential requirements for entrepreneurial motivation, as well as an attempt to undertake entrepreneurial activities.

4.13 Hard and Soft Skills Training

> I see two very important issues in the failure or success of knowledge-based companies in marketing, the research, and technology achievements: 1. the ability of team-building to see all dimensions of the business. 2. The attention we pay to soft skills of a person, whether he's a student, who is a graduate and or he just wants to attend, is learnable. The summary I can say based on what I've seen over the past 10 years, as well as the growth and failure process of about 260 companies, is that our students and our graduates do not learn soft skills to the degree that they learn hard skills.

Jin [38] believes that soft technology, as a new technology paradigm will soon change our attitude towards industry, research production, marketing education, business, and even security and defense. Also, Norin et al. (2015) emphasized the importance of researching the success of soft technologies with hard technologies for the success of commercialization of research.

4.14 Business Skills Training

The United Nations Educational and Cultural Organization has described modern universities in the global perspective of higher education for the 21st Century: a place where entrepreneurship skills can be developed to convert graduates to job creation [39].

4.15 Interdisciplinary Training

> It's almost impossible to line up the disciplines, when, for example, I get an application to the market that you are working on in the field of psychology. Well, you will see a collection of experts in the field of humanities and behavioural science, information technology engineering, which cooperate with each other.

An interdisciplinary approach to research is the result of the collaboration of two or more academic disciplines to solve a science problem during the era of specialization, and in an era that has gone astray between different disciplines. It has a unifying view of human knowledge and seeks to establish a logical connection between science and answering questions that specialized fields alone cannot find an answer for them. This approach is of particular importance in recent decades following the pathology of pure specialization and revealing its adverse effects and has been raised in academic centres and research in the world (Rahmdel and Farangi, 2008, p. 24).

4.16 Create Loop Communication

> There must be a university, a research institute, and accomplish their duty alongside us, there must be an industry, and each executive must have its own particular organization. They are all loops and are put together.

Etzkowitz [40] argues that academics in the country, in addition to modifying their interactive ways and their internal structures, need to establish effective communication with other sectors of society and always seek to strengthen and consolidate them. This is because, throughout the world, the interaction between government, industry, and the university has distanced from previous models of control and separation of these sectors and has become interactive, overlapping, and relatively autonomous relationships among these three parts.

4.17 The Process of Facilitating the Commercialization of Knowledge

Participants in our research believe that the processes facilitate the role of higher education in orienting the growth of knowledge-based business knowledge. Sohn and Moon's (2003) study showed that studies on the commercialization process deal mainly with defining the concepts of commercialization and its conceptualization. The process of commercializing knowledge is not a simple and linear process, but rather a complex process in which many actors play a variety of abilities.

4.18 Authenticity to Education

> I started to answer the question and give authenticity to the training. We set the basis for our startup, we taught it on our training many times, but since we gave authenticity to the creation of discourse and training, I think we are getting more successful every day.

Khalidi and Agahi [41] argue in their research that entrepreneurship education can, in addition to creating knowledge and skills, increase the readiness, motivation, self-esteem, the need for progress, risk taking, opportunism, and the ability to tolerate ambiguity, the power of management and leadership, detailed analysis of issues, and the power of innovation in students. The development of entrepreneurship is considered to be the responsibility of universities, which is possible through motivating and increasing the qualifications and abilities of graduates.

4.19 Creating a Commercialization Discourse

> But with the very few numbers that we could see for the teams that they are working on, this meant that we could create this discourse, and that this should be produced by the universities that you and the university graduate are not obliged to pursue the position of a government job; you can do it yourself, by working and working well and creating wealth.

4.20 Creating Functionality

> We need to be able to build on our various situations; probably this is the most complex part of our business.

Schotter and Bontis [42] has the capability to mean capacity or ability in a particular job and defines it as a set of behavior. According to Carneiro [43], organizations differ in how their resources are used, capabilities depend on how resources are exploited. At this level of hierarchy of capabilities, which consists of a set of processes in the organization, the organization manages resource interactions. For example, an organization for capturing marketing capability can focus on the interaction between human resources (marketing comrades), technology and finance.

4.21 Best Practices

> In the current situation, given the limited resources and time that we have in comparison with our rivals, we need to find the least costly and the most ideal technique or techniques that results in more significant outcomes than the other methods for success in business.

Best Practice means to find and use the best strategy for a particular practice to consider the objectives to be fulfilled. The methods include strategies that have already been put into practice and ensure the achievement of a specific goal [44].

5 Discussion

5.1 Conclusion and Implications for Theory and Practice

The biomedical knowledge-commercialization industry in Iran is under development and needs to be addressed in a wide range of areas. Legal, financial, technical and technical advice, legislation improvement, administrative simplification, innovative supply chain, education and employment, etc. are among the services that explain the need for knowledge-building commercialization of ecosystems. Knowledge commercialization elements (government, research institute, market, startup companies, consultants, investors, science and technology parks, etc.) each contribute to the success of the knowledge economy. In the meantime, the inseparable role of higher education in the dynamics and maturity of knowledge economy commercialization is not at stake. The higher education system of the country can add to the dynamics and maturity of the commercialization of knowledge of the ecosystem by removing the above-mentioned mental and practical barriers. After removing the obstacles, there are pioneers that can turn higher education into the engine of the knowledge-building commercialization mechanism. Creating a belief in ability leads to national self-confidence and national self-confidence. This vigorous and motivating element causes a change in perspective and, as a result, positive changes in the growth, prosperity and excellence of the country's higher education will appear. Learning soft skills, hard skills, and skills related to business development can be one of the drivers of higher education in the eco-system of knowledge commercialization. Hard skills include the ability to apply specialized knowledge in the real working environment, the ability to write and submit resume in the workplace, the ability to use information and communication technology, written and spoken English skills, and reinforce research skills. Soft skills also include: individual development skills, self-awareness skills, problem-solving skills and decision making, teamwork skills, effective and constructive communication skills, excitement and stress skills, and creative thinking ability. The skills and rules for business creation and development include: familiarity with business and business laws, the ability to adapt to changes in working and living conditions, teamwork ability, planning ability, entrepreneurial skills, and the ability to use computer-based technologies. In the process dimension, it is also possible to create a subjective commercialization of knowledge in the field of opinion and practice for decision-makers, policy makers, professors and students, and by building on the role of education, the maturation of the knowledge economy commercialization biomarker in Iran can be reached. The resulting outcomes include the application of knowledge to meet the needs of the market, industry and society. As a result, the production of science in the country leads to the production of technology, and the country can achieve the national knowledge of the technical, the premier industry, trade and, in general, and national wealth. The training of skillful and efficient force is one of the achievements of maturation of knowledge economy commercialization ecosystems. The desired effect of higher education creates entrepreneurship and value creation.

5.2 Limitations and Future Research

This study developed our understanding of what factors of higher education context influence maturity of knowledge commercialization ecosystem. While the number of participants interviewed and the perspectives of them on the role of higher education in the maturity of knowledge commercialization ecosystem was in line with the recommendations given by qualitative researchers, it still provides only a small glimpse into the experience of knowledge commercialization ecosystem. Therefore, it is difficult to reach broad conclusions.

More research is needed to further explore and test our findings in more detail and different contexts and different knowledge commercialization ecosystems.

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Cross-Border Trade Through Blockchain

Hussam Juma

Abstract The emergence of blockchain technology has created a buzz and a mind shift for organizations and industries. Governments and international bodies are increasingly discussing the potential implications of blockchain's distributed ledgers on business, governments and the economy. In this paper we present theoretical study that investigates whether the technology is ready to disrupt the way business is conducted or we still at an early stage. Distributed ledgers are possibly most useful in scenarios involving multiple parties where items change their state or status frequently. These scenarios involve parties who are generally distributed and using different technologies, systems and applications. The intended purpose of the technology is to connect business network members in a decentralized fashion. An essential element of this network is adherence to a common protocol for validation of blocks. By distributing data across the network, the blockchain eliminates the risks of centralization. The technology enables exchange and sharing of information without the involvement of intermediaries acting as arbitrators. Powered by its decentralized nature, the network will not have any single point of failure and will not rely on any single entity. Multiple industries and organizations are attempting to obtain a lead position by adopting the technology in their business or within the supply chain. However, due to various technical, social and political challenges little progress has been made thus far. Although the technology of blockchain holds a lot of promise it's still not mature enough for general implementation. Once enough evidence proves the effectiveness of the technology for different industries, the adoption level is expected to increase and the benefits will be better understood.

Keywords Blockchain · Distributed ledger · Trade supply chain

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1 Introduction

The formalities of trade and supply are often burdensome, time consuming and inefficient. Trade being a major factor in determining a country's economic viability, eliminating unnecessary cost and procedural challenges will ensure delivery of effective trade services.

The supply chain involves a number of activities performed by various private and public parties. Activities are carried out subject to certain terms, factors of business and methods of operation. For a supply chain to operate effectively and efficiently we need to clearly identify and manage relationships and activities. Blockchain is considered to offer large potential for improving processes and enhancing business models in the trade, transport, logistics and supply chain management. Connecting all members of the supply chain to a decentralized network and allowing them to exchange data and documents in a secure and trusted manner is what blockchain promises to provide.

Blockchain technology is said to guarantee trade integrity, secure global supply chains and protect revenues [4]. Additionally, it provides critical factors to all parties involved:

- Real-time visibility and control
- Strengthens law enforcement capacity
- Helps in meeting regulatory requirements
- Cost effectiveness, security and privacy.

This paper is organized as followed. Section 2 presents the definition of blockchain technology in general. Then a discussion of the potential of blockchain in the trade supply chain in Sect. 3. Section 4 introduces the scenarios in which blockchain can add value to the trade industry. Through an explanation of the challenges facing the supply chain, Sect. 5 describes how the technology can support the various parties and use cases. In Sect. 6 we envision the role of government in helping shape the future of the technology. An important factor hampering the value and adoption of blockchain is the lack of governing standards is discussed in Sect. 7. Finally, we make a brief conclusion for this paper in Sect. 8.

2 Literature Review

2.1 Blockchain

Blockchain is grabbing the headlines and the interest of governments and companies alike. It is no surprise that the trade supply chain is investigating the potential of this technology, particularly in the context of exchanging the paper-based documents required at every step of the trade journey. The ability to connect all carriers, banks, forwarders, traders and other parties of the international trading supply chain to ensure compliance and gain control is the desire of the trade industry. Managing provenance and ownership of documents on the blockchain eliminating disputes, forgeries and unnecessary risks are what is anticipated with the blockchain technology [11].

2.2 Demystifying Blockchain

A blockchain is a type of distributed ledger that is shared across a business network. A distributed ledger is a ledger of digital records accessible to participants of a network of distributed nodes running the same protocol eliminating the need of a middleman or central authority [17]. It is simply a distributed database with many participating nodes in a network. Records are not communicated by a central authority, instead they are independently created, held and updated by every node. That is, every single node on the network maintains its own identical copy of the ledger after consensus from all participants. This system of record serves as a single source of truth for the network and goes beyond being a simple database. Costly risks and inefficiencies are eliminated as custody of blocks change hands through the blockchain network members using the consensus method agreed upon [6, 17].

The consensus mechanism is an essential feature of a blockchain. It ensures that all members of a blockchain network or participants of a distributed ledger are in agreement and enables the network to keep functioning despite failure of some of its members. Simply, consensus mechanisms decide how blockchain works. The consensus protocol provides an official system of rules that ensure common, assured ordering of transactions and blocks and guarantees the integrity and consistency of the distributed ledger across geographically distributed nodes [5, 17].

Consensus attempts to ensure the inviolability of data recorded on the blockchain. It ensures that the blockchain functions correctly in normal as well as adversarial conditions. Consensus is the process by which network participants validate the blocks of transactions [9, 17, 19]. Service interruptions and faults in blockchain cannot be tolerated. There are many consensus approaches available in the market each targets different network requirements and fault tolerance models.

A blockchain network can take two forms either private/permissioned or public/permissionless. Public networks are open to any participant, and transactions are verified against the pre-existing rules of the network. All participant of the network can view transactions on the ledger, even if participants are anonymous. Private networks are restricted to participants within a given business network. Participants of a private blockchain are allowed to view only the transactions applicable to them and are able to add the data elements for which they are responsible for to the database as well as alter the data they provided, not the data elements submitted by the other participants. Accuracy of the data provided is ensured by cryptographic technologies [7].

Blockchain differs from traditional distributed databases in many ways. While distributed DBs are owned by a single entity, blockchain is owned by all participating parties in the chain. At the time, distributed DBs have a central operator when blockchain is operated by its participants who control who can join the network and gain access to blocks. Trust among parties in a traditional distributed DB is inclusive, however, in blockchain trust is not a factor.

So the question becomes 'why would we and when do we use blockchain while we can use traditional databases?' This basically depends on organizational intent. Firms that are interested in doing things with data within their own network using their computers and have full control, will be served best using traditional distributed DBs. However, Blockchain is an "append only" data structure [19]. Data added to a blockchain remains in the blockchain. Therefore, firms that are interested in highly available and immutable data, then the use of blockchain makes more sense.

3 The Promise of Blockchain

From the perspective of the trade supply chain, availing information about goods to all participating parties at the right time and place. For example, information about the provenance of goods, the terms of trade, the ownership of goods, the credit exchange data, tariff codes, classification data, import/export data, certificates, manifests, loading and unloading lists, customs values and status information is highly critical [13].

Distributed ledgers provide a secure and reliable ledger on which blocks are stored, validated, and managed. This is enabled by adhering to an applicable and efficient consensus protocol with three key properties [3, 10].

- Safety—If all participating nodes declare a block as valid per rules of the consensus protocol. This is also known as shared state consistency.
- Liveness—If active participating nodes produce a value then liveness is guaranteed.
- Fault Tolerance—The ability to recover from failure caused by faulty nodes.

Hardware or software crashes are faults where nodes stop responding and participating in the consensus protocol. This is referred to as Fail-stop faults. Another type of fault occurs as a result of a software bug or a node being compromised. This fault is referred to as Byzantine fault in which nodes behave erratically or provide ambivalent and misleading responses. Consensus protocols provide a level of assurance that consensus can still be reached in the presence of these types of faults and guarantees the nodes continue to operate.

The technology could help determine as well as prove ownership and source to help tackle fraud and theft problems. There are various other use-cases being considered, including letter of credit, cargo (bills of lading), gold and precious metal trading, Intellectual Property Rights—in fact, virtually any assets that can be exchanged digitally where there is either no existing formal register, or where the register is expensive to maintain or work with [14].

A range of consensus models are available today such as Proof-of-Work (PoW) and Practical Byzantine Fault Tolerance (PBFT) in its original form or flavors of it providing certain advantages desired over the original model. Additionally, new models continue to surface, such as Proof-of-Stake (PoS), Proof-of-elapsed-Time (PoeT) and different versions of PBFT appear as viable alternatives [9]. There different types of consensus for blockchain which are described below:

1. Proof-of-Work (PoW): The most commonly used consensus mechanism to create a distributed trustless consensus. Miners confirm the transactions by making lengthy trial and error computations until a consensus is reached to validate a transaction.
2. Practical Byzantine Fault Tolerance (PBFT): Another type of consensus mechanism that allows nodes to guarantee the validity of transactions within a blockchain network. Each node in the network publishes a public key. Then, messages are verified for correctness and signed by the node as they pass through. Consensus is reached on the validity of the message once there are enough identical responses. PBFT uses the replicated state machine concept and voting by replicas for state changes. It also provides capabilities like signing and encryption of messages exchanged between replicas and clients. This approach contributes to a reduction in the size and number of messages exchanged, and provides practical security in the face of Byzantine faults. It also imposes a low overhead on the performance of the replicated service. PBFT is reported to have a 3% overhead for a replicated network file system (NFS) service. However, only up to 20 replicas have been scaled and studies with PBFT. It's messaging overhead increases significantly as the number of replicas increase. No hashing power is required with PBFT consensus mechanism to validate transactions within a blockchain, this also means the need for high energy consumption and the risk of centralization is lower than in PoW-based blockchain networks.
3. Federated Byzantine Agreement: Another consensus mechanism is the federated Byzantine agreement (FBA). FBA assumes that participating nodes or parties know each other and can distinguish which ones are more important than others. The majority of important participating nodes must agree on the validity of transactions. Once enough important nodes verify a transaction, it's determined as valid.

There are two other variations of blockchain based platforms and payment protocols. Both are open-ended with respect to node participation. Additionally, both use variations of the BFT consensus. These typically target financial use cases and the payments domain in particular. These can settle cross-border transactions within seconds as compared to today's infrastructure which takes days to accomplish the same.

Certain blockchain implementations use consensus protocols that are mainly motivated by the type of applications they expect to provide and the foreseen threats to the integrity of the chain. The public/permissionless blockchains realize consensus

Table 1 A comparison of popular blockchain consensus mechanisms

	PoW	PoS	BFT and variants	Federated BFT
Blockchain type	Permissionless	Both	Permissioned	Permissionless
Token needed?	Yes	Yes	No	No
Scalability of peer network	High	High	Low	High
Trust	Untrusted	Untrusted	Semi-trusted	Semi-trusted
Tolerance	≤25%	Depends on algorithm used	≤33%	≤33%

among a very large number of untrusted participants in a robust manner using computational complexity while sacrificing transaction conclusiveness and throughput. Conversely, the private/permissioned consortium blockchains typically opt out for a less scalable but much higher throughput model that ensures faster transaction finality.

Therefore, to determine the right platform and consensus model (Table 1) to use a number of very important factors must be considered such as the scale of the intended network as well as the relationships between participants. Additionally, both functional and non-functional aspects (such as performance and confidentiality) must be factored in.

4 The Blockchain Impact on the Trade Supply Chain

Efficiency of trade procedures refers to the speed and ease with which cross-border business transactions are conducted with high degree of quality. Lowering supply chain barriers is critical in eliminating resource waste and reducing costs to trading firms, consumers and society.

Supply chain barriers can result from inefficient procedures, regulations and infrastructure services, among many others. The supply chain is a set of activities performed in producing and getting a product to consumers (Fig. 1). It spans the manufacturing process as well as transport and distribution services.

4.1 Consequences of Barriers to Trade

Supply chain barriers is a major burden for governments, businesses and the economy resulting in the following:

1. Greater operating cost and increased expenditures
2. Long and unpredictable formalities
3. Reduce volume of trade

Fig. 1 Buy-ship-pay model [18]

4. Increase risk.

Reducing operating costs remains the most frequently pursued goal. Consequently, companies incurring additional costs due to barriers may discover that it is no longer feasible to continue participating in a specific market and resort to reducing their volume of trade. Companies that suffer reduced volume usually see a rise in their production costs due to their inability to sustain and capture economies of scale [12].

Procedures, formalities and mechanisms that help simplify and standardize information flows related to the import and export of goods can help reduce or eliminate un-necessary steps and improve transparency. Countries that are interested in attracting investments need to essentially increase the speed at which and the reliability of movement of goods they import or export within their borders.

The economic impact is felt by many countries and action is required to ensure the current barriers do not impact their GDP. Authorities and businesses must immediately collaborate on effective ways and mechanisms to eliminate supply chain barriers and encourage participation of small and medium-sized enterprises.

Table 2 Actors and roles

Actor types	Description	Possible actors and roles
Customer	A party acquiring goods or services through trade	Buyer
		Consignee
		Payer
		Importer
Supplier	A party providing goods and services	Consignor
		Payee
		Seller
		Manufacturer
		Exporter
Authority	A statutory body who regulates trade and monitors compliance	Chamber of commerce
		Consular
		Customs
		Health
		Licensing
		Receiving authority (port authority)
Intermediary	A commercial party providing services within the international supply chain	Bank financial institution
		Broker
		Carrier
		Credit checking company
		Credit insurer
		Commission agent
		Export agent
		Freight forwarder
		Import agent
		Insurer
		Receiving authority

So how the trade supply chain being impacted? In international trade, there are potentially between 40 and 50 different actors involved. These commonly fall under 4 categories: Customer, Intermediary, Supplier and Authority (Table 2).

4.2 Parties and Information Flow in the Supply Chain

See Fig. 2.

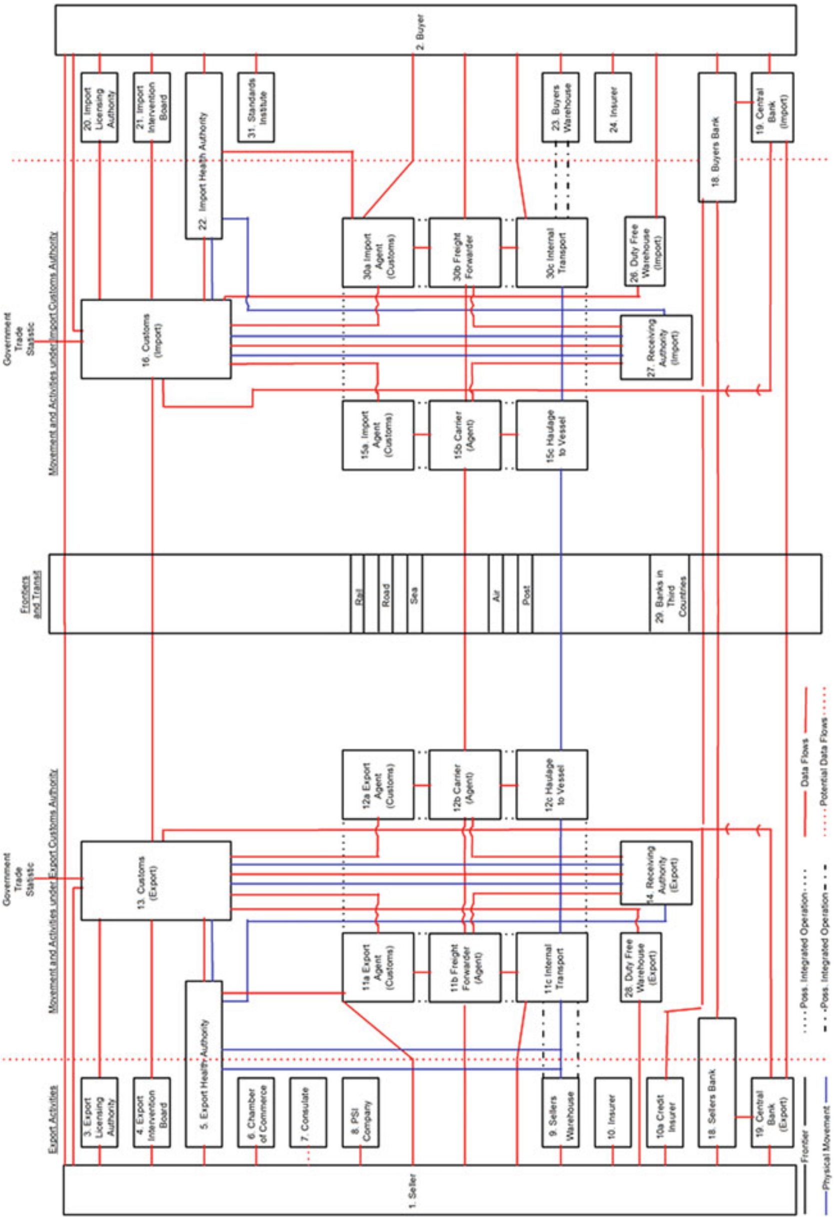

Fig. 2 Parties and information flow in the supply chain

4.3 Paperwork Processing

Global trade involves a lot of paperwork—costing time and money. In trade, the legal instrument which is as old as trade itself is called the Bill of Lading (BoL). A BoL is a legal document issued by the Carrier or agent of the Carrier and has three main attributes:

- Document of Title to the goods: possession of the BoL is equal to proof of legal rights of ownership of goods which can be transferred from one person to another merely by its delivery or endorsement
- Receipt—Provides evidence the Carrier has received the goods in compliance with the Commercial Contract between the parties
- Contract of Carriage—Evidence of the Contract of Carriage (CoC)—that the carrier will transport the goods in compliance with the Commercial Contract.

Paper-based freight documents like the bill of lading are susceptible to loss, tampering, and fraud. Additionally, Letter of Credit as a Financial Instrument is required if the Seller and Buyer do not have a trust relationship. When the goods are shipped using at least two different transportation modes, Letter of Credit will require a standard document which is the Bill of Lading to acknowledge receipt of Cargo. By providing the necessary transparency and consensus, the risk of documentary fraud can be mitigated resulting in the reduction of reconciliation transaction cost between and within the participating parties.

Paper-based Bill of Lading the standard document for trade are causing difficulties, costs, discrepancies and counterfeit products.

Counterfeit goods and products is a growing problem for parties of the supply chains. Counterfeits and pirated goods have a major impact on world market. It is estimated the imports of counterfeits are work half a trillion dollars a year amounting to 2.5% of global imports [15]. On the other hand, reports indicate that the counterfeit market today including online piracy generates returns of up to $600 billion annually. This amounts to $600 billion losses for businesses from across the world. This has major adverse influence on the sales and profits of firms as well as on revenue, security economy, health, safety and environment. This is a major concern for governments, businesses and consumers. Fake goods reaching consumers and markets are a global problem. Counterfeiting produces copies that endanger lives: faulty products or parts, medicines that make people sick, harmful toys, zero nourishment baby formula and instruments delivering false readings. Parties have to make sure authentic goods are sold and delivered to the consumers and can identify authentic products and avail to consumers where they can obtain them. Improving traceability of physical goods by creating an auditable and tamper-proof record of the journey behind all products across the supply chain. By preventing the selling of fake goods and counterfeits many benefits will be realized by businesses, society and the environment.

4.4 Origin Tracking

In the trade supply chain, identifying the origin of goods and products is a challenge for authorities. They have to get a quick and accurate information on where the goods originated or came from and which are affected and have to be removed from the stores. Failure in determining the origin of products is contributed to inefficient border procedures which lead to loss of revenue for governments and increased cases of smuggling. For example, the diamond trade market could potentially use blockchain for authenticity. Specific data about each diamond including its country of origin and the mine where it was recovered, is permanently recorded on a blockchain so it can be viewed by potential buyers who may want to check its credentials prior to completing a transaction. Goods Traceability within a blockchain platform could theoretically provide guarantees about the authenticity of products in the supply chain.

4.5 Smart Contracts

Smart contracts are computer code capable of handling the establishment and governance of the negotiation or execution of a contract using blockchain technology. The code expressing the smart contract defines the rules, terms, conditions and consequences in a similar fashion to traditional legal documents, with the stated obligations, penalties due to either party in different circumstances. The entire process of formalizing and executing a typical contract is automated which can be considered as a complement or substitution for legal contracts. Terms of the smart contract are a set of instructions recorded in a computer language.

In the trade supply chain any time goods or services are exchanged across borders authorities as well as other parties including banks deal with large volume of paper documents including Letter of Credit. The exporter's bank transfers payment to the importer's bank upon delivery of the goods to the buyer per the agreed terms. Using blockchain technology to process Letter of Credits can streamline the traditional manual processing nature of import/export documentation and reduce common errors to improve security.

Trade deals can then be conducted automatically through digital smart contracts once certain conditions are satisfied. Real-time visualization of data is availed to all participating parties. Having the possibility of self-executing (smart) contracts triggered by the efficient exchange of data, can potentially revolutionize the traditional Bill of Lading and Letter of Credit. The network allows both buyers and sellers to trace the letter of credit path and eliminates the chance of fraud and system errors. The banking sector sees this as a major shift in enhancing operations and user experience [1].

5 Approach and Challenges

How should firms approach blockchain? To start with, firms need to identify the most compelling and critical use cases by considering where blockchain might provide the highest value. Experiment with blockchain technology where the attributes will drive rapid impact. This can be achieved by starting with single-use applications to minimize risk because they involve little coordination with third parties. Testing out single-use applications will help firms develop and build the necessary skills they need for more-advanced applications. Ultimately, this should help them experiment with different approaches and practices to prepare them to tackle bigger more complex implementations that span multiple parties of the supply chain.

International trade has a long trail of paperwork associated with it [16]. For example, shipping goods from a manufacturing warehouse to a store in a different country requires stamps and approvals from around 30 people and organizations that must interact with each other on over 200 occasions.

Challenges with the current system can be summarized as following:

- Theft—BoL is a bearer document of title. This bears a particular risk that anyone who has possession of the BoL has a self-evident claim to the goods. Because possession equals ownership this creates an incentive for BoL theft.
- Fraud—Manipulation/alteration of BoL to hide accountability due to shipment damage or other issues.
- Inefficiency—BoL are issued as three original physical documents. One document is managed by the banks involved in trade finance. One document is couriered to the recipient of the goods. And one document is retained by the Carrier.
- Physicality—Delay in distribution of the BoLs. Due to the originals only existing in a physical form, this means that the Carrier has to courier one of the originals to the Consignee. This leads to a situation where the goods have arrived at a Discharge port but that the Consignee has not received their BoL.
- Amendments—Making amendments to a BoL are complicated. All three BoLs have to be sent to the Carrier who destroys them then issues a new set of BoLs with the intended amendments.

Taken together, the cost of the trade-related paperwork processing is estimated to be between 15 and 50% of the costs of the physical transport. To tackle such process inefficiencies and digitize paper records, a blockchain solution is required as means to connect the vast global network of shippers, carriers, ports, and customs.

The Blockchain technology offers a potential medium to exchange financial and non-financial data without intermediaries, and the immutable nature of the blocks eliminate fraud. This technological advance can potentially address operational risk by providing the necessary transparency, thus significantly helping all parties reduce their operational costs.

The success of a blockchain implementations, is grounded on two foundational concepts: data immutability and the distributed nature of how data is assembled. That includes everything from bills of lading to shipping instructions, customs documentation, even letters of credit for suppliers in foreign countries.

6 Discussion

Any successful shift to blockchain relies on clarity of roles, proper governance and the effective monitoring of implementation and objectives. Proper management of the network across parties is an example of the importance of cross-party coordination. Successful implementation requires public/private sector partnership.

Many organizations contribute to border management procedures, and activities. Any plans for blockchain implementation should be handled in incremental stages, starting with the most immediate impact. This will require establishing a shared understanding of business intent and how each party will participate and contributes to it. Furthermore, determining which tasks contribute to security and which contribute to trade facilitation must be identified early on.

The role of government is to sponsor and organize this initiative and through proper governance can help bridge the gap between the various parties in the trade supply chain. Although, the potential of blockchain seems to be great for the trade supply chain, it appears that the technology has not matured enough to be used by governments. Many areas of concern are still in experimentation mode and are not suitable for large scale deployment. Some of these concerns are platform throughput, identity management, cross-chain consensus, and security. This doesn't mean governments and organizations should not be involved with blockchain. Instead, it is recommended to keep a close eye on the technology and build the readiness to respond to this anticipated market change.

7 Future Prospects

There has been growing use and application of blockchain technologies across a number of industries and sectors around the globe. This includes the financial services sector, government services and supply chain management. Interest and confidence in the technology is also gradually growing. The development of International Standards to support privacy, security, identity, smart contract, governance and other matters may contribute to further establishing market confidence to ensure proper roll out of the technology.

The aim of establishing standards is to provide strategic insight:

- Early identification of the different technical issues concerning the development, governance and utilization of blockchain and distributed ledgers;
- Discovery of the various blockchain and distributed ledgers use-cases relevant to stakeholders of each industry and sector and assess the need for standards to support the specific use-cases;
- Consider the role of standards in supporting potential future regulation on blockchain and the relationship between the law and standards; and
- Consider the pathways and structures that can be utilized to undertake the development of International Standards for blockchain.

8 Conclusion

Trade facilitation, is the desire of all nations competing in the trade supply chain. Facilitation is centered around simplifying and harmonizing trade procedures. The goal is to establish clear and precise standards that provides a high level of confidence, reliability, predictability, efficiency and security of goods and people accompanying across international borders. It puts a major emphasis on enhancing trade procedures, practices, activities and formalities involved in collecting, handling, presenting, publishing and processing data required for the movement of goods throughout the international trade supply chain. The burden of complying with regulatory controls, despite increased political pressures, can be significantly reduced by encouraging trade facilitation and adopting supply chain management principles.

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Knowledge Influence on Innovation

Hussam Juma

Abstract Innovation has become part of the national identity and self-image of countries and businesses. Nations that bring to market successful innovations will be able to compete in the global market over the coming decade. The aim of this study is to show that nations that invest in their talent base will have a stronger chance of competing in the world economy. They have a greater potential of successfully transforming their society and economy in innovative ways. The present study follows a case study approach that employs qualitative data. This approach uses interviews to gain insights on users' perception regarding the direct influence of knowledge acquisition, creation on research, development, and thus the potential for innovation. This correlation will facilitate organizational innovation and consequently improve competitiveness to a great extent. There is a plethora of activities supporting the relationship between knowledge and innovation. Nations have been competing over the talents that can potentially give them an extra edge. The tacit knowledge these individuals possess is considered the economy of the future. The manner in which nations and organizations will manage and utilize this critical resource will greatly influence their growth potential and competitive advantage. The building blocks of this model are based on the efficiency of intellectual capital. This factor creates the needed knowledge and conducts quality research. The results of this consorted effort is innovative outcomes, which realize the goal of gaining competitive advantage. If these components are looked at strategically, examined properly and managed effectively they will hold the key to future prosperity.

Keywords Knowledge · Talent · Competitive advantage · Knowledge economy · Innovation · Research & development

1 Introduction

World economies today are competing based on information and knowledge. Knowledge in advanced economies over the last few years has been recognized as a key

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driver of competitive advantage and economic growth. With the growing sense of the importance of knowledge, the public and private sectors are becoming more dependent on the creation, acquisition and production as well as the distribution and use of knowledge than ever before. The knowledge production and consumption in some countries has been a source of critical foreign direct investment. By tapping into the talent of local human capital and facilities, countries are able to turn this knowledge into economic viability.

The aim of this study is to determine relations between knowledge management, research and development, and organizational innovation in driving competitive advantage. The goal is to show the direct influence of knowledge acquisition on research and development and thus the potential for innovation. Knowledge a key driver of the emerging knowledge economy with an overall aim to increase competitiveness and accelerate growth. Innovation has become a critical part of the national identity of countries and self-image of businesses. Nations that bring to market successful innovations will be able to compete in the global market over the coming decade. This natural correlation will facilitate organizational innovation and consequently improve competitiveness to a great extent.

The knowledge frontier involves combining disparate ideas or existing knowledge into novel ideas and innovations that impact or disrupt major industries and/or societies [13]. By obtaining and fusing knowledge across different areas and domains radical ideas are generated. Creating or acquiring, then sharing the right knowledge at the right time provides the foundation for proper Research and Development (R&D). The creation of knowledge is a recognizable method of formal R&D which is knowledge-intensive and aims to solve technical problems and produce innovative solutions.

R&D will typically come in different forms, some of which are:

- Centers of Excellence (CoE)
- X-Works Teams
- Partnerships.

Centers of Excellence exist to either raise maturity of companies and industries or facilitate adoption of new technologies and practices. They are managed by teams of Subject Matter Experts and serve as the primary repository of knowledge and know-how within organizations.

X-Works R&D is focused on radical breakthroughs whose objective is take businesses, industries or societies to the next level. This type of R&D typically involves thinking very broadly about the future and introduce completely new and disruptive offerings as well as novel business models. It may include a variety of User Research, Design Research, and human-centric business prototyping labs.

Partnerships involve engaging other focused research or engineering specialists for the purpose of expanding someone's own capabilities. They provide resources with special skills and competencies beyond those possessed by an organization.

This paper is organized as follows. Section 2 presents the economic value of knowledge in general along with a brief of the Knowledge Economy, Innovation and Talent. Section 3 introduces the methods, which are being used in today's market to compete for talent. Through a set of interview questions, Sect. 4 describes how the innovation is being handled at the public-sector level. In Sect. 5 we analyse the data collected to determine the state and focus of innovation. A brief discussion to raise the focus on knowledge management is discussed in Sect. 6. Finally, we make a brief conclusion for this paper in Sect. 7.

2 Literature Review

2.1 The Knowledge Economy

In the knowledge economy, the production of goods and services is based upon knowledge-intensive activities. Economic growth is a result of knowledge-intensive activities, which involve the collection, analysis, and synthesis of information.

A commitment to the continuous learning and to increase skills and expertise, which will foster innovation, ensures success in a knowledge economy. Knowledge being at the epicenter of national innovation, it is the foundation that steers research and development in the right direction. Further, it aims to influence idea development on international, regional and local level by mainstreaming new knowledge and best practice into the innovation making process. For these obvious reasons, knowledge is considered the catalytic agent and nerve in modern economies [13].

As innovation is on the national agenda of every country around the globe, it is mandatory to begin with leveraging the knowledge power of the local resources. Whether this power comes from individuals, academia or research firms, innovation starts with establishing the basic level of know-how for various industries and practices. Governments and businesses are the parties responsible for harnessing the national talent pool to establish a solid base for knowledge creation and sharing. Innovation programs and initiatives must form a close alliance to raise the potential and value from their practices [4].

Building a broad and cohesive knowledgebase is a major asset of knowledge management practices. Innovation consumes this knowledge to develop new knowledge that translates into innovations. Consequently, these innovations contribute to economic development and drive competitive advantage.

2.2 Factors of Innovation

Innovation is about doing something in a new or novel way that delivers more value and/or better experiences to customers and markets in a way that is profitable to the business/organization. Innovation is a process that produces novel ideas that affect society [8].

Economic growth thrives in an environment that is conducive to innovative drive, thinking and activities. Quality research resulting from R&D activities generates the basic knowledge needed to deliver new value. These factors are so critical for sustainable growth into the future. The outcome and value of research and innovation efforts are enhanced or inhibited by the level of funding allocated and the access to knowledge and talent [14].

To address these challenges businesses and organizations must constantly strive to reconnect to their markets and customers in increasingly more meaningful ways.

2.3 Human Capital Global Competition

The value of human capital is generally recognized as a necessary investment in both the public and private sectors. The growth in the demand for talent and knowledge skills has put a premium on high-quality knowledge and skills. Governments are carefully studying how to engage the talent pool around the globe. This has forced some governments to change a number of policies and practices to maintain a sufficient stock of talent and skilled workers. In fact, the competition for talent and research capabilities is becoming fiercer as the demand increases.

Countries and businesses mainly in advanced economies are altering the landscape of their local talent by importing foreign skills to their local market. Recognizing the skill gaps and sustainability needs in their local market has led them to provide incentives to lure external knowledge capacities. Immigration has been one of the tools countries use to reduce the knowledge gap in addition to offering lucrative pay packages. The goal is to seek knowledge assets from countries that have a wealth of talent. At the same time, this has introduced a problem to talent exporting countries. The departure of talent limits domestic access to the country's best and brightest human capital, hindering the progress of innovation efforts. This migration of talent has forced countries with limited knowledge pool to come up with ways to entice their knowledge assets to remain and protect their talent pool from depletion [3].

Governments in some parts of the world have put programs to polish their workforce and improve R&D performance by dispatching their citizens to advanced foreign countries to seek advanced education and research experience. This offers citizens exposure to top practices and standards in specific domains and industries. On their return to the home country they are given top positions that can reshape the traditions and propel the economy to the top tier of competitiveness [2].

On other occasions governments and businesses in some countries establish alliances with foreign counterparts to increase their competitive advantage without the need disrupting each other's talent pool. Both parties are able to build the required knowledge and innovate with the goal to have mutual benefits.

These methods have proven their value on many occasions and the economic returns are evident in various countries and industries around the world. This drive toward maintaining a stack of talent and high-end knowledge seems to be paying off. Countries have been seeing progress and potential can be credited to the increasing

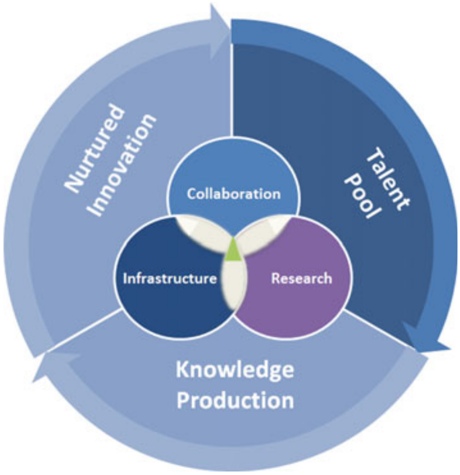

Fig. 1 Innovation model

productivity and performance of the maintained talent (see Fig. 1). Sustaining an adequate pool of qualified, knowledgeable and experienced individuals provides countries and businesses a leading edge. Attaining a lead role in the research arena to enhance R&D efficiency and improve prospects for the commercialization of new knowledge is the economical means of today's economy.

Investing in the knowledge power increases the potential of driving innovations that change the way societies act and interact. It's therefore essential to truly recognize knowledge as a strategic vehicle of innovation and thus economic sustainability. It is an integral part of the modern economy and should be considered a fixed investment with long-term benefits (see Fig. 2).

3 Methodology

Many countries are feeling the economic impact and are taking steps to ensure the current knowledge and talent challenges do not impact their Gross Domestic Product (GDP). Public and private sector collaboration on ways to eliminate these challenges is required (Fig. 3).

An important determinant of long-term success and prosperity is driven by how nations develop their human capital. The knowledge and skills people possess enable them to create the desired value. This knowledge plays an implicit role in research and development. It conveys a human-centric vision that recognizes people's knowledge, talents and skills as key drivers of a thriving and inclusive economy.

Knowledge management is an essential contributor to innovation and sustainability through effective focus on knowledge acquisition, use and reconfiguration. Knowledge is the base for realizing the power to respond to the fast changing needs of the market and society [5, 9]. Gaining insight into what techniques and vehicles

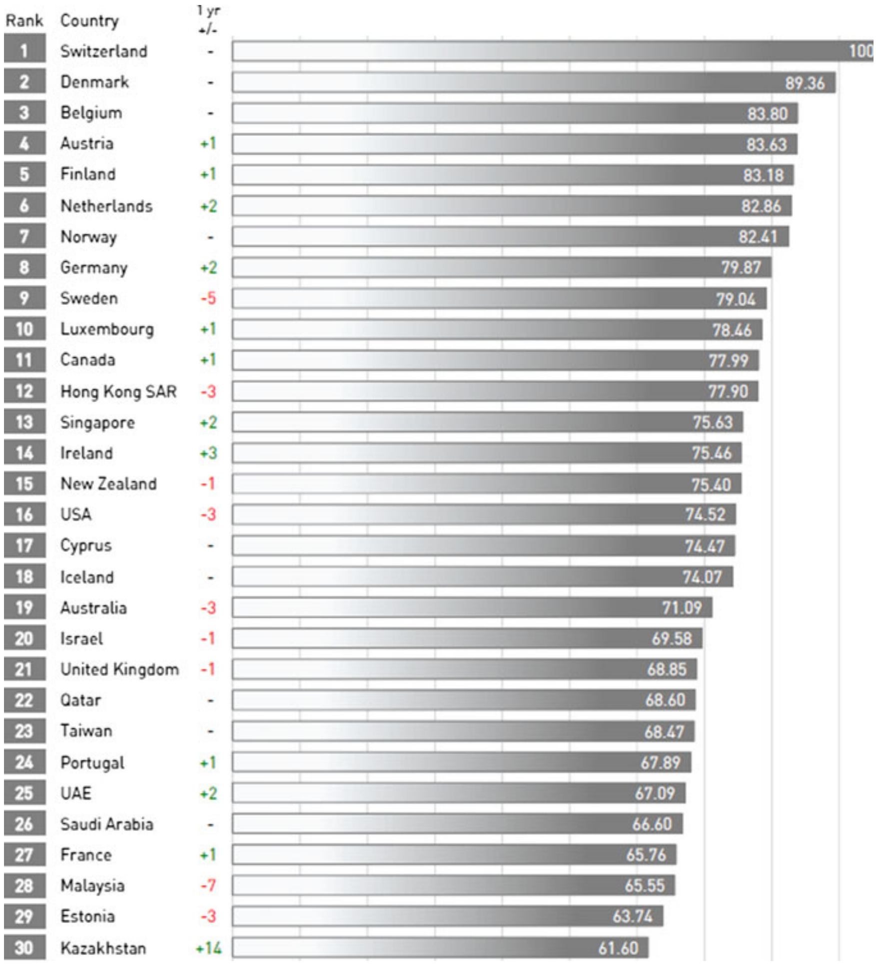

Fig. 2 IMD world talent ranking [6]

ensure relevance and resilience is critical in today's economy. The following research questions frame the research study:

1 How can businesses become innovative?
2 How does the human factor contribute to innovation?
3 Why some businesses are more innovative than others?

These questions are an attempt to understand what are the key drivers of innovation that put governments and businesses on the leaders' board. These questions will help determine how public and private sectors are increasing their value and what components they depend on to build up an engine of innovation.

Global Reach
European countries still dominate the worldwide competition for talent

	2017 Ranking	2015/16 Ranking
Switzerland	1	1
Singapore	2	2
United Kingdom	3	7
U.S.	4	4
Sweden	5	6
Australia	6	13
Luxembourg	7	3
Denmark	8	5
Finland	9	10
Norway	10	8

Source: GTCI Bloomberg

Fig. 3 IMD world talent ranking—global reach [6]

4 The Interview

To ensure interviewees are clear on the objective of the interview process. Questions were formulated in a way that allows freedom of responses. The participants are selected from the public sector with relative function in the innovation and other related practices. The intent is to understand how government organizations interpret and realize innovations.

4.1 Interview Protocol

Multiple parties with diverse backgrounds were selected for the interview. Following a thorough examination of the relevant literature, a pilot interview was conducted to shape the interview to ensure clarity and reduce ambiguity. The interviews were carried out using simple and clear questions giving participants to elaborate as much as they like.

10 interviews were conducted with individuals holding a role in a public sector organizations. Members of the innovation team, knowledge team, enterprise architecture team and the reform and modernization were interviewed as they are responsible for key decisions pertaining to how innovation is promoted in public sector organizations. Confidentiality and anonymity was assured to all participants. The interviews

analysis resulted in a more thorough understanding of how innovation is pursued and managed.

The interviews were structured to gain insight into the following areas:

1 Understanding and requirements of innovation
2 Successful Innovation Influencers
3 Challenges and barriers to innovation
4 Characteristics of innovators.

4.2 Interview Questions

4.2.1 How Can Businesses Become More Innovative?

By merely improving business conduct is not sufficient to meet the needs, demands and aspirations of a strong and competitive economy. Being innovative means resolving problems by finding new strategic approaches instead of traditional ones. Viable success depends upon operating business in novel value-creating ways. Success with innovation depends on having flexible and multidisciplinary skills to respond to the changing market needs [1]. Having the ability to harness, capture and generate sufficient amount of knowledge and experience globally and combine them in smart ways that create value [7].

Public and private sector organizations must invest in building adequate innovation infrastructure and vehicles to compete in today's economy. Innovation needs more than small donations to survive and create a strong and competitive self –image for a sustainable economy [10]. This investment starts with the intellectual capital that creates the desired value. Knowledgeable, skilled and talented assets yield the strongest dividend and maximize economic wealth [12].

To identify how businesses determine critical factors for ensuring innovativeness we conducted a number of interviews with market practitioners. The interviewees held various positions including reform and modernization, innovation, enterprise architecture and strategic planning.

4.2.2 How Does the Human Factor Contribute to Innovation?

Innovation is the driver of economic growth. Nations are forced to focus on and foster innovation to gain competitive advantage. Embracing innovation helps lower unemployment, increase economic performance and citizens prosperity.

A poorly educated society is a chief factor holding back innovation. This type of society typically imitates innovative societies but can't compete with them. They are simply followers of innovation produced elsewhere. The human factor in innovation is about more than just the number of university graduates. A well-educated society is a prime potential for new innovations.

Well-educated individuals are relatively scarce and they typically tend to their home base in more advanced countries that foster innovation. United States, Canada, Western Europe and the Arabian Gulf countries are the most popular destinations for skilled people most commonly from China and India. Countries with the most influx tend to value knowledge, experience and talent of individuals and have well-designed programs to exploit these skilled minds for economic advancement.

4.2.3 Why Some Businesses Are More Innovative Than Others?

Components and factors that have significant influence on innovation relate to intellectual capacity and the environment in which they live in. In particular, educational attainment from well-known educational institutions tend to weigh in on the level of knowledge acquisition and production as well as shaping the creative thinking of individuals. Furthermore, individuals residing in countries that are close to or operating in countries with economic stability and entrepreneurial spirit are more likely to engage in innovative business ideas.

5 Analysis

In the interview process conducted it became evident that a number of key factors are considered critical to innovation. Respondents indicated that leadership, environment and culture on one hand are of great importance:

Leadership support for innovation culture can overcome the slow adoption of innovation. Leadership nurtures creativity and drive more effective innovation.

Others viewed learning, education; knowledge and talent are the key ingredients of innovation:

Good education and training lead to an increase in organizational excellence, by equipping employees with greater skills and knowledge.

The results of the interview show clear consensus that knowledge and talent are the most critical factors for innovation.

Having organization knowledge base, data analytics tools, experienced staff, and a leadership that supports innovation (Table 1).

The results lead us to comprehend the necessity of having a sufficient knowledge-driven, skilled workforce and talented individuals as the cornerstone of innovation (Fig. 4).

6 Discussion

An innovative knowledge-driven economy mandates a strong workforce with high levels of science and engineering skills and an education system that can prepare

Table 1 Innovation factors importance

Factors	Criticality (%)	Repetitiveness (%)
Leadership	15	10
Environment	35	10
Culture	35	20
Education	80	40
Training	80	40
Knowledge	100	100
Talent	100	100

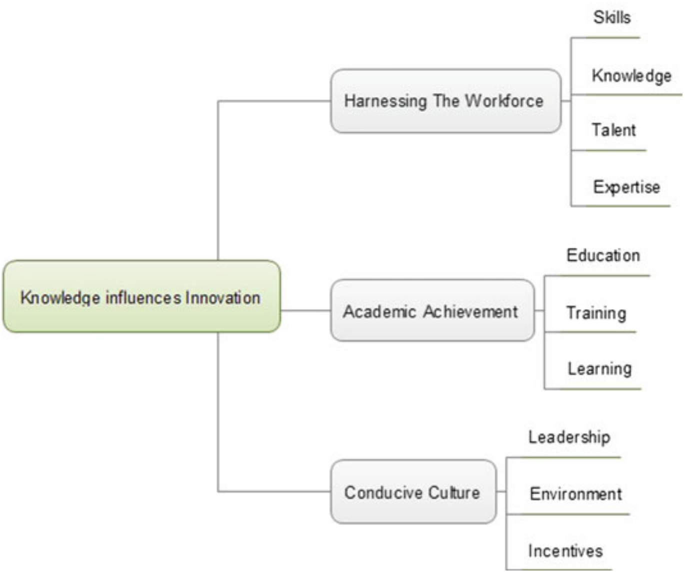

Fig. 4 Categories of research

and produce these workers in sufficient numbers. Both governments and businesses must work together to provide workers with the necessary skills and qualifications to compete in this era.

Knowledge being the primary factor in problem solving, knowledge-driven individuals can solve challenges and solve problems faster and easier. They have the ability to deliver new insights, valuable solutions and novel ideas. They can alter or shape new perspectives that lead to innovative solutions.

7 Conclusion

Knowledge, skills and talent affect the propensity of individuals to become innovative and the likelihood of their success. Evidence points to the importance of these skills for innovative economies. These competencies are closely related to skilled labor, migration and attitudes toward entrepreneurship. Suitable education programs to help develop innovative mindsets and company training in innovation skills are considered critical.

Knowledge is the essence of a global public good. It is normally consumed everywhere and by everyone and is not diminished by use-indeed it may grow with use. It can also be transferred to anybody instantly. It can provide the basis for major contributions to the innovation process and to economic growth.

Nations that invest in their talent base will have a stronger chance of competing in the world economy. They have a greater potential of successfully transforming their society and economy in innovative ways. The world has shifted focus from an industrial economy dependent on hands, to a knowledge economy dependent on heads with innovative knowledge-driven skills.

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Digital Speedway to Future Smart Cities

Hussam Juma

Abstract The world is experiencing huge digital transformation, whether by choice or due to internal and external influences. It is inevitable for citizens and equally for public and private sector to react and respond to this shift. Building on this mandate, the governments are instituting smart cities to maximize the use of advanced technologies as backbone for delivering services that are interconnected, viable, sustainable, scalable, secure, smart and meet the expectation of humans. In this paper, we discuss proposals that present various smart city models in practice across the globe. This paper also describes a holistic approach that fosters collaboration among future smart city governments, academia and industries to innovate smart city services.

Keywords Blockchain · Distributed ledger · Trade supply chain

1 Introduction

Rapid advancements in the field of information technology such as big data, Internet of Things (IoT), Artificial Intelligence, Blockchain, Robotics, UAVs, Self-driving Vehicles, 3D and 4D Printing, Augmented, Virtual and Mixed Reality have impacted governments, industries and societies in numerous ways. New avenues have been unlocked, and old ones have diminished. These technologically driven automations have changed the way we produce and consume resources. The pace is so rapid that in order to meet the demand of the future cities software engineering practices have to be adapted and made more competitive with this speed of innovation. Software engineering with its remarkable achievements is still relatively younger discipline than other branches of engineering, nonetheless it has been at the forefront of new modern world as we know today, and certainly is going to define and lead the future of the smart cities and enhance the lives of its citizens.

Smart city is a city where information and communication-based solutions are employed along with infrastructure and architecture, where things and societies are

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interconnected to address social, economic, civics and environmental problems in a cost efficient and optimised manner [1]. The concept of smart city is not new, governments have always pursued to implement smart city models across the developed world. From fiction movies to more realistic models have been thought of and proposed, before this latest profound progress in information technology it looked mostly a fantasy. But now it's obvious that we are close to realising this fantasy, it has become an imminent need and governments and industry has shown quite an interest towards achieving this. The technology available today have made it feasible to develop the required infrastructure, solutions and services enabling the future vision of smart city [2].

This study will look at main aspects of the impact of smart cities on various facets of society. In addition, we clearly present the challenges and the proposals with detailed research direction. The paper is organised as followed: Sect. 2 presents the Literature Review covering the technological elements of future smart cities with a focus on the role of for Governments, Academia and Industry. Then a discussion of the potential of big data and impact on smart cities and various facets of society and the envisaged challenges in Sect. 3. Section 4 provides a brief conclusion and future prospects for this paper.

2 Literature Review

The world population is expected to reach 9.8 billion by year 2050 [3]. Most of the population of the world is concentrated in the cities, this move from rural to urban areas is driven by rapid urbanisation, industrialisation in the past few years, and this trend will continue further. Another factor is the natural human desire to have access to better health, education, job opportunities and improved living conditions. The cities infrastructures and resources need to scale in order to meet this growing demand, the governments, city planners and researches therefore need to respond by employing innovative smart city models where energy, water and other natural resources are used efficiently with minimal and controlled impact on environment while providing enhanced health, educational, civic and security services to its citizens. Governments that are at the technological forefront around the world have initiated smart city projects and are working in collaboration with industry leaders, academic researchers, technology experts, city planners, environmentalists and security experts to share their knowledge, develop a holistic smart city framework and standardise the policies, strategies, governance structure, and future roadmap of smart cities. US, Japan, Singapore, Germany, Netherlands are leading the way while many countries in Europe, Middle east and South Asia have initiated smart city projects recently. The smart city infrastructures require sophisticated networks, IoT, cloud computing, energy grids, and big data technologies to automate and improve the services across various domains directly or indirectly impacting citizens. Figure 1 shows the topics of interest in smart city projects across the world.

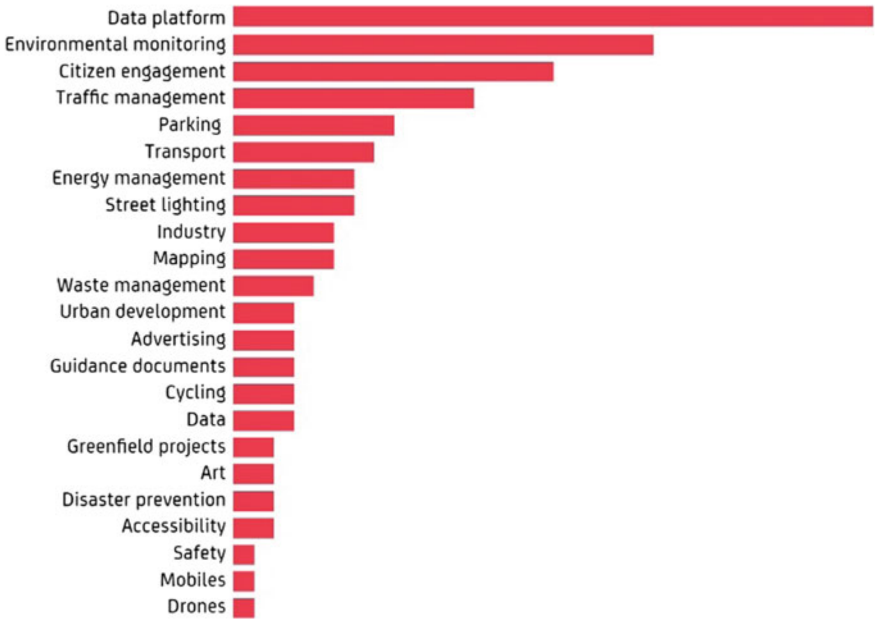

Fig. 1 Smart city projects (topics of interest)

For better use of resources across the cities and optimise them based on patterns of usage smart devices and sensors have to be connected through networks (IoT) and sharing data in real time and in batches, this data is massive and need special storage and processing capabilities, Mckinsey Global Institute estimates that the data volumes are expected to grow 2X every three years, big data solutions are the key to solve these challenges. There are three main objectives of smart cities, including optimised production and management of energy resources, and innovative economic and business models leveraging technology for service delivery, efficient operation and energy consumptions [1]. Smart cities can provide multiple benefits to its citizens in purview of the following areas:

Safety and security by employing surveillance cameras integrated with command and control centers, efficient emergency response centers accessible through smart communication channels. Transportation and traffic management through the use of smart integrated traffic lights and with central traffic management solutions. Energy management using smart metering solutions. Educational infrastructure using smart technologies. And the most important benefit is citizens' health and wellbeing by exploiting new technologies like implantable sensors and other smart health monitoring devices connected with smart phones and health services providers to receive basic and advanced health related metrics and respond swiftly in case of emergency and proactively in case of future risks, even propose life style changes by analysing daily patterns of activity. Figure 2 shows the smart city model proposed by U.S National Institute of Standards and Technologies. Such a model has to be supported

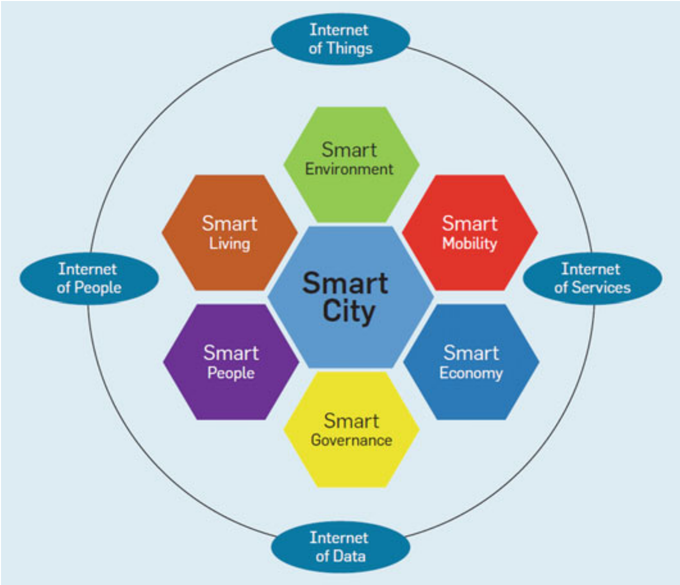

Fig. 2 Smart model (U.S National Institute of Standards and Technologies)

by elementary architectural components such as broadband infrastructure to connect all components and services together for intercommunication that form the basis of IoT and smart services making use of big data.

An efficient and sustainable infrastructure spanning across essential domains (energy, transport, architecture and information technology) is mandatory for any smart city. Among other essential components such as IoT, cloud computing, service-oriented architectures, networking, cyber security architectures, big data has a vital role in smart cities. Tens of thousands of sensors and devices producing humongous data cannot be processed without employing big data solutions.

Awad et al. [4], have researched on global smart cities programs and have particularly conscripted the smart city initiatives in the GCC member states. They argued that factors like lavish life-style, tax-free and peaceful environment in the region have resulted in influx from other countries causing challenges like housing, traffic congestion, natural resource scarcity, and high energy resources consumption. To overcome these concerns and support this growth the governments of Saudi Arabia, UAE, Kuwait and Qatar have initiated smart city projects. The authors analysed smart city models proposed by European Commission, see Fig. 3. The model is built around information technology solutions integrated across vertical and horizontal industries, service providers and municipality encompassing the city management processes. Data from various layers and IoT components takes the center stage in the smart city solutions.

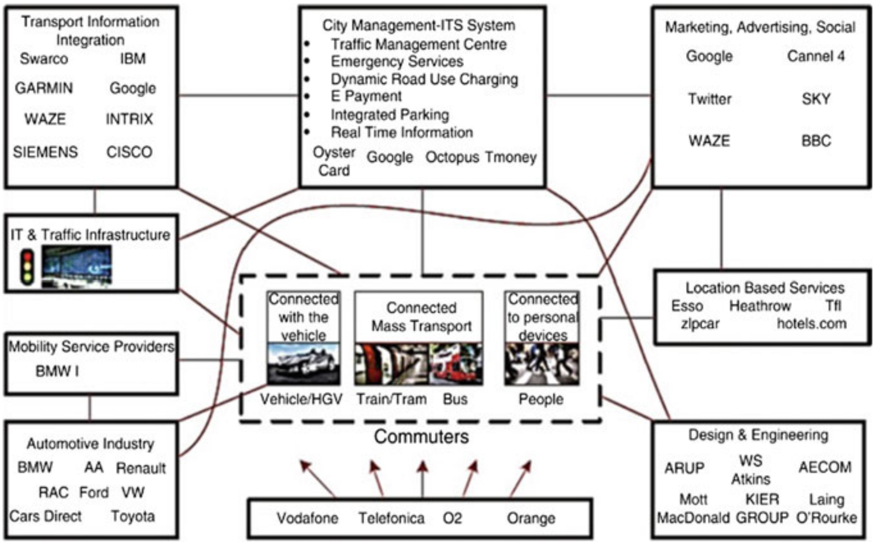

Fig. 3 Smart city management model in the UK

The study also describes models for developed and developing countries proposed by United Nations Economic Commission for Europe (UNECE). These models likewise other smart city models around the globe give emphasis to ICT based solutions. ICT solutions are crucial for the successful operations of the city. One interesting factor though in their model is the focus on reducing poverty and improving economic conditions by encouraging budding policies for business and respective technology infrastructure. Similarly, another key factor is the collaborative research by public and private sector to develop innovative solutions to solve urbanisation problems. However, the smart city model by UNECE does not addresses security comprehensively which is important element of smart city models. Smart city initiatives in GCC [4] are also commencing by government at a rapid pace. UAE among these is quite ambitious in transforming its cities into smart cities. It has launched Smart Dubai program and various strategies to support its future smart cities plan. Dubai Smart City program focuses on 3 areas of impact, i.e. Customer, Financial, Resources and Infrastructure, the program is unique from the other smart city initiatives across the globe as it focuses more on happiness of citizens than any other aspect of the model, see Fig. 4.

Through launching series of programs with aggressive timelines to achieve their objectives, the government plans to make Dubai a smart city by 2021 [5]. The smart city plan has six strategic themes to make Dubai the smartest city on earth [6], these themes are depicted in Fig. 5. The government is investing in its ICT infrastructure to enable services centered around its citizens, use of emerging technologies, like IoT, big data, and autonomous vehicles for public transportation. Focus on customer experience of services and products offered by smart city creates sense of happiness

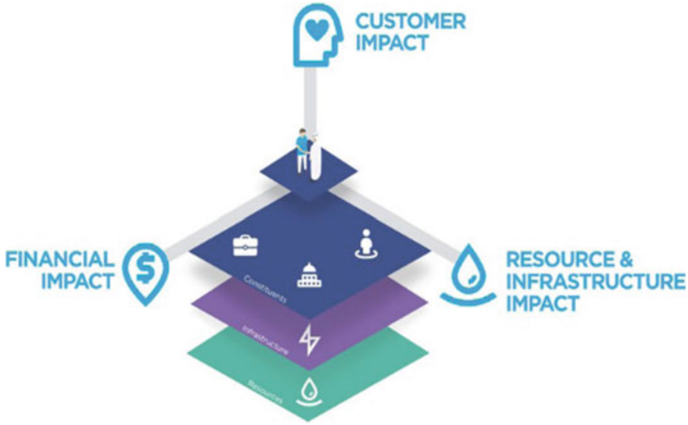

Fig. 4 Impact areas of smart Dubai plan

Fig. 5 Strategic themes of smart Dubai program

and satisfaction. Smart cities need to continuously identify expectations of smart citizens keeping in view the overall impact on economy. Efficient technological and city infrastructure requires exploitation of new trends and emerging technologies to deliver services.

Importance of data analysis is becoming critical as the basis of automation and smart decision management. Data and analytics are changing the rules of competition, new disruptive business models are being formed on the basis of new data insights—detailed in a report by McKinsey Global Institute (MGI) [7]. The report focuses on criticality of data analytics and its role in future world. The future systems employing machine learning will depend heavily on data collected from large numbers of heterogeneous sources, process them at scale, and will make decisions thus increasing productivity, efficiency in operations and quality of decisions. According to McKinsey US and EU's public and health sectors have only used 10–20% of the potential of data though they could have saved €250 billion had they used the full potential. They claim that there will be a potential impact of up-to $2.5 trillion on economy across various sectors due to the mobility services like ride-sharing, and car sharing by 2030. This reveals the impact of big data on smart cities and domains that directly or indirectly related to smart cities models being operated or initiated across the world. Smart cities need innovative solutions to bring the benefits to corporates, SMEs, individuals and governments alike. Big data and analytics can bring this innovation by looking at data insights from different perspectives, it can help in identifying new market opportunities, it can reveal information about performance, skill shortage, aid scientific research in crunching massive data volumes to reach new findings and hypothesis, can adopt the utilisation of energy and natural resources like water based on the data of real usage from sensors, help in medical diagnosis based on analysis of millions of patients records in lot less time a human or a team of humans can do, can avoid possible machine/hardware failures before they occur by analysing the information generated from sensors, can help security agencies in identifying criminals by face recognition or even predict their possible crimes by analysing their behavior. Segments across industries and governments are expected to have disruptions [7] in these segments, this will transform the way they operate and interface with citizens and among each other. Operating models of smart cities and infrastructure, health care, transport and logistics, education, public sector are among the to-be disrupted segments in future due to the use of huge potential of big data for risk management and operational efficiency.

For better use of resources across the cities and optimise them based on patterns of usage smart devices and sensors have to be connected through networks (IoT) and sharing data in real time and in batches, this data is massive and need special storage and processing capabilities, Mckinsey Global Institute estimates that the data volumes are expected to grow 2X every three years, big data solutions are the key to solve these challenge [8]. There are some major challenges for developing smart cities; the cost and continuous investment to operate them in developing supporting infrastructure and solutions is enormous and particularly in these turbulent financial times it is difficult to allocate huge budgets for such ambitious projects. Availability of Smart services and citizens' involvement is also a challenge, citizens need to be connected to their homes, transport system, security systems with government and be able to communicate effectively while keeping the social elements of the society intact. Cyber security and related policies is imperative for this. Any breach of security can impact the whole system and citizens. Continuous monitoring and surveillance of data to analyse citizens' behavior can raise privacy [9] concerns for the citizens. Confidentiality of information, governance and respective policy frameworks and tools without impacting the citizens experience is essential for the smart cities success.

More research is required for standardising IoT and communication protocols that are reliable, secure and efficient. Big data needs special management and there is lot of research opportunities exist on how to process, analyse and store this data efficiently and cost effectively. Researches and successful implementations from companies like Google, Facebook and Yahoo have shown great advancements in developing and promoting big data. Google File System, Hadoop and MapReduce are some examples. The variety of information sources with heterogenous formats and volume makes it difficult to manage big data and challenging to analyse it. It's an iterative process and requires planning and design to get the real value of that data and understand the patterns of information and anomalies that can be used for decision making and planning for smart city [10] .

3 Discussion

Current researches and studies have identified the core elements of the smart cities with broadband network, infrastructure, big data and IoT at its core; the benefits and challenges. This study will predict the state of future smart cities, their impacts and challenges. Future smart cities will not have many of the challenges as of smart cities of today. Social, economic, technical, and environmental factors will determine the future of smart cities. Technology has been at the forefront for automating human tasks in the past, the role of technology will grow exponentially in human development. It is projected that 70% of the world's population in 2050 will be living in metropolitan cities and suburbs [11]. hence more strain on the municipalities to provide services in an efficient and inexpensive way. The cities of future will be using state-of-the-art technology coupled with high speed network infrastructure central to the city connecting things with things, things with humans. Such IoT generating massive amount of data in real-time will need big data analytics to store, process and understand the meaning of this information in order to predict the future needs and take smarter decisions for optimising and planning resources for citizens. In the following text this study predicts the state of the future smart cities assuming IoT and big data at its core [12].

Automation will increase productivity to many folds, autonomous cars and self-driving vehicles will be the norm of the life. There will be no need for traffic lights, cars will be connected to central traffic management system and will be aware of their surroundings and things, even the roads, and other vehicles on the road. People will fly in autonomous drones, as the drones will be a common mode of travelling short to medium distances. Drones will deliver the food and medicines around the metropolis. In emergency and disaster situations, services in remote areas will be facilitated using drones. There will be fully automated grocery shops, avoiding the hassle of queuing up. Almost all the payments will be made through NFC chips, smart phones, or even bionic chips installed in humans. Businessmen will have meetings in virtual world using virtual reality tech. The succeeding subsections highlights some specific future characteristics of future smart cities.

The digitisation and integration of core systems of the city should be used to exploit city data to take intelligent and timely decisions. Below illustration in Fig. 6 by British Standards Institute (BSI) [13] shows relationship between infrastructural

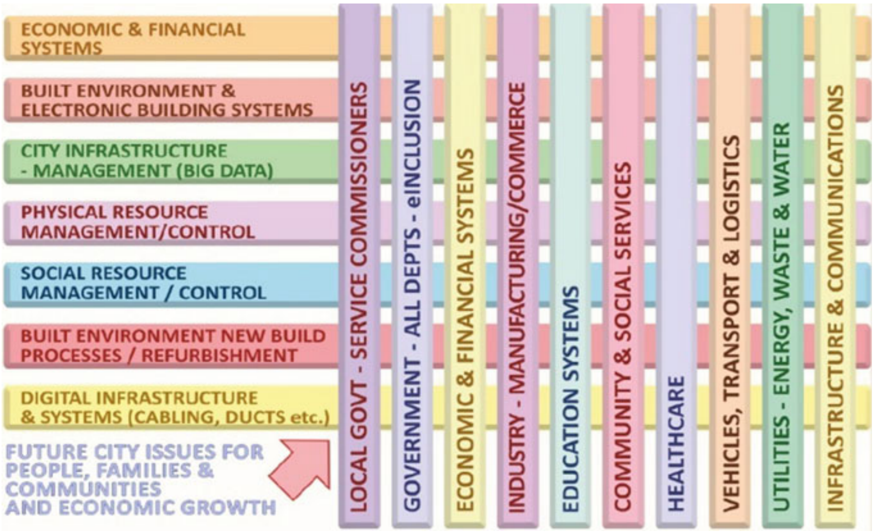

Fig. 6 Physical, social, technical elements of the smart cities

elements of the smart city (horizontal) and service delivery channels (vertical), notice the socio-physical systems as delivery channels depends on the data sourced from systems. Their study argues that the more the silos among these critical pillars of smart city the less effective and less efficient will be the smart city.

By using city data and integrating social, cyber and physical elements from across all spheres of city, the cities can minimise the footprint and optimise their utilisation of the city's natural resources, provide more insight to city planners and decision makers which ultimately improve city's operations, citizen's life and will also contribute in increasing citizen's happiness and satisfaction.

3.1 Smart Healthcare

Centrally connected health care systems, providing personal healthcare services no matter where you are, sensors implanted into your body will continuously take readings and will communicate with the smart app on your phone to let you know of any risks you may be exposed to. In future, humans will have overcome blindness by using AI based bionic eyes. Human capabilities will be enhanced by genes therapy, gene editing, by modifying their genes, thus removing diseases [14]. Much advancements in fight against cancer using nanoparticles. Scientists will be able to reverse effects of Alzheimer, and thus overcoming the disease. New treatment options such as stem cell therapy, heart muscle regeneration will eradicate almost all heart diseases. Artificial wombs for child birth will be available to control nutrition, prevent exposure to viruses in a safe environment. You will not be visiting the doctors physically, the doctor will be able to see and analyse all your records while sitting in his/her office, in real-time from the sensors and chips installed in your body, these can even inject the medicine dosage if the need be. You will have your personalised medication and dietary plans in your smart phones. Using AI and analytics diseases could be diagnosed and predicted in advance. Nevertheless, there will be privacy concerns. Governments will have to ensure that the health data is secured and protected. The health data accessible to government, will lead to challenges for the citizens in some situations where the disease is not curable, therefore proper steps be taken to continue providing other services.

3.2 Smart Education

Imagine the future classroom will not have any student physically present in them. Classes will be virtual worlds, students will learn in the virtual environment, virtual reality (VR) based learning will be part of learner's daily routine. The whole courseware will be available for use online, just wear VR goggles enter in the virtual world. Access information as if it is in front of you, feel it, touch it and interact with it. VR along with Augmented Reality (AR) will change the way we used to interact with teachers and classrooms. Using big data and analytics, students will be provided with a personalised plan to suit their learning needs, based on their previous performance and future goals. Society will greatly benefit from this type of data insights. Every student will have access to their learning progress and data profiles using smart devices. Learning new languages and skills will be just a matter of uploading the information in our brain. The use of brain imaging will help us fine-tune the teaching methods that works best for each individual and making it more effective. AI will be our teacher, intelligent machines will replace the human teachers, these teachers will be able to communicate with us anytime based on our preference and will adjust their teaching methods according to our progress and response. Traditional testing methods will become obsolete; assessments will be more holistic and will test ability to use information. Smart cities will make education pervasive part of our lives, on-demand easy access to information will make our lives much more enhanced and informed. However, this will be without human touch from the education, which exists between human teachers with their students. Much impact on social norms, parent's child discussion and moments of consultation will be gone from our lives. Virtual classrooms will replace many of the brick and mortar teaching institutes in the middle tier thus affecting jobs.

3.3 Smart Transport

Smart cities of the future will have almost all of the vehicles autonomous, through collaborations will stakeholders in private and public sector; we will see full-integrated transport system in which all the vehicles will be connected to other vehicles in their surroundings, destinations, traffic control and city management system. IoT and Big data will play the core role to sense, monitor, control and plan the traffic. Owning personal cars will not be a common trend, instead self-driving ride hailing services will be the mainstream mode of transport. Autonomous flying taxis with vertical takeoff capabilities will be common, smart cities will have landing stations everywhere around the city. All of these services will be accessible through the smart phones or implanted chips on our body. Hyper loop will be connecting cities, used for passengers and cargo deliveries. Drones will be employed for on-demand delivery for e-commerce. Cars that fly, and drive on the road will be available for public use. In case of emergency the vehicles will be able to communicate with emergency response systems automatically their location, impact of the accidents and passenger riding the vehicle at the time of accident. Smart transportation will have increased efficiency in resource utilisation, less CO2 emission, improved quality of life, inexpensive travelling, more safe and secure, reduced stress and more time for learning or entertainment. Challenges include access and uninterruptable connectivity to high speed network, any glitch or malfunction in network and or software will halt the traffic and will bring things to standstill, privacy concerns will be at large as the government and transport providers will gather personal and journey information of each citizen. Security from cyber-attacks is another challenge for the transport systems of the future. There will be hit on driver's jobs due to the self-driving cars and heavy vehicles. Auto-industry business model will have to change as ride-sharing will have effect on their sales.

Next section will focus on big data challenges in smart cities for governments, education sector and industries and ideas to solve them.

3.4 Big Data

Whether AI can evolve beyond the science fiction age of robots taking over the world and human race or not, it is certain that IoT, big data, 3D/4D printing, genome engineering, AR, VR, mixed reality, self-driving cars and autonomous drones will have remarkable impact on society, industry, economy, and environment. Whether the future looks optimistic on the job opportunities or suggests otherwise, researches must start thinking about solving these challenges now. Out of the many impacts discussed in the previous sections due to future technological advances in smart cities, the subsequent sections talk on how challenges specific to big data can be addressed to maximize the benefits for smart cities [8].

- Data Policies—Digital information in the form of structured or unstructured data maybe shared across boundaries. Appropriate policies to govern this data will be important, policies to protect privacy, intellectual property rights and liability, including private and public data. Similarly, data security policies for sensitive data will be needed as data is valuable and any breach of information may result in financial or national loss.
- Tools and Technology—Big data is ever increasing, though with the advent of quantum physics, nanotechnology, and inexpensive hardware infrastructure to store Big data, organisations will have to deploy sophisticated analytical software solutions to get value out of this data. New problems and competition fueled by Big data will spur the development of new analytical methods, tools to visualise the data will be more important than current way of looking at the information. Policy makers should consider infrastructure and technology part of their business plans.
- Corporate Culture Change—Organisation will have to undergo mind-set change to embrace the use of new technologies. Those who'd resist will be out of competition and business. Competition will be around Big data and its usage to gain competitive advantage and timely decision.
- Access to Data—Smart cities cannot succeed without sharing data between stakeholders, public data access to private sector and individuals will result in innovative use of data to provide services and products that will benefit everyone. Private sector will have to play an important role to share non-public data to build upon each other's data without compromising privacy and security, stakeholders considering control of certain data-set from competitive advantage would be hesitant to share this data, other stakeholders might need to provide equaling value proposition to use this data. Policy makers should align incentives to promote data sharing for the mutual benefits of the society and businesses.
- Organisational Capabilities—Big data will push organisations to work differently, public sector and corporations will have to devise novel and innovative operating models to cope up with the pace and productivity demands. Executives and policy makers will have to maximise the value creation from Big data by deploying Big data solutions and engaging data scientists, and data analysts who can operate and analyse on data and present the quality information for the decision maker's consumption.
- Human Capital—Governments and private sector will have to create learning opportunities to increase the supply of Big data talent pool. Initiatives to promote science, technology, engineering and mathematics (STEM) education are inevitable. Big data, statistics and machine learning, deep learning and advanced analytics will be essential in the courseware. Traditionally data science and analytics has been men's only domain however for future policies and steps to be taken to encourage more women into this field will be necessary to increase the supply of the required talent.

Whether the future looks optimistic or not is a subjective debate, it is certain that it is going to have a major impact on us. We have to embrace ourselves for the technological shift. The society will deliberate on the ethics, economic, social, cultural and environmental fronts to counter challenges and find solutions as this natural resilience is built into humans. More collaborated research by scientists and thinkers is required to keep a balance of dominance between artificially intelligent being and naturally intelligent being aka humans. AI experts are already warning us of the potential perils of AI growing beyond human control and becomes super intelligence and come face to face with its own creator [15]. Excessive dependence on fully autonomous machines and AI to allow making its own decisions puts humans to eventual risk. Future research should study how integration and synergies between AI and humans and building ethical and moral responsibilities in artificially intelligent beings of the forthcoming era.

4 Conclusion and Future Prospects

Although smart cities bring a host of much-needed benefits, they also have associated risks to public safety and, potentially, national security. Smart cities are susceptible to a number of vulnerabilities the consequences of which are still unclear. As more new devices are introduced the vulnerabilities, risks, threats, and consequences will be better understood.

For example, smart city transportation systems and water systems bring a unique set of security challenges, including:

- Remotely executed attacks on Autonomous vehicles.
- Engineering collisions with other vehicles or cause a vehicle to crash by gaining control of one or more autonomous vehicles could cause considerable danger and physical damage.
- Targeting vehicles carrying hazardous materials or crashing vehicles into city infrastructure such as bridges and tunnels, could bring significant loss of life.
- Gaining control of stop lights and road signs to cause accidents and disrupt traffic flow.
- Signal jamming GPS devices on autonomous vehicle making them unable to distinguish normal inputs from potentially disruptive inputs.
- Attacking trains by creating unsafe conditions through transmission of an “all clear” signal, despite the presence of a stalled train, or by blocking transmission of a signal warning of a stalled train or upcoming sharp turns.
- Controlling Traffic signals to disrupt the flow of traffic.
- Gaining access to the water supply systems or other control systems within a power plant to damage components and disrupt electricity delivery.
- Intercepting and manipulating energy price data in demand response systems to cause demand fluctuations and potential outages.
- Manipulating smart meters to alter usage information, gain access to in-home devices, or cut power to consumers.

- Gaining remote access to a smart waste water facility to cause water system backups and potential environmental damage.
- Remotely attack smart water distribution systems to damage system components, disable system sensors, disrupt storage and flows, or distribute contaminated water.
- Targeting smart pumps, valves, and other components in smart water-storage facility control systems to manipulate water flow.
- Manipulating safety sensors to mask the presence of dangerous substances in smart water-storage facilities.

There are other challenges not related to attacks, including:

- Securing mobile device connectivity to the networks and distinguishing legitimate mobile device queries from anomalies.
- Large number of system access points stemming from the presence of networked technology across large systems, raising the cost and difficulty of properly securing each system device.
- Ensuring smooth interface, communication, and security among multiple interdependent systems, including sensors, computers, fare collection systems, financial systems, emergency systems, ventilation systems, automated devices, power relays, etc.
- Demand for nonstop access to real-time data that smart city systems require, and the related costs associated with maintenance and service downtime.
- Logistical and security hurdles of physically accommodating enormous volumes of passengers and freight, along with the reality that security breaches could result in public safety risks.

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Using Fuzzy Expert System for Performance Evaluation and Decision Making in Project-Based Companies

J. Almaazmi and Khalid Al Marri

Abstract It is well known that business performance can be improved with effective knowledge management, especially with today's competitive atmosphere. Thus, a proper performance measurement and evaluation system supports the decision makers to measure progress, identify assets of improvement, and find unidentified difficulties within the company. Accordingly, study about utilisation of expert systems like fuzzy logic and understanding their importance is worthy; to support the performance evaluation and decision-making processes in companies. Therefore, a comparative study has been practiced for this research, through reviewing existing papers and mechanisms in expert system fields. A conceptual framework is then introduced; to demonstrate the idea of using the fuzzy expert system for performance evaluation and decision making in project-based companies. Finally, this paper presents a fuzzy model integrated with other methods BSC, AHP and MCDM (TOPSIS), to measure the performance, evaluate the performance and rank them as per performance results in project-based companies by using MATLAB.

Keywords Expert system · Fuzzy logic · Project management · Project performance management

1 Introduction

The power of nations nowadays is not by the number of their soldiers or strongest weapons they use, but in the knowledge, they practice. Thus, in 1970s, it was believed that a machine can be made to explain a rational difficulty. Which means to use the power of knowledge to find the correct solutions. "Knowledge is a theoretical or

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practical understanding of a subject or a domain. Those who process the knowledge are called experts. They are the most powerful and important people in their organisations" [16, P. 25].

Accordingly, as of interest of the few researchers to support the humanity in decision-making, a new science of an Artificial Intelligence (AI) was born in late 1950s. And, valuable tools developed through the years; from the first expert system in the 1960s, a simple binary prototype of neurons offered in the 1940s, and the primary fuzzy set theory in the 1960s; to the mature expert technologies, rebirth of the field of artificial neural network, and several fuzzy products in the 1980s. As a result, the most widespread methodologies to machine learning are expert systems, artificial neural networks, fuzzy logic and genetic algorithms [16].

This paper reminder will be as follows: section one presents study problem statement, aim of the study, and the study justifications. Section two talks about earlier studies in expert systems, fuzzy logic philosophy, performance evaluation, project management performance and project success criteria and fuzzy methods. Section three outlines the methodology of the research, the research questions, and proposed fuzzy logic framework in project management efficiency evaluation. In section four an overview of the research, discussion and conclusion are provided.

1.1 Research Problem Statement

More applications for expert systems are established in the operation and production management area, and less in the human resources area. But what about the part of performance evaluation? Human resource software applications contain performance assessment of workers, but not cover an overall area of the company. Performance evaluation could be found in the part of the internal control assessment or auditing, but non of them is specially committed for performance assessment. Performance evaluation involves in applications for understanding and analysis [1].

As performance analysis, practice is not usually used in business, and proficiency seems to derive from experience not from official education. Managers overlook performance analysis since they do not have time to do so and as they have limited staff. Besides, lack of recognised integrated practices for understanding and evaluation performance of project data. Therefore, valuable information is lost that could help to improve the performance and provide some good opportunities for operational and strategical performance enhancement process [1].

And since, project management implicates in complex decision-making conditions that require sensitive abilities and methods, and wants the volume of data to describe the present status of the project to make sound decisions, specially the one that related to performance analysis practices [14].

1.2 Aim of the Research

The aim of this research is to verify that the usage of fuzzy expert system is sufficient for performance evaluation of the projects; in order to provide the correct decisions at the right time.

1.3 Research Justification

Effective project management in organisations is critical for their existence and development, since development lead to growth and growth is the feedback of successful project management. Therefore, in this competitive world, project-based organisations must adapt a new and updated scientific tool, which support them in the evaluation of their projects [5].

As specified by Qureshi et al. in [19] that project management is crucial in today's business lifecycle. Moreover, one of its main necessities is the performance management, and how to improve it for business development purpose. Nevertheless, since performance measurement is a vague thing, especially in case of performance management, thus choosing the right tools for measuring the performance is also a critical duty.

The latest IT development enabled us to develop strong expert systems that changed the old way of information gathering, handling and decision-making. One of the key concerns is the ability of such system to gather the appropriate data and to process them in such a way that creates the best results and solutions to business process [4].

In 2008, Azadeh et al. indicated the reasons why to use an expert system tool. Since, the introduction of expert system, the applications related to expert systems started increasing to numerous problem domains in business.

In addition, when a complication becomes excessively countless, the interrelations and probabilities come to be so fuzzy that the system required to be supported by applicable tools and abilities [14].

Since decision-making is not always a matter of right and wrong, black and white; sometimes contains gray zones and the term may be vague, this is the reason why the fuzzy logic approach is the suitable method that could be used [12].

By using the technique of fuzzy logic that deals with vagueness. This technique, which uses the mathematical thinking of fuzzy sets, mimics the process of human normal rational thinking via letting the computer to perform less surely and logically than predictable computers. Consequently, innovative decision-making courses can be considered formless, playful, argumentative, and confused [9, 12].

Human errors to be reduced, expert knowledge to be created, and ability of dealing and understanding with large amount of imprecise and unclear data, were the most important reasons that let us to use fuzzy expert systems for performance assessment [1].

As well as, fuzzy set theory has been implemented in many zones related to managing an engineering [5].

2 Literature Review

2.1 Background

Choosing the right system to specific problem can be tough. Therefore, the need for knowledge engineering was essential. Knowledge engineering definition is the method of constructing the intelligent knowledge-based system. It goes through phases, start by assessing and understanding the problem domain. Then, choosing a suitable instrument and finally, developing the system with that tool. Thus, choosing the right tool for the task is certainly the most serious part of constructing an intelligent scheme [16].

No solo tool is appropriate for all jobs. For instance, expert systems, neural networks, fuzzy systems and genetic algorithms all have numerous suited applications for practicing them. And not like old days, it has taken years to build an intelligent system, today any intelligent system can be constructed within months. Moreover, organisations can report their problems with proper intelligent tools [16].

In order to be more specific, and to know why this report selects the fuzzy logic tool in project performance assessment and in decision making as an intelligence tool, the following units, will elaborate more about most applications used for different intelligence systems/tools that can be employed for solving specific problems. Then more details related to fuzzy logic will be exposed.

2.2 Expert Systems

The simple definition of expert system as per Liao, in 2004 is that expertise, which is a massive group of task-specific knowledge, moved from a human and kept on a computer, then it can be re-called for guidance if required. It is alike a human advisor, can offer guidance and explanations.

In 2004, Liao published a paper; to show expert systems and their related applications, through using eleven classes with their applications and domains: knowledge-based systems, rule-based systems, fuzzy ESs, neural networks, case-based reasoning, object-oriented methodology, database methodology, system architecture, intelligent agent systems, ontology and modeling.

Expert system does not have experiences to learn or improve themselves. However, machine learning can rush this practice very fast and boost the quality of knowledge. In general, the expert system main applications are diagnosis and troubleshooting problems (Medical diagnosis) and Classifications problems [16].

In terms of artificial neural networks, which motivated by biological neural networks, learn from past and historical cases then make it possible to produce rules automatically and accordingly escape the dull and costly process of knowledge gaining, confirmation and amendment. Neural networks represent tools used for predictions, recognizing, grouping, and classification problems [16].

On the other hand, fuzzy logic provides a means to figure words, thinking in vague terms and dealing with uncertainty that is similar to human expert's way of thinking. The main fuzzy expert system applications for showing human decision making in practice of vague expressions and common sense (decision support fuzzy systems) [16].

2.3 Fuzzy Logic Philosophy

In this unit, it is important to introduce a fuzzy system, and to know more about the philosophical ideas behind the fuzzy logic. Hayward and Davidson mentioned in 2003, that the concept of fuzzy logic was first presented in 1965 by the researcher Lotfi Zadeh. They defined the fuzzy logic as "a proper mathematical method for demonstrating complex systems, which been used in many control systems successfully".

And as per Dweiri and Kablan, in 2006 fuzzy logic defined as "a problem solving technique that was introduced by Zadeh to deal with vague or imprecise problems".

Siler and Buckley, in 2005 published a book that described the two fuzzy expert systems types: fuzzy reasoning and fuzzy control. Both systems make usage of fuzzy sets, but the difference is in methodology. Mamdani in 1976 achieved the fuzzy process control for controlling a cement field. From that time, fuzzy control has been commonly recognized, starting from Japan reaching all over the world.

Although a wide range of principles of fuzzy logic exist, still the main four concepts are fuzzy sets, membership functions, fuzzy if-then rules, and linguistic variables [5]. Where, linguistic variables shown in the form of membership functions and rules process the model. All the rules are generated from expert knowledge. And the membership functions (input and output) are based on approximations of the vagueness of the descriptors used. Once inputs and outputs are defined, the operational procedures for the calculations are sound fixed out [7].

In a simple description of the fuzzy control system process, known as a fuzzy interface process, that captures input (figures or numbers), then turns the crispy numbers into linguistic terms like Slow, Medium and fast, which called fuzzification. After that rules match the input linguistic terms onto alike linguistic terms as output. In the end, the defuzzification is happened, where output linguistic terms are converted into an output crispy number, which known as [20] (Fig. 1).

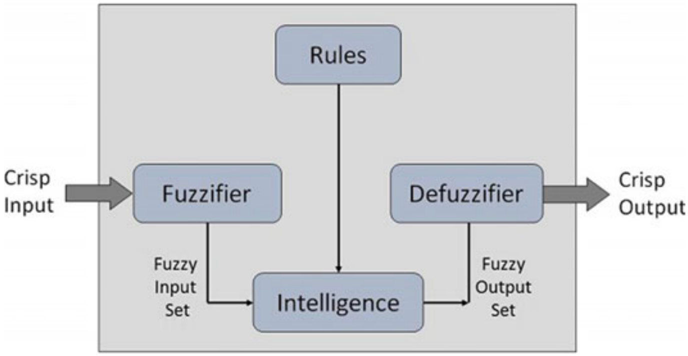

Fig. 1 Fuzzy logic systems architecture [8, 15]

The fuzzy interface process has two techniques: Mamdani and Sugeno. Mamdani method is used to capture expert knowledge in fuzzy rules. While Sugeno method is very well with optimization and adaptive approaches [16]. Example: the temperature is the variable displayed in Fig. (2). Cold, comfortable, and hot are the fuzzy sets that have been defined by membership allocations over a series of real temperatures [7].

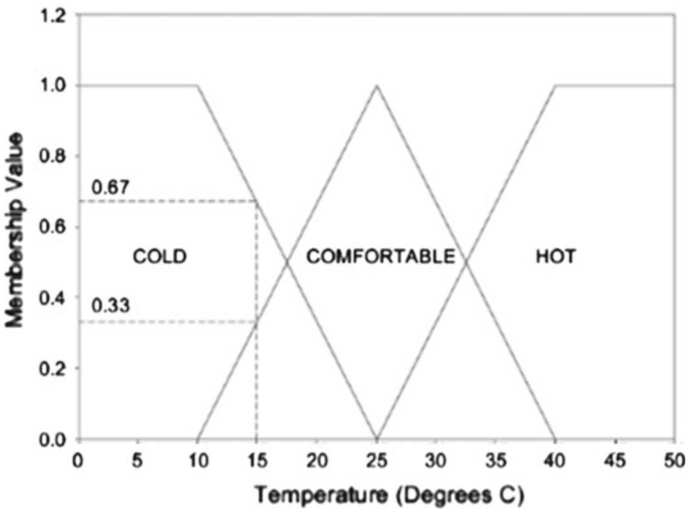

Fig. 2 Example: fuzzy logic systems membership functions [7]

2.4 Performance Evaluation

The description of the performance and evaluation as following: Performance is a single kind of measurement of the goals of the organisation, whereas evaluation is mentioned as the goal that a company can effectively gain in a particular period.

Performance evaluation is a vital action of management mechanism, used to examine whether assets are allocated professionally. Also, it is implemented for operational control to accomplish an objective correction in the short and the long run of the business strategies. Besides, it is a perfect technique to review the financial/non-financial objectives accomplishment of the organisation. Moreover, performance evaluation gives suggestions of how the staff knows their works, in order to provide proper communication and the right decision-making for seek of improvement and development.

Accordingly, in-terms of performance measurement it can be defined as a system that a company controls and observers its day-to-day operational works, and evaluates if the organisation is reaching its objectives.

2.5 Project Management Performance and Success Criteria

As per PMBOK Guide "project success is measured in terms of completing the project within the constraints of scope, time, cost, quality, resources and risk as approved between the project managers and senior management" [17].

As, the team of the project is accountable for all project results and they must be continually alert about the project objectives, targets, goals, project purpose, and the project performance. Project efficiency, which is another means of project success, is measured as per the degree of accomplishment of project goals [5].

Project success perception is a debated conception. Numerous studies reflected that the vital factors for project success are project time, cost, and quality [5].

In [2], Baccarini indicated, proper distinction between the project success components to eliminate confusion amongst them:

Project management success: related to the project process itself, considering the way of the project management process was led. Specifically, in achievement of cost, time, and quality objectives successfully.

Product success: related to the impression of the project's ultimate product.

Project success: related to the mixture of both the product success and project management success.

Conceptually, it should be highlighted here that the determination of project management success ignores product success, for instance project can meet cost, time and quality, which are project management success factors but still it can be product failures and vice versa. Therefore, project success is measured by achieving both project management success and product success [5].

Now, after knowing our project efficiency measurements, there still will be an evaluation obstacle (vague problem) for those measurements. For example, we need to know when a project progress is low or medium, or high in regard to cost/schedule, are they over-lane or under-lane. In this case, we need expert judgment and knowledge to indicate the exact evaluation. Therefore, the fuzzy logic approach is needed in this situation [5].

2.6 Fuzzy Methods

This part of the research is to show some previous studies related to the Fuzzy logic that integrated with other methodologies, and have been commonly used for performance assessment.

In 2001, Carr and Tah come up with the fuzzy risk assessment model as shown in Fig. (3) that applied fuzzy concepts to identify connections between risk causes and the impact on project performance measure. The system has been settled on Microsoft Visual Basic.

In 2004, Lin and Hsieh proposed study decision support system DSS that used the concept of fuzzy logic in it for strategic portfolio selection, where different stages used to do so, starting from pre-evaluation, to preference elicitation and finally data analysing and reporting.

Dweiri and Kablan, in 2006 designed a fuzzy decision making system by using a MATLAB for evaluating a project performance efficiency, in integration with AHP model to fix the weight of the selected factors (cost, time and quality).

In 2007, Zeng et al., worked on the fuzzy reasoning application for construction project risk assessment. They applied the method of AHP process, to build and arrange various risk factors.

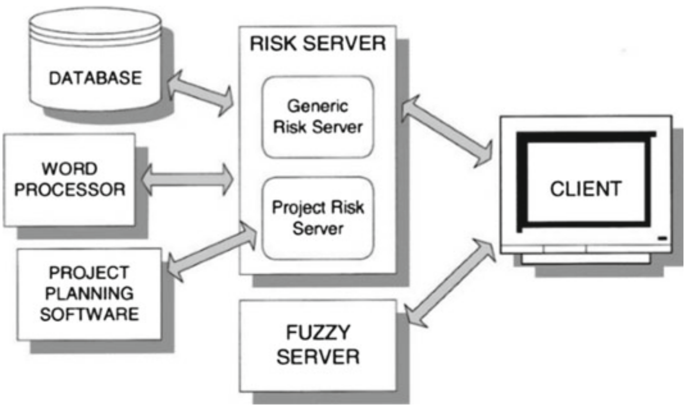

Fig. 3 Fuzzy risk assessment model [3]

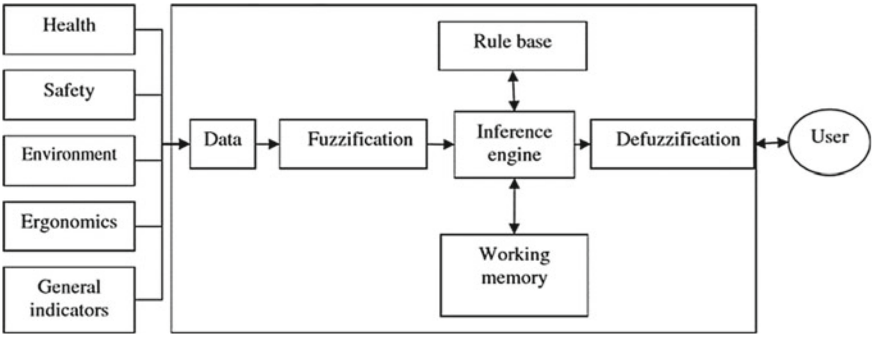

Fig. 4 Rule-base fuzzy expert system for performance evaluation of HSEE [1]

Moreover, to define the effects of fuzzy logic in performance evaluation Azadeh et al. [1] designed a fuzzy expert system as shown in Fig. (4) for HSEE performance evaluation in a gas firm. Which led to a strong system for continuing evaluation and enhancement of HSE performance by identifying the causes of positive or negative performances. And, it measures all indicators and works as a decision support system.

Lee et al. [10] research was about building a fuzzy method shaped for the balanced scorecard (BSC). A fuzzy AHP methodology used to manage vagueness and uncertainty of information. This information system was developed to support the solving exercise. In the end, this system gives a right guidance to IT departments in Taiwan for their strategies and enhance the department performance.

Ertuğrul and Karakaşoğlu in 2009 developed a fuzzy model for performance evaluation of 15 Turkish cement companies via using financial ratios with judgments views consideration. Suggested method was established on FAHP (fuzzy analytic hierarchy process) that used for defining the weights of the measures and TOPSIS (Technique for order preference by similarity to ideal solution) technique used for ranking of the organisations.

In 2009, Wu et al. offered a Fuzzy Multiple Criteria Decision Making (FMCDM) methodology [23], for banking performance evaluation based on the four Balanced Scorecard (BSC) sides. Started from summarizing the assessment indexes connected to banking performance extracted from the literatures. Where, 23 indexes were acceptable for banking performance evaluation. Then, the qualified weights were measured by Fuzzy Analytic Hierarchy Process (FAHP). Multiple Criteria Decision Making (MCDM) investigative techniques of TOPSIS, SAW, and VIKOR were individually accepted to rank the banking performance. The examination consequences highlight the serious features of evaluation principles and the gaps to develop banking performance for reaching wanted level.

In 2010, Sun proposed a paper for performance evaluation model using fuzzy logic along with AHP and TOPSIS methods in order to assess the top 4 international notebook computer ODM companies. The notebook computer ODM companies' performance criteria contain human resources skills, financial skills, manufacturing skills, innovation skills, service quality skills, and supply chain skills.

Table 1 Literature review summary table

No.	Article	Fuzzy system	Other methods combined with fuzzy system		
1	Carr and Tah [3]	Fuzzy risk assessment model			
2	Lin and Hsieh [13]	Fuzzy DSS			
3	Dweiri and Kablan [5]	Fuzzy logic	AHP		EC
4	Zeng et al. [11]	Fuzzy risk assessment model	AHP		
5	Azadeh et al. [1]	HSEE Fuzzy expert system (DSS)			
6	Lee et al. [10]	Fuzzy logic	AHP	BSC	
7	Wu et al. [23]	Fuzzy logic		BSC	MCDM (SAW, TPSIS, VIKOR)
8	Ertuğrul and Karakaşoğlu [6]	Fuzzy logic	AHP		(MCDM) TOPSIS
9	Sun [21]	Fuzzy logic	AHP		(MCDM) TOPSIS
10	Pourjavad and Mayorga [18]	Fuzzy logic			(MCDM) TOPSIS

Pourjavad and Mayorga, in 2017 constructed Mamdani fuzzy interface system (FIS) to measure the performance and evaluate the efficiency of the manufacturing systems, with real case study of 5 manufacturing plants in Iran. They applied a comparative study and showed lots of previous works related to Performance measurement, conventional and MCDM methods, Fuzzy MCDM methods, DEA methods.

Although there is a wide range of research related to the application of fuzzy logic utilization in performance evaluation and efficiency analysis. However, for this study several literature reviews have been done and has been summarised, as shown in Table (1).

3 Future Prospects

3.1 Methodology

The methodology practiced for this report in order to achieve the research objectives is by using a comparative analysis method. A comparative analysis compares two or more things: for instance, two theories, or texts, or historical statistics, or technical processes, or frameworks, or units [22].

Therefore, for this research plan to be accomplished, previous related literatures approaches along with their frameworks/models has been reviewed critically and compared; to suggest the proposed framework, that can serve the aim of this study, which is the utilisation of the fuzzy expert system for project performance assessment in order to practice the right decisions; to improve and enhance the project-based business objectives.

3.2 Research Questions

Which technique or tool to use to investigate and analyse data according to decision-maker situation/opinion? [14]. How to construct a model that tolerates a bulky number of information (performance measurement) to be kept and easily accessible for consultation and/or adjustment? [14]. Is fuzzy logic technique suit for evaluating the project performance? Why?

3.3 Proposed Fuzzy Logic Framework for Project Management Efficiency Evaluation

Where the Balance scorecard (BSC) is used to select the most effective and major performance criteria from the four perspectives (financial, customer, internal processes and learning and growth). Then, to define the hierarchy and determine weights for the selected criteria by utilising the fuzzy analytic hierarchy process method (FAHP). For sure, with taking into consideration the subjective judgments and decisions of the decision makers. Finally, for benchmarking purpose MCDM model like TOSIS is used to rank many companies based on their measured performance-if required—for better comparison and increasing the company performance.

The main 4 components and their interrelationships with fuzzy decision making system framework will be as: fuzzification interface, a knowledge base, decision making logic, and a defuzzification interface, and of course project management experts' experience and knowledge added to this system [5]. Where the knowledge base used to govern the associations among inputs and outputs, the decision making logic was involved here to mimic the human decision making based on the rules of implication in fuzzy logic, and for fuzzificaion and defuzzifications roles were already explained in previous sections [5].

The review of the project management efficiency can serve the project-based firms as a sign of the level of success of the project management goals. Hence, the objective of this study is to combine the criteria of project cost, time, and quality into only one main criteria known as the project management core efficiency to know an overall judgment about project execution performance. It is important to mention that to implement this system we can use a MATLAB software to implement the fuzzy logic module [5, 18].

Additionally, as project management internal efficiency PMIE is a vague value. Thus, steps have been provided for how to use fuzzy decision-making system to overcome vague problem as following:

- Find factors or performance criteria, which may affect the PMIE. Like project cost PC, project time PT, and project quality PQ by using the concept of BSC, [10].
- Find their corresponding priorities project time weighting factor PTWF, project cost-weighting factor PCWF, and project quality weighting factor PQWF by using the concept of FAHP. Where AHP is an ordering procedure, which can handle formless and multi-aspect decisions. The AHP approach is based on pairwise comparison of components which support in reducing the complexity of the judgment problem [5, 6, 10, 11, 21].
- Set fuzzy subsets and membership functions, integrating expert's understanding and experience for the input variables and the output variable of PMIE which can be called as "fuzzy conclusion" [5, 18].
- Fix judgment rules: Expert understands and experience is used here for creating the correct IF-THEN rules to manage the associations amongst inputs and the outputs.
- Link fuzzy sets to their related input values and put on the decision rules manner.
- Combine the fuzzy outcomes for the output values and her the center of area method (COA) applied, which is the best popular defuzzification technique, to get the output value as a crisp value [5, 18].

4 Discussion and Conclusion

This paper presents a fuzzy model integrated with other methods BSC, AHP and MCDM (TOPSIS), to measure the performance, evaluate the performance and rank them as per performance results in project-based companies.

The establishment of the fuzzy system for evaluating of project management efficiency can be easily implemented with the MATLAB software, since it is a friendly interface user software and allows to implement the fuzzy concepts [5].

The implemented fuzzy decision making system relied on expert's experience and knowledge, especially when setting the membership functions and fuzzy subsets for each input and output variable, and in the IF-THEN rules that manage the interactions between inputs and the output [5]. And the proposed framework can be a perfect technique for solving other decision-making problems with multiple-criteria [10].

Numerous possible benefits can be calculated by employing expert systems such as fuzzy logic. These contain: extra dependable decision-making, better decision-making, reduced decision-making time, well usage of expert's time, working cost savings, improved service/product levels, improved training, and rare knowledge captured. Benefits to business productivity analysis contain faster investigation of productivity difficulties, more reliable appraisals and understanding of productivity performance, and cost reductions due to the less need of work force. Escalation in management review into productivity performance, which impact positively to firm's short-term and long-term effectiveness [1].

Limitations of the study can be reflected as following: fuzzy-AHP, in which the number of alternatives is totally depends on human ability to reasonable judgment. Also, it required a huge amount of calculations, in order to do pair comparisons, which is documented as disadvantage for fuzzy MCDM [18].

In this paper it has been defined 3 measures to obtain effective performance results linked to project management, which are (cost, time and quality); while other critical measure could be added to this prototype.

Future recommendations can be suggested as following: data-driven models like artificial neural networks can be considered for further researches and studies to develop membership functions in performance effectiveness. In addition, for future research a genetic algorithm can be evolved and valuable in the optimal setting of the fuzzy rule base [18].

A practical case study would be a worthy impression to practice the proposed system and get results to insure the reliability and validity of the system.

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Application of the Triple Helix Model in the Creation and Evolution of Areas of Innovation

Josep Miquel Pique, Francesc Miralles and Jasmina Berbegal-Mirabent

Abstract This study aims to contribute to the understanding of the revitalization projects of metropolitan areas and the evolution of ecosystems of innovation. Using a case method approach, this work explores four Brazilian urban revitalization cases and dives into the evolution of the *22@Barcelona* innovation district and the San Francisco-Silicon Valley ecosystem. From these cases, several implications can be drawn. On the one hand, from an academic point of view, both the Quintuple Helix model and the Knowledge Based Urban Development (KBUD) theory are found to provide an appropriate framework to map the revitalization processes analysed. On the other hand, policy makers in urban revitalization can benefit from this work by learning the lessons from the cities reviewed. We believe such cases can inspire other cities that want to transform old industrial areas (brownfield transformation) into socially conscious, creative and knowledge-based economy hubs. This study suggests the adoption of a holistic perspective that brings together the triple helix agents—universities, industry and government—while considering the local specificities in the urban, economic, social, and governance dimensions. We do so by theorizing the evolution of Areas of Innovation (AOIs) from inception to maturity.

Keywords Areas of innovation · Triple helix · Knowledge based urban development · Clusters of innovation · *22@Barcelona* · Silicon valley

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1 Introduction

City planners face the challenge of playing a relevant role in the knowledge-based economy where face-to-face interactions, networking and trade remain vital [32]. The trend of urban planners is now to replace old manufacturers and industrial metropolitan areas with knowledge cities, which emerge from the balance between the production system and the urban cultural environment [54]. Cities that stimulate and rejuvenate various forms of knowledge serve as knowledge centres [30] and attract a creative and highly skilled workforce [25].

Science parks built in regenerated zones of inner cities have gained greatest momentum from a wide variety of stakeholders, ranging from policymakers to academics. Their role has been deemed as crucial for the evolution of innovation ecosystems of cities in the knowledge-based economy. Yet, this has implied that traditional science parks have been forced to evolve in order to play this role. Unlike traditional science parks, knowledge cities are urban enclaves that concentrate creative industries—including high technology, artistic and cultural sectors – which are integrated in a wider social context [53], while at the same time, provide socio-cultural amenities [61].

New cities hardly retain any of their former traditional, local and static nature [48]. In the inner cities, clusters of interlinked firms and organizations operate at world-class levels of competitiveness [49]. Companies take advantage of social agglomeration factors such as critical masses of skills and relationships, access to information, and the availability of specific infrastructures in a given field [27, 48, 55]. As a result of agglomeration effects, new economy metropolitan clusters emerged, comprising not only isolated firms but rather substantial ensembles of dynamic industries [27] that have been transformed into urban science parks or Areas of Innovation (AOIs) [35, 36].

Increasingly, knowledge-based and technology-intensive industries are taking the place of old industrial—and, in some cases, even residential—districts in the large urban agglomerations [27]. As clustering forces drive talented, innovative and creative people to concentrate in the most knowledge-intensive cities and regions [25], the new trend consists in promoting the creation of metropolitan clusters [11] that set up "new" versions of traditional science parks. Retention factors of talent are thus of utmost importance [2].

These new urban science parks combine technology—including computer graphics and imaging, software design, multimedia industries and graphic design industries that have been deeply influenced by technological development—with culture—represented by creative human capital and design functions—and the geographical location, more specifically, the innovative milieu of the inner city [27].

Although existing literature has focused on the evolution of traditional science parks, there is a lack of research exploring the drivers of the evolution, either organic or intended, that have transformed traditional suburban science parks into active areas of innovation (AOIs). The goal of this work is thus to shed new light on this issue and propose an enhanced framework that assists in the understanding of the evolution of AOIs in cities, from inception to maturity, and to map how the role of the Triple Helix agents (university, industry and government) changes throughout the lifecycle of an AOI. The theoretical background is rooted in the conceptual frameworks of the Triple Helix model, the Knowledge Based Urban Development paradigm, the Clusters of Innovation and the lifecycle model of a new venture creation.

The remainder of this paper is organized as follows. Section 2 summarizes the theories used to frame our research. Section 3 describes the research strategy, which includes the research questions, the objectives, the scope and the methodology. Next, Sect. 4 presents the results of the different studies and discusses their implications. Lastly, in Sect. 5 the conclusions and futures research lines are put forward.

2 Theoretical Foundations

The theoretical foundations of this work come from different models and theories. To start with, the Triple Helix model [21], which focuses on the relationships between universities, government and industry. For the purpose of this research, this model is used as a framework that helps to better understand how ecosystems of innovation develop in cities. Second, to characterize how cities transform in the different dimensions—urban, economic, social and governance—the Urban Development approach [57, 58] is considered. Third, the Clusters of Innovation theory [16] is used to map the components of an ecosystem of innovation from the point of view of the interactions between start-ups, venture funds and corporates, contributing to the creation and development of high potential entrepreneurial ventures. Finally, as this work aims to advance the current knowledge on the evolution stages of AOIs, we use as an analogy the lifecycle of a new venture [26], which includes the traditional four stages: inception, launching, growing and maturity. The next subsections summarize the main theories mentioned above.

2.1 The Triple Helix Model

Etzkowitz and Leydesdorff [21] used the Triple Helix model (university-industry-government) to explain the development of knowledge-based economies. The model goes beyond linear systems based on policy innovation demand (market pull) or supply policies (technology push) and suggests reinforcing the emerging synergies between agents in a bottom-up perspective versus top-down government sponsored innovation initiatives. According to this model, ecosystems of innovation are composed of three types of agents:

– Universities (also including institutes of technology and research centres), which behave as magnets for international talent, stimulate the development of local talent, and are sources of scientific and technological knowledge for business.

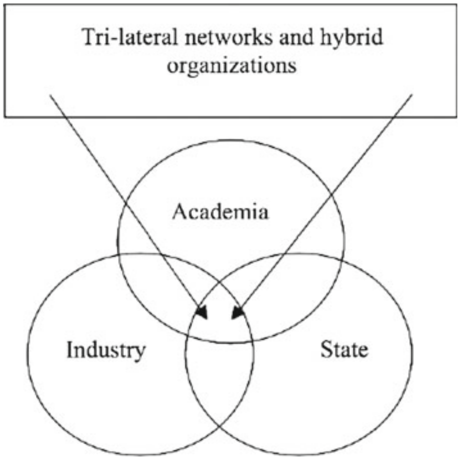

Fig. 1 The triple helix model of university-industry-government relations. *Source* Etzkowitz and Leydesdorff [21]

– Industries (large corporations, SMEs and start-ups), which are the key for the creation of economic value. Entrepreneurship is what translates the knowledge and talent of the individuals, teams and companies into innovation.
– Government (local, regional, national and international), which becomes the third party providing an active role in scientific, technological, business and land use policy making.

The Triple Helix model (see Fig. 1) is one of the most referenced models used to characterize an innovation ecosystem. The Triple Helix thesis postulates that the interaction among university-industry-government is the key to improve the conditions for innovation in a knowledge-based society: (a) industry operates as the centre of production; (b) government as the source of contractual relations that guarantee stable interaction and exchange; and (c) the university as a source of new knowledge and technology.

As the behaviour of each component in a system depends on the behaviour of the others, government's role in the Triple Helix model is interdependent on the role played by the university and the industry within the same system. Triple Helix agents play different roles in urban, economic and social development. While the university has traditionally been viewed as a support structure for innovation, providing trained people, research results, and knowledge to industry, in recent years it has increasingly become involved in firm formation, often based on new technologies originated thanks to academic research. It is therefore not surprising that in a knowledge-based society the university has been raised to an equivalent status, compared to previous institutional configurations where it had a secondary role. Rather than being subordinated to either industry or government, the university is emerging as an influential actor and equal partner [24].

A Triple Helix regime typically begins as university, industry and government enter into a reciprocal relationship with each other in which each of them attempts to enhance the performance of the other. Then, collaboration typically starts among the institutional spheres more involved in innovation, taking place through their traditional roles. The increased interaction among university, industry and government as relatively equal partners, and the new developments in innovation strategies and practices that arise from this cooperation, are the core of the Triple Helix model. The creation of new organizational schemes to promote innovation such as incubators, science parks, and venture capital firms are other examples resulting from the interaction among the Triple Helix agents.

The next step of development of the Triple Helix is that, in addition to each agent performing its own tasks, they are also expected to "take the role of the other". This statement implies that, over time, each agent assumes some of the capabilities of the others while maintaining their primary role. Said differently, although each of the three helices continues with its traditional functions—teaching and basic research for universities, market operation and experimental development in the industry sphere, and multi-level decision making and rule setting in government—the helices interact and transform each other, thereby moving from single functions to multiple shared functions, and promoting the active circulation of people, ideas and policies among and within the three core spheres [6, 15, 24]. The three agents can act separately or in coordination by developing new knowledge, economic sectors, regions or cities. In promoting an ecosystem of innovation, players can assume the roles of the others, and hybrid structures that articulate joint actions may also be created [29].

The Quadruple Helix advocates for the addition of a fourth sphere, that is, the public and larger society [5]. By acknowledging the role of society in using, applying, and generating knowledge, this formulation explicitly introduces the democratization of knowledge production and innovation, as well as the impact of culture and creativity. Culture encompasses diversity in terms of values, lifestyles, and multiculturalism, but also in terms of multilevel local, regional, national, global, and *glocal* approaches. This diversity promotes creativity, a key component for new innovations and knowledge to spur [39].

Building upon the Quadruple Helix, the Quintuple Helix adds the natural environment as the fifth sphere for knowledge and innovation models, thereby positioning sustainable development and social ecology as a component equivalent to the other four helices for knowledge production and innovation [7]. Since socioecological concerns are incorporated as key drivers of innovation, this model supports the development of innovations oriented towards both problem-solving and sustainable development, and informed by multilateral interactions with the four other helices [39].

In this study we rely on the Triple Helix model to explore the role of the three agents in the promotion of urban, social [19] and governance development of cities.

2.2 Urban Development

Cities have always been considered as centres for economic and social development, and knowledge has become a key factor driving urban development [31]. In the rapidly growing knowledge economy, talent and communities are crucial for economic and urban spatial transformation [50]. Cities have become "knowledge community precincts" [8, 58], that is, spaces for knowledge generation and for hosting knowledge communities [61]. More precisely, such precincts are initiated with the lead of the government, but with the support from either industry or/and academia, following the Triple Helix model. Central urban locations are the home for such precincts and benefit from the socio-cultural environment of the city. Knowledge community precincts have also been analysed in seven asset-bases [61]: (1) symbolic assets, (2) social assets, (3) human assets, (4) heritage and cultural assets, (5) natural environmental and infrastructural assets, (6) financial assets (7) knowledge assets and (8) relational assets.

Cities play an important role in the new economy where personal networking is of paramount importance [32]. The trend of urban planners is to transform old urban industrial zones into knowledge cities, which emerge as a balance between working and living [59]. Cities that stimulate different forms of knowledge serve as knowledge centres [30] and attract creative and highly skilled talent [25]. In the recent years some scholars have also included the artistic, cultural and social approach into this research field and have focused on analysing *creative cities* and *creative industries* for local development [4, 33, 53, 54].

The association of the terms "knowledge" and "city" (as in "knowledge city") combines the clusterization of activities related with science, technology and innovation in urban areas, which operate as engines for economic development [9]. Universities, industry and government are promoting knowledge-based activities for urban development as innovation districts [42]. Cities like Barcelona, Melbourne and Singapore are examples of this development [60].

During the last decade, scholarly articles dealing on urban development issues have notably grown. However, the investigations combining the topics of knowledge creation/diffusion and innovation spaces [62] are scarce. According to Bontje et al. [1, p. 1], "*the economic future of cities and city-regions increasingly depends on the capacity to attract, generate, retain and foster creativity, knowledge and innovation*". This paradigm, namely Knowledge-Based Urban Development (KBUD), has been first introduced during the last years of the 20th century as a result of the impact of the global knowledge economy on urban localities and societies [57, 58]. In 1995, Richard Knight argued the need for a new approach to explain the development of cities given the knowledge-based development [30]. He defined KBUD as "*the transformation of knowledge resources into local development*" [30, pp. 225–226].

Several models have been proposed for the conceptualisation of KBUD [51], yet, they all include: (1) social and cultural development (e.g., housing, community facilities, education, social capital and knowledge workers); (2) economic development (e.g., R&D centres, knowledge based companies and start-ups), (3) environment and urban development (e.g. green areas, green infrastructures—mobility, energy, waste, water—and green building); and (4) governance development (e.g. public and/or private bodies that manage the urban transformation and the process of participation of the citizens).

Knowledge assets and strategies have been found as the central concepts in the research domain of knowledge cities [20]. Researchers have identified knowledge and creative talent, universities, IT infrastructures, real estate development, and citizen decision-making as essential assets for the cities of knowledge. Universities and research centres are critical as they are the backbone of a knowledge based economy. In this sense, some authors emphasised the importance of Triple Helix partnership and the addition of the society in the Quadruple Helix to build knowledge cities [34], and even the environment in the Quintuple Helix model. In broader terms, knowledge assets in knowledge cities might also be considered the combination of both hard (tangible) and soft (intangible) assets [61].

In the urban development context, assets are defined as attributes of city-regions [56]. They are vital for the dynamics of urban life and crucial for the sustainability of the environment, economy and society. Therefore, the key local assets of a city-region—as the starting point of any transformation—are related with the success of development strategies. Managing both the tangible (i.e., physical infrastructure and buildings such as transport, property and utilities) and intangible assets (i.e., knowledge, collaboration and creativity) contributes to the competitiveness of cities (Fig. 2).

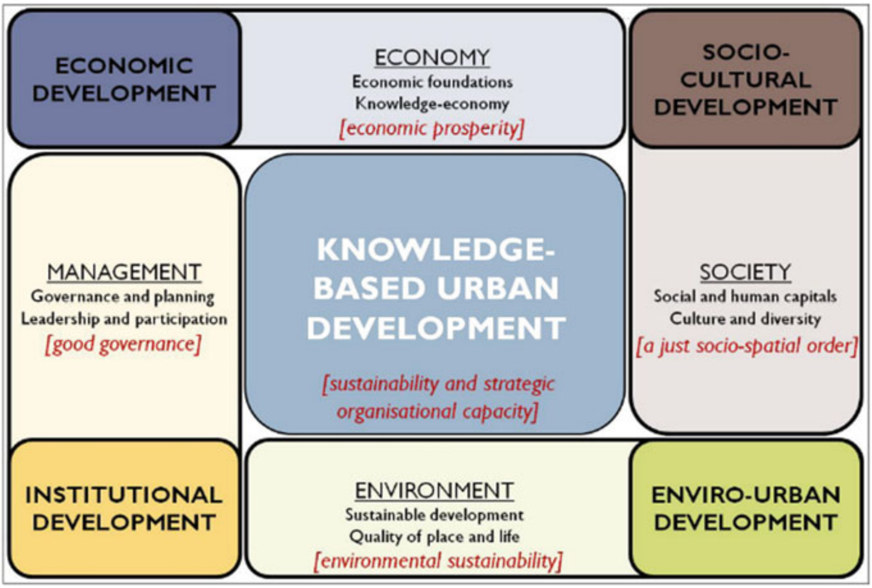

Fig. 2 Knowledge-based urban development model. *Source* Sarimin and Yigitcanlar [51]

2.3 Clusters of Innovation

Clusters of Innovation (COI) are global economic "hot spots" where new technologies germinate at an astounding rate and where pools of capital, expertise, and talent foster the development of new industries and new ways of doing business [18]. A COI is similar to, but somewhat different from, the well-established understanding of a business cluster [26]. In a COI, the entrepreneurial process is a mechanism for continuous and rapid innovation, technology commercialization, business model experimentation and new market development, and the process is encouraged by a dense venture capital cluster and the related facility for the creation of well structured, funded and connected start-ups. In these environments, start-ups benefit from being co-located with other providers, including lawyers, bankers, venture capitalists and a myriad of consultants who are well versed in the needs of start-ups and small technology companies [52].

The emergence of clusters in new industries that do not benefit from agglomeration externalities indicates the presence of several factors that characterize a COI [14], namely: (1) new firm creation as a rapid and frequent mechanism for innovation, technology commercialization, business model experimentation and new market development; (2) staged risk taking and commitment of resources; (3) rapid market testing and validation or failure; (4) tolerance of failure; (5) continuous recycling of people, money, ideas and business models; (6) intra- and inter-firm mobility of resources; (7) shared identities and values; (8) alignment of incentives and goals; and (9) a global perspective.

In 2009, Engel and Del-Palacio extended Porter's definition of industrial agglomeration to delineate a Global Cluster of Innovation framework that describes business clusters defined not primarily by industry specialization but by the stage of development and innovation of the cluster's components. While industry concentrations do exist, they are not definitive. It is rather the nature and the behaviour of the components that is distinctive—the rapid emergence of new firms commercializing new technologies, creating new markets, and addressing global markets [18] (Fig. 3).

2.4 The Lifecycle of a New Venture

The evolution of an ecosystem of innovation can be mapped in 4 phases following the analogy of the lifecycle of a new venture: inception, launching, growing and maturity [26]. Four steps were also proposed in the evolution of regional innovation ecosystems [22], including the development of the idea of a new regional model, the starting of new activities, the consolidation and adjustment and the self-sustaining growth of the ecosystem.

In contrast to biological evolution—which arises from mutations and natural selection—co-evolution occurs through a conscious intervention of every agent or with the creation of new hybrid organizations as a mix in terms of governance of universities,

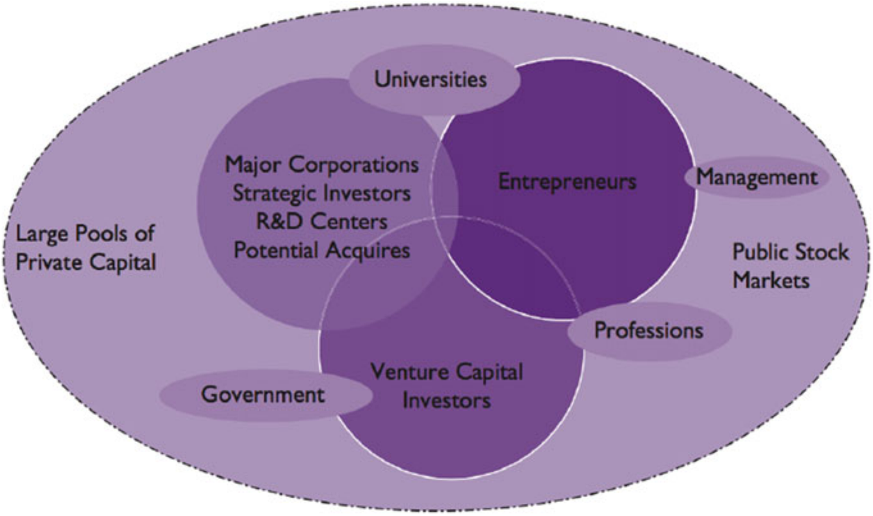

Fig. 3 Clusters of innovation theory. *Source* Engel [17]

industry and government—such as clusters or science parks [38]. Knowledge-based economic development can be traced to specific actors, typically operating in collaboration with each other. The institutional functions most appropriate to succeed can also be implemented from academic, industrial and governmental spheres. When one sphere is lacking, part of a knowledge based-strategy will substitute that actor and fill the gap [24].

Each phase will require the contribution of the Triple Helix agents—universities, industry and government—for urban, economic and social development to take place. In this study we aim to characterise, at each stage, the role played by each of the Triple Helix agents, and more importantly, how this contribution is shaping the subsequent stage, that is, boosting or hindering the evolution. The roles adopted by Triple Helix agents can change from phase to phase. Also, the roles might be connected with other's functions in the same phase but also in the forthcoming ones. For instance, in the urban dimension the government's regulation of the land in the inception stage will allow, in the subsequent phases, the investment of real estate companies in buildings and the use of the offices by start-ups.

In countries that—to a less or further extent—rely on central planning, it has become accepted that government programmes have an important role to play, not only from the national level (top-down) but also from the local level (bottom-up), often in collaboration with other organizations from the civil society (Fig. 4).

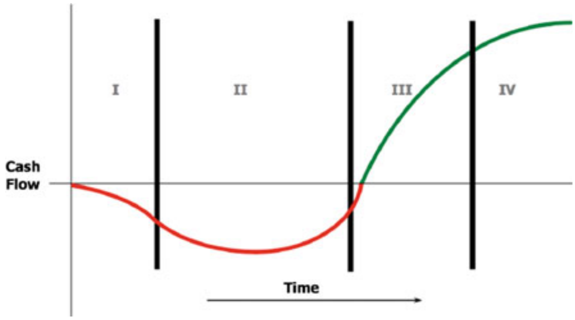

Fig. 4 Lifecycle of new venture model. *Source* Engel, from "The Innovative Organisation", session held in June, 2017, Berkeley, CA

3 Research Strategy

3.1 Research Objectives and Scope

Three are the main research questions that this work aims at answering:

(1) How do ecosystems of innovation evolve?
(2) Does the Triple Helix model (university-industry-government) help to understand the KBUD in the urban, economic, social, and governance dimensions?
(3) How does the role of the Triple Helix agents evolve in the different phases of the lifecycle of an AOI (inception, launching, growing and maturity)?

To address the above research questions, we have divided this research into four studies. Figure 5 graphically illustrates the research strategy followed, and the scope of each study.

In order to respond to the above questions, we rely in the theoretical frameworks revised in Sect. 2. Specifically, we use the Triple Helix model [5, 7, 21] to characterize the role of the university, the role of the industry, the role of the government, the role of the society (Quadruple Helix) and the role of the environment (Quintuple Helix). We use the Knowledge Based Urban Development paradigm [51] to investigate different areas of development: social and cultural, economic, environment and urban and governance. The Clusters of Innovation model [16] is helpful for the analysis of the mobility of people, capital and technology. Lastly, we use the different stages of the lifecycle of a new venture [22, 26]—namely, inception, launching, growing and maturity—to map how Areas of Innovation evolve the evolution of an Area of Innovation.

The first study, *Modelling the Ecosystems of Innovation* [45], tries to give a response to research questions (1) and (2). It is focused on a holistic model of Areas of Innovation in Cities, analysing the urban, economic, social, and governance dimensions of urban revitalizations. In this study we posit that the creation of innovation districts, scientific parks, urban clusters and smart cities has become a common tool for urban revitalisation. Usually, it has been applied in former industrial neighbourhoods in need of regeneration (brownfield), as it is the case of *22@Barcelona*. In

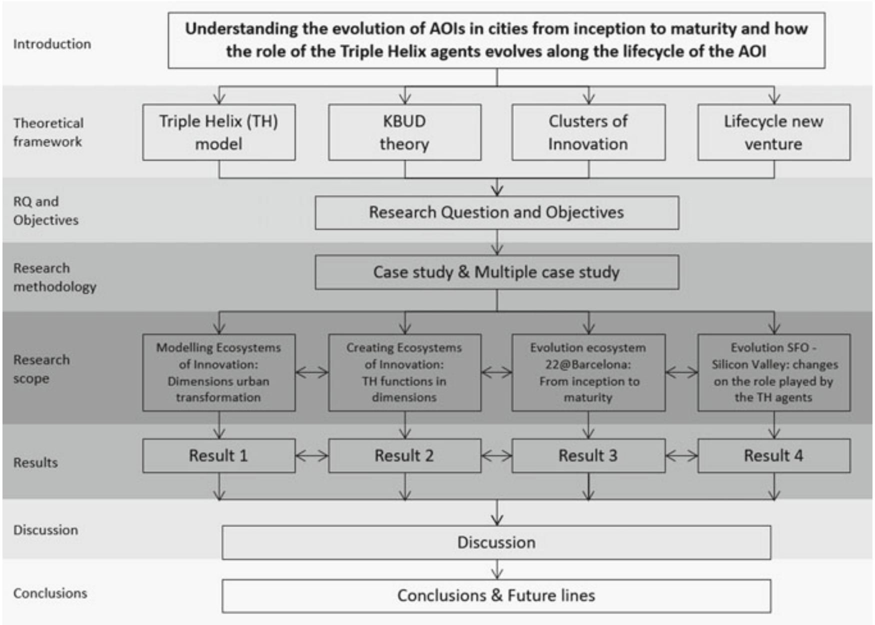

Fig. 5 Research scheme

other cases, projects are starting from scratch (greenfield) as in Skolkovo Technopark. The top-down approach to this type of urban development requires not only a clear methodology but also an in-depth knowledge of the context as well as of the stakeholders that participate in the transformation. Factors for success and failure related to the transformation of an area have been widely studied and documented [37, 40]. Yet, the mechanisms through which how cities and urban environments can promote the engagement and attachment of talented people in the nurture of the knowledge economy remains little explored. It becomes thus essential to provide mechanisms and tools to develop a dense network of relations that not only stimulates talent but also transforms it into added value creation. Aiming at fulfilling this goal, this study proposes a holistic model for Areas of Innovation in cities. Several variables will be taken into account on the effect this type of development might have as a driver for change in the city.

The second study, *Urban Revitalization: Creating Ecosystems of Innovation* [46], is focused on the role of the Triple Helix agents (university, industry and government) in every dimension of the urban transformation, and also aims at answering research questions (1) and (2). In this case, we argue that the revitalization of cities impacts on the urban, economic, social and governance dimensions [39, 51]. In this context, Triple Helix agents [21] can play different roles at each dimension. This study examines the revitalization of cities under the perspective of the Triple Helix model applied at Urban Development. To do this, four Brazilian cases in the process of revitalization of urban areas are analysed: *Porto Digital* (Recife), *Porto Maravilha*

(Rio de Janeiro), *4º Distrito* (Porto Alegre) and *Centro Sapiens* (Florianópolis). The *22@Barcelona* is included as a control case. Started in 2000 the *22@Barcelona* has now become a world reference of districts of innovation [28, 41]. It also exemplifies how the Triple Helix agents can cooperate in the Urban Transformation [23, 43]. Although each city and district is unique, regeneration of old districts share similar dimensions that can be extracted from a Triple Helix perspective. This study is guided to allow: (1) theoretical learning regarding the Knowledge Based Urban Development and the role of the Triple Helix agents; (2) the understanding of the role of Triple Helix agents in the *22@Barcelona*; and (3) an analysis on the Brazilian projects that, through a series of interventions of the Triple Helix agents, are recovering the strength of their cities.

The third study, titled *Evolution of ecosystems of innovation: the 22@Barcelona Case* [47] is simultaneously addressing the three research questions. In this case we adopt a case-oriented approach. Specifically, we examine the *22@Barcelona* innovation district, a case of a sound effort in building an Area of Innovation promoted in the metropolitan area of Barcelona that flourished from a traditional industrial district regenerated in an inner district of the city. The goal of this study is to better understand the evolution of Areas of Innovation, from inception to maturity, and investigate how, the role of the Triple Helix agents changes over their lifecycle. The *22@Barcelona* case is currently a model for ‘innovation districts’ in cities [10, 13, 42]. Also international stakeholders such as the International Association of Science Parks and Areas of Innovation (IASP) consider *22@Barcelona* as a reference source for policy transferability and experience-based knowledge. More than 354 delegations from all continents visited *22@Barcelona* from 2011 until 2015 according to the data from the Barcelona City Council.

Last but not least, the forth study explores the three research questions and is focused on the *Evolution of San Francisco - Silicon Valley ecosystem* [3]. In this study we argue that Silicon Valley has been at the top of ecosystems of innovation for so many years that many voices are now arising trying to identify why it will soon fail. But Silicon Valley seems to always recover and find a way to improve and tune its ecosystem in a more efficient way. This study aims at identifying and characterising the changes experienced by the Triple Helix agents in a strong entrepreneurial environment such as Silicon Valley. Also, the study tries to identify if the changes experienced by one of the agents trigger the evolution of the others. To do so, a timeframe—from 2006 to 2016—is considered. The focus is thus on how the role played by universities, industries and the government has changed during the past 10 years in Silicon Valley, paying special attention to their impact on start-ups creation.

3.2 Methodology

In the Foreword of the book “*Case Study Research: Design and Methods*” [63], Donald Campbell asserted that “*the core of the scientific method is not experimentation* per se *but rather the strategy connoted by the phrase ‘plausible rival hypothesis*”.

Case studies are extensively used in social science research [63], including the traditional disciplines (psychology, sociology, political science, anthropology, history and economics) as well as practice-oriented fields such as urban planning, public administrations, public policy, management science, social work and education.

The case study is one of several ways of conducting research in social sciences. Case studies are the preferred strategy when "how" or "why" [63] questions are being posed, when the investigators have little control over events, and when the focus is on a contemporary phenomenon within some real-life context. Case studies are found even in economics, in which the structure of a given industry of the economy or a city or a region may be investigated by using the case study method. In all these situations, the distinctive need for case studies arises out of the desire to understand complex social phenomena. In brief, the case study method allows retaining the holistic and meaningful characteristics of real-life events such as life cycles, organizational processes, neighbourhood change and the maturation of industries. That's the situation of the four studies that integrate this work. More specifically, we use single and multiple-case studies, combining both qualitative and quantitative information.

4 Discussion

From the results of the four studies, several implications can be drawn. This section groups the main implications into for domains: (1) cities as platform of the knowledge based economy; (2) city revitalization needs urban, economic and social transformation; (3) Triple Helix agents develop different functions in city transformation; and (4) Triple Helix agents change the role in the lifecycle of an Area of Innovation.

4.1 Cities, the Platform of the Knowledge Based Economy

Cities are the platform of the knowledge based economy because they are the platforms of talent, the real raw material of the new economy. Cities must provide a good place for working and living if they want to attract, retain and create talent [39]. On the other hand, cities are also a goal of innovation. For this reason, they can be a place for learning new applications. Policy makers, universities and industry can use the city as a lab to learn locally in order to compete globally.

The Quadruple Helix model includes the demand side of innovation. Citizens are the beneficiaries of the innovation, but also they could play a key role in the process of innovation [44]. Cities that want to develop Areas of Innovation will need to develop hard factors and soft factors for urban, economic and social transformation.

Both greenfield and brownfield developments should create an ecology of innovation that will include all the agents of the ecosystem (universities, industries and government). The starting point may be different, but the vision must be clear in the direction of the knowledge based economy and society. Cities should understand the challenges to achieve this vision, and develop actions to address the urban, economic and social challenges, taking advantage of the capabilities of the agents of the ecosystem [45].

4.2 City Revitalization Needs Urban, Economic and Social Transformation

We can summarize the lessons obtained from the Brazilian cases [46]:

- Holistic approach: The urban revitalization needs an integral approach, including the (1) infrastructure and urban dimension, (2) businesses and economic dimension, (3) talent and social dimension, and (4) governance dimension.
- Urban transformation: Each project needs (1) an urban plan, (2) an infrastructure plan, and (3) a legal framework that allows the use of the land for knowledge based activities, and the attraction of real estate investors for retrofitting old buildings and creating new office and public spaces. *22@Barcelona* and the Brazilian cases have special laws for urban planning and infrastructures plan.
- Economic transformation: Innovation districts need smart specializations. This implies selecting what sectors (clusters) to be developed and what agenda of technologies is needed for the value chains of innovation.
- Social transformation: Talent is a key asset of the knowledge based economy and society. Innovation districts must develop a strategy for talent creation, development, attraction and retention, and provide enjoyable spaces where to live and work.
- Governance: The Triple Helix agents play a key role in the transformation, and should create hybrid organizations (public private partnership platforms) in order to share the vision to achieve in the innovation district, and to add actions to be developed in all the dimensions of the project.

4.3 Triple Helix Agents Develop Different Functions in City Transformation

Areas of Innovation need urban, economic and social transformation. The role of each agent of the Triple Helix model (Government, Universities and Industry) is different depending on the dimension of the transformation [3, 46, 47]:

- Government, in the local, regional (state) and national (federal) levels plays a key role in the transformation. In the urban dimension, it defines the uses of the land, the infrastructures plan, green spaces and the incentive for real-estate developers. In the economic dimension it invests in research and technology, promote attraction of companies and the creation of new start-ups, promote clusters and create conditions for pilots. In the social dimension, it creates the conditions for living and working, including housing and schools.

– University is the source of talent and technology. The university is a key tool impacting at all the dimensions. In the urban dimension, they develop land and buildings as anchor institutions (for research, teaching, incubation and residences). In the economic dimension, they provide science, technology, labs and entrepreneurs to the ecosystem. In the social dimension, provides fresh talent to the district and experienced staff that will be also living in the district.
– Industry represents all the companies—of different sizes in sectors—in the area. In the urban dimension, on the one hand, through real state, develop and build new building and retrofit old ones for new proposals; utilities companies provide the key infrastructures; end users use the buildings and provide the return of investment. In the economic transformation dimension, large corporations, SMEs and new start-ups are clustered with universities and institutions, creating jobs and turnover. Lastly, in the social dimension, the industry provides professionals to the district as citizens, and allows talent to be involved in companies with internship and jobs.

4.4 Triple Helix Agents Change the Role in the Lifecycle of an Area of Innovation

The case of *22@Barcelona* provides evidence that, in each phase, each agent works in a different way, and that all agents are necessary to fulfil all the phases. A co-evolution process is therefore developed, interacting government, universities and industry. All agents need the others to evolve, and hybrid organizations as clusters are coordinating expectations and actions. Main roles that should be performed at each stage are summarised below [47]:

– Inception: A clear leadership of the government is needed to create an AOI (in some cases the Mayor of the city, in others regional and national policies). The involvement of the universities and association of companies are key factors to generate the vision and trust in the project. Without clear rules of the uses of the land and clear vision about the type of AOI will be difficult to advance in all the transformation.
– Launching: The AOI will need basic infrastructures for starting, and the first buildings to settle the first users. Also, tractor companies and universities will be necessary for stimulating others to come. The AOI will need full time managers for promoting the place and organizing the landing of organizations and investors.
– Growing: Investors will need clear pieces of land or buildings to invest or build. A cluster strategy should be developed in the district. The creation of start-ups will be one of the sources of growing and innovation. Synergies among the tenants in the district should be developed. In the social dimension, international professionals

will need landing aid and the creation of communities and networks of people will generate synergies and sense of belonging.
– Maturity: The AOI must evaluate the opportunities to expand the area around the original district, or transferring the experience to other zones of the city. The AOI should be a hub of innovation connecting with other parks and areas, creating superclusters of international networks. In the social dimension, the AOI will include the whole society being involved. In terms of governance, the leadership of the area should be in the hands of the associations of companies and social entities.

5 Concluding Remarks

5.1 Conclusions

This work aims to contribute to the understanding of the revitalization projects of metropolitan areas and the evolution of ecosystems of innovation.

Adopting a case study approach, in this work we have explored four Brazilian urban revitalizations, the evolution of *22@Barcelona* Innovation District and San Francisco-Silicon Valley Ecosystem. Several are the lessons learned.

First, we have been able to characterize and map the role of the different agents of the Triple Helix (government, universities and industry). Also, from the analysis it can be inferred that role differs depending on the dimension of the transformation. Specifically, from the government's standpoint, the case illustrates that this stakeholder should add and impact with projects in the same area mixing local, regional, national, and in some cases international bodies (like the case of the European Union or international organizations). The government plays key roles in urban planning, infrastructures regulation and urban services. In turn, these, attract companies, promote entrepreneurship, develop sectorial programs and invest in research, innovation, entrepreneurship and sophisticated demand. Public-Private Partnerships are needed to organize and add all public and private contributions. In the case of *22@Barcelona*, the City Council played a key role in public and private leadership. From the standpoint of universities, we have seen that these institutions perform the role of the entrepreneurial university as defined by Clark [12]. Universities provide talent from education, technology from research, and knowledge-based entrepreneurs from university incubators. Universities are key pillars of the knowledge-based economy. Universities also transform the urban dimension with their buildings in the city. They are anchors and magnets of knowledge-based companies and service companies. They impact on the community providing fresh and young talent that will be mixed with the neighbourhoods, transforming the life of the streets. In the case of *22@Barcelona*, universities are the lighthouses of urban, economic and social transformation. Lastly, in the case of the industry, companies are located in the Area of Innovation in order to offer professionals a place for working. Companies can take advantage of the outputs of the universities, hire talent, use labs, absorb technology, and interact with the new knowledge-based start-ups. Also, companies provide experience, market technologies and focus on the real needs to Universities. They can cluster with other companies, start-ups and institutions. In the urban dimension, they are the tenants of the building owners, and pay the bill of the investment of the real estate developers. *22@Barcelona* developed a comprehensive cluster strategy, attracting investors and promoting entrepreneurship.

Second, from the above analysis, it can be distilled that every member of the Triple Helix works in all the dimensions from different perspectives, but all the members are needed in order to produce an urban, economic and social transformation. Hybrid organizations can be also created for joining efforts and activities. In the *22@Barcelona*, such organisations are exemplified by the Cluster programs and the Public-Private-Platforms partnerships. Likewise, governance platforms are needed to organize and coordinate agents and functions. In the case of *22@Barcelona*, Horizontal (22@Network) and Vertical (Clusters) were used to orchestrate the ecosystem of Innovation.

Third, we have been able to test the adequacy of applying the evolution model of an Area of Innovation using the phases of a new venture. In this sense, the *22@Barcelona* case is very illustrative, as it reveals that in each phase, each agent works in a different way, being however, all of them necessary to accomplish the ultimate goal. In this respect, a co-evolution process is required, with government, universities and industry interacting. Hence, all agents need the others to evolve, and hybrid organizations are necessary to coordinate expectations and actions. Particularly, from an in-depth analysis of the different phases, we can conclude that, in an inception stage, a clear leadership from the government is needed to create an Area of Innovation (in some cases the Mayor of the City, in others, regional and national policies). The involvement of universities and the association of companies are key factors to generate the vision and trust in the project. Without clear rules of the uses of the land and clear vision of the kind of Area of Innovation to be built, it will be difficult to advance in all the transformation. In the launching phase, the Area of Innovation needs basic infrastructures for starting, and the first buildings to settle the first users. Also, tractor companies and universities are paramount to stimulating newcomers. The Area of Innovation will need full time managers for promoting the place and organizing the landing of organizations and investors. In the growing stage, investors need clear pieces of land or buildings to invest or build. This means that the development of a cluster strategy is paramount. The creation of start-ups is one of the sources of growth and innovation as well as the establishment of synergies among the tenants in the district. In the social dimension, international professionals will need landing aid and the creation of communities and networks of people will generate synergies and a sense of belonging. Lastly, during maturity, the Area of Innovation must evaluate to expand the area around the original district and/or transfer the experience to other zones of the city. The Area of Innovation should be conceived as a hub of innovation connecting with other parks and areas, creating superclusters of international networks.

Fourth, it is worth signalling that in each phase, the Triple Helix agents work for the next phase. That is, the government defines the use of the land, allowing universities and companies to locate in the Area of Innovation. In return, universities develop the academic offer, providing talent to the companies. Also, universities should promote entrepreneurship, as a way to generate new start-ups that government and investors can fund in order to provide new innovations at the ecosystem. Big Corporations can buy start-ups as a way to absorb innovation. Operating like this, the horizontal value chain of the urban, economic and social dimension is vertically connected to the governance of universities, industry and government. In the case of San Francisco—Silicon Valley, Universities are getting closer to industry and the Big Corporations engage sooner with start-ups.

Fifth, the ecosystems of innovation evolve, but only if each Triple Helix agent co-evolves its role when others adopt new functions. In the specific case of *22@Barcelona* we have seen that for the case of urban transformation, the first effort came from the Government, investing in infrastructures. In a mature moment, the real estate took this role and invested in new buildings instead of the government. In the economical dimension, when the culture of entrepreneurship was needed, public programs were launched to provide financial aid to start-ups, while in a mature stage, business angels and venture capital firms led the investments. Lastly, in the social dimension, in the inception stage changing the traditional mindset of the neighbourhood was crucial, while in a mature stage the culture of innovation and entrepreneurship was instilled in schools. In the specific case of San Francisco-Silicon Valley, from the analysis of data collected during the interviews, we can conclude that the role of the Triple Helix agents evolved with time. The main changes identified during the study are (1) raise of accelerator programs as new player in the ecosystem; (2) early engagement of some corporations with start-ups; (3) geographical expansion of Silicon Valley, now including San Francisco; (4) increasing commitment of universities with capital funds; and (5) raise of micro-multinationals due to talent shortage and fierce competition in the area. Other changes have helped to increase the efficiency of an already highly innovative ecosystem.

Overall, we posit that *22@Barcelona* is a good example to illustrate that every agent of the Triple Helix has its internal agenda. Universities play a long-term vision, government has the elections timeline in its agenda, and industry pays salaries every month and shows the results on an annual basis. Aligning vision agendas at short, middle and long term is paramount, at the governance level, in order to make the ecosystem evolve in a synergic way as the *22@Barcelona* one has done.

In the case of San Francisco-Silicon Valley, through the changes identified in this study, we can conclude that the role of Triple Helix agents has evolved over time in Silicon Valley. Since the Triple Helix model is used to characterize an Ecosystem of Innovation, we can extrapolate that the Ecosystems of Innovation also evolves over time.

5.2 Limitations and Future Lines

Although this work provides useful insights into the analysis of ecosystems of innovation in urban areas, we identified some limitations that clearly represent future research lines. Concerning the methodological approach, it is worth highlighting the limited number of cases covered. We encourage future studies to corroborate the model of Areas of Innovation presented with quantitative data validating the effectivity of the model as a tool to analyse the impact of the interventions of the Triple Helix agents in all the dimensions of the transformation and the lifecycle of the Area of Innovation.

As for the theoretical foundations, this research is grounded in the Triple Helix Model in order to understand the role of the universities, industry and government developing urban ecosystems of innovation. While the model seems appropriate, future studies might consider adding other perspectives (Regional Innovation Ecosystems) and theories (Open Innovation) to better understand how the different agents interact and evolve.

It is also important noting that this work has focused on the analysis of Areas of Innovation in urban areas. A recommendation for further studies relates to exploring the usefulness of our model in other settings, that is, changing the unit of analysis. For instance, it would be interesting analysing how the model proposed here applies to regions (adopting a more “macro” approach). Likewise, the model can also be applied to non-urban areas that want to develop ecosystems of innovation. Cases like Atlanpole in France or Richardson Telecom Corridor in USA are Areas of Innovation that work beyond the city as epicentre of the ecosystem of innovation are just some examples. This scenario opens new challenges on governance, urban, economic and social development.

Lastly, this study has mainly focused on brownfield cases, that is, transforming districts or parts of the city with previous activities. Further research could explore how to apply this model in unused zone development, such as areas without any urban legacy (greenfield transformation). The Yachay City of Knowledge in Ecuador is an example that might benefit from the application of this research to its specific context.

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How to Measure Triple Helix Performance? A Fresh Approach

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Abstract Global and local success of a country is largely dependent on the level of collaboration between the three main pillars: Government, Industry, and Academia. Successful management of this collaboration requires development and observation of performance measures. In the past few years, a steep rise of interest in composite indices is detected. They measure different aspects of national performance: innovativeness, entrepreneurial activities, sustainability, etc. Approaches to measuring the Triple Helix synergy have been introduced before. In particular, applications of Shannon's equation grasped the attention of various researches. Still, a single measure for comparing countries has yet to be introduced. This paper aims at establishing the performance measure of industry-university-government relations. As a case study, OECD countries are compared based on the indicators from the official OECD Main Science and Technology Indicators, classified according to the Triple Helix actors. The authors apply the two-step Composite I-distance method for creating composite measures of multivariate problems. The results imply that it is possible to measure the Triple Helix performance at the national level. These measures provide valuable data for more effective management within and among main Triple Helix actors. The policy-makers may use the results to determine further development directions and corrective measures.

Keywords Triple helix measures · Performance management · Composite indicator · Two-step Composite I-distance · OECD

1 Introduction

Science and technology are important determinants of national development. Continuous upgrading of technological capabilities is seen as a necessity for both firms and countries to reduce the technology gap and remain competitive and competent [22, 51, 52]. However, contemporary exponential changes put some new challenges to cope with. Thus, it is essential to have a successful collaboration between the three

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main pillars of an economy: Government, Industry, and Academia. Triple Helix (TH) concept emphasises the importance of this collaboration and highlights the role of the University as a leading actor in this synergy [13, 14, 38]. Intensive research and development (R&D) activities are not always resulting in successful innovation. The *Swedish paradox* has shown that the R&D investments did not manifest the appropriate level of production due to the specific nature of firms and national environment in Sweden [12]. This phenomenon highlights that there is a high proportion of Gross Domestic Product (GDP) invested in formal R&D activities with below-average R&D-intensive production in comparison to the other OECD countries [12]. Similarly, Levi Jakšić et al. [35] specify the so-called *Serbian paradox*, where there is a disproportional amount of investment in scientific R&D activities in comparison to the commercialisation results on the market, with missing entrepreneurial link. The phenomenon even emerges as the *European paradox* that represents the stagnation of economic growth despite of the high level of R&D investments [34, 39]. Thus, the proper management of the main national activities and collaboration is essential for the successful return on investment. However, a wide scope of the activities of these subjects is one of the major reasons why it is difficult to manage their interaction. This interaction is to be coordinated at the national level with structured roles, actions, and measures. This is a very challenging task, due to the scope of the activities of these three main pillars. Nevertheless, it is also a necessity because these measures provide an in-depth analysis of their performance, which is crucial to provide the control of their interaction, identify the gaps, make improvements, and derive the implications for future strategies and development directions [34]. Despite the importance of this topic, there is still no widely accepted methodology for measuring the TH performance and covering all specific areas. In the paper the authors suggest a fresh, comprehensive approach to measuring this phenomenon.

The paper is structured as follows. Section 2 examines previous efforts and approaches used for measuring the TH management performance. Next section presents the two-step Composite I-distance method used in this paper and explains the selected set of indicators and the research sample. Section 4 gives the results obtained in the research. Section 5 discusses the results and explains the implications, limitations and further research. In the end, the authors give the conclusion of the research.

2 Measuring Triple Helix Performance—A Literature Review

Recently, various composite indices examining a countries' global performance emerged [31]. Nations are struggling to "win a gold medal" on different ranking lists for global competitiveness, innovativeness, and sustainability. However, none of the official institutions evaluates how successful is the interaction between national actors, nor how effective is the implementation of the policies.

Etzkovitz and Leydesdorff [14] created an analytical tool to explain the complex dynamics of the relationships and activities of the institutional arrangements between academia, governmental agencies, and industries [13]. The systems nature of the model, with clear roles and actors, makes the concept perfectly suitable for creating a performance measure that will help to identify the weak links and recognising good practices in a national system. This concept draws the attention of the researchers. Journals are having special issues about this topic [41], researchers developed the model for assessing technology management [34], and suggest new indicators [44]. However, complex and interweaving activities of the three main pillars make it difficult and challenging to develop a proper, comprehensive methodological approach.

Each complex management system must be observed through a number of indicators that are appropriate for the examined phenomenon. As Peter Drucker states "never look at any one measure alone in any business: look at multiple measures… I have given up even looking for the right measure. I want multiple measures" [10]. Examining the emerging research field of the TH indicators and providing a review of the existing measures, Meyer et al. [48] stress out: "… more enriched indicators that are multi-layered and multi-dimensional are required to unpick the situation from different and differing angles, thus allowing for the heterogeneity of the different actors to be voiced and heard". However, there is still no widely used composite index methodology of TH performance [61].

Singer and Oberman Peterka [61] examined the existing methodologies and justified the need for the evaluation of the TH performance. They highlight the main issues and specific characteristics that a potential methodology should cover but do not propose a concrete solution. On the other hand, Leydesdorff and Meyer [39] in their research on the TH indicators derive an analytic scheme from the neo-evolutionary perspective, where the patents have a crucial role and are listed as a main indicator of the successful innovation system. Although patent activity is one of the main outcomes of R&D activity, this indicator does not capture all complex aspects of the TH relations. Patents are also determined as the leading indicator in the study written by Meyer et al. [49], where the so-called hybrid indicators were used to evaluate the collaboration of the TH pillars. From another perspective, Xu et al. [63] assess the success of university-industry-government publishing activity. They compare the results of individual TH pillars, but also the double helix (i.e. the number of papers as a result of industry-university collaboration) as well as the triple helix collaboration. This approach evaluates the TH partnership in a proper way but encompasses only one perspective of the research activity. An interesting approach was suggested by Tarnawska and Mavroeidis [62]. They used the efficiency approach to estimate the knowledge triangle policy in 25 EU member states. They applied the Data Envelopment Analysis (DEA) on a set of 6 variables that measure various aspects of a national ecosystem. The results provided insights to estimate which EU country is efficient in its knowledge-based activities. Although this method is suitable for the problem of measuring the TH performance, the conducted research is related to the limited set of chosen variables. Mêgnigbêto [46] applied game theory in his research, where he structured the model of TH relations and examined synergy indicators. However, this research was again based solely on number of papers as a leading indicator.

To the best of our knowledge, the most developed approach to measuring the TH performance is based on the Shanon's entropy formula [13]. This approach uses probabilistic entropy to measure the synergy of three TH dimensions and estimates the reduction of uncertainty in a system [23, 36, 37]. Although Loet Leydesdorff successfully applied this approach in the Netherlands, Germany, Hungary, and Russia, it measures the internal consistency of the system and does not put the emphasis on the entrepreneurial role of the university [40]. Additionally, the approach does not provide an insight on the performance of the actors and does not enable detection of the weak links in the system.

This paper proposes another approach to measuring TH management performance. The two-step Composite I-distance (CIDI) is used as the aggregation method, on a set of OECD's main science and technology indicators [52]. The measured activities are related to each TH actor and oriented on more than one aspect of R&D activity. Next section gives the details on the research methodology.

3 Methodology

3.1 Creating a Composite Measure

In this paper, the authors followed the steps listed in the OECD guidelines for the creation of the composite indicators [53]: (1) Developing a theoretical framework; (2) Selecting variables; (3) Imputation of missing data; (4) Multivariate analysis; (5) Normalisation of data; (6) Weighting and aggregation; (7) Robustness and sensitivity; (8) Back to the details; (9) Links to other variables; (10) Presentation and dissemination. The theoretical framework is set based on the TH model, and the relevant indicators are selected from the set of the Main Science and Technology indicators measured by the OECD [54]. These indicators evaluate science and technology performance of a country and are related to R&D, patent activities, technology balance of payment (BoP), and international trade. What is even more important, these indicators are convenient to be used in the TH performance model, since the indicators are measured separately for Industry (Business), Government, and University (Higher Education). Performance measurement based on composite indices has some common issues that should be stressed out. This mainly refers to choosing the variables, methods for the pretreatment of data, and the weighting and aggregation scheme [26, 31, 45]. Subjectivity, reliability, and availability of data are also some of the main concerns [57, 65]. To overcome these issues the authors used an objective set of quantitative indicators measured by an official institution. OECD provides quantitative, objective data for almost all 130 indicators measured in 36 OECD member countries. Since some of the data was redundant as well as highly correlated, a set of 20 indicators was selected for this pilot research to test the applicability of the CIDI method. The selection was based on the bibliographical research given in Table 1.

Table 1 Literature review of the indicators

Pillar	Indicator	Source
Industry subindex	Business Enterprise researchers as a % of national total	Jones-Evans et al. [29], Murashova and Loginova [50], Mahroum [42]
	BERD as a % of GDP	Pessoa [55], Filippetti and Peyrache [17], Falk [15, 16], Aiginger and Falk [1], Sandu and Ciocanel [58], de la Potterie [5], Murashova and Loginova [50], Havas [20]
	Business Enterprise researchers (FTE)	Havas [21], Zabala-Iturriagagoitia et al. [64]
	% of GERD performed by the Business Enterprise sector	Jones-Evans et al. [29], Dosi et al. [9], de la Potterie [5], Murashova and Loginova [50], Havas [20]
Government subindex	% of GERD performed by the Government	Dosi et al. [9], de la Potterie [5], Havas [20]
	Government researchers as a % of national total	Havas [20]
	GOVERD as a % of GDP	Sandu and Ciocanel [58], Filippetti and Peyrache [17], Zabala-Iturriagagoitia et al. [64], Havas [20]
	% of GERD financed by government	Coccia [4]
	Government researchers (FTE)	Zabala-Iturriagagoitia et al. [64], [21]
	% of GOVERD financed by industry	Serbanica [60]
University subindex	% of GERD performed by the Higher education sector	Jones-Evans et al. [29], Murashova and Loginova [50], Havas [20], Santiago et al. [59]
	Higher education researchers as a % of national total	Jones-Evans et al. [29], Murashova and Loginov [50], Santiago et al. [59]
	HERD as a % of GDP	Jones-Evans et al. [29], Filippetti and Peyrache [17], Murashova and Loginova [50], Havas [20]; Santiago et al. [59]
	Higher education researchers (FTE)	Zabala-Iturriagagoitia et al. [64], Havas [21], Santiago et al. [59]
	% of HERD financed by industry	Dosi et al. [9], Serbanica [60], Havas [20], Santiago et al. [59]

(continued)

Table 1 (continued)

Pillar	Indicator	Source
Ind-**Gov**-**Uni** subindex	Technology BoP: receipts	Guellec and de la Potterie [19], Lee and Park [33], Mendi [47]
	Technology BoP: payments	Guellec and de la Potterie [19], Mendi [47]
	Total R&D person./thousand labour force	Coccia [3], Jones-Evans et al. [29], Murashova and Loginova [50], Havas [20]
	No. of "triadic" patent families	Baudry and Dumont [2], Filippetti and Peyrache [17], Lee et al. [32], Lee and Park [33], Dernis and Khan [6]
	GERD per capita population	Coccia [3], Fred [18], Havas [20]

Initially, the research covered all 36 OECD countries, but the United States of America, Turkey, and Chile did not have complete data. The missing data imputation could not have been performed, so the countries were excluded from the research. Since Lithuania became a member state in July 2018, it was also excluded from the research. The research results, implications and conclusions are based on the 2015 data from 32 OECD country members.

3.2 Two-Step Composite I-Distance Method

In the literature review, the authors recognised a research gap for composite index methodology that evaluates TH performance. Some previous research identified the multivariate I-distance method as the appropriate approach for aggregation of individual indicators into one composite measure [7, 27, 28]. This method has proven to be a stable ranking methodology [11, 30, 43], as it was established in 1970's as a method for ranking countries according to their socio-economic development [24, 25]. This research uses its variation—the two-step Composite I-distance (CIDI).

The first step of this methodology is to determine the I-distance value based on a set of indicators. For a selected set of indicators (entities) $X^T=(X_1, X_2, \ldots X_k)$, the square I-distance between the two entities $e_r=(x_{1r}, x_{2r}, \ldots, x_{kr})$ and $e_s=(x_{1s}, x_{2s}, \ldots, x_{ks})$ is defined as

$$D^2(r,s)=\sum_{i=1}^{k}\frac{d_i^2(r,s)}{\sigma_i^2}\prod_{j=1}^{i-1}\left(1-r_{ji.12\ldots j-1}^2\right) \quad (1)$$

where $d_i(r, s)$ is the distance between the values of variable X_i for e_r and e_s, e.g. the discriminate effect, $d_i(r, s)= x_{ir} - x_{is}$, $i \in \{1, \ldots, k\}$, σ_i is the standard deviation of

X_i, and $r_{ji.12 \ldots j-1}$ is a partial coefficient of the correlation between X_i and X_j, $(j < i)$, [24, 25]. Calculation of the TH performance index followed these steps:

(1) I-distance calculation for the 4 pillars based on the set of indicators for each pillar;
(2) I-distance calculation of the TH performance index based on the 4 pillar values.

I-distance values also determined the set of weights for the indicators. The main feature of this methodology is that it does not use a predetermined set of weights. The values are based on the coefficients of determination between the calculated I-distance value (D^2) and input indicators. In this way, the subjectivity of weights, one of the main issues of most methodologies, is significantly reduced by replacing expert-driven weights with the data-driven [8]. The final value of the weights is determined by:

$$w_i = \frac{r_i}{\sum_{j=1}^{k} r_j} \tag{2}$$

where r_i, $(i = 1, \ldots, k)$ is a Pearson correlation between ith input variable and I-distance value. Thus, the methodology overcomes the frequent issue of expert-based weights identified in most composite index methodologies.

3.3 Triple Helix Performance Model

In this paper, the authors used the set of indicators classified according to the three main TH pillars: Industry, Government, and University. The initial idea of the research was to include both double (Industry-Government, Industry-University, and Government-University) and triple helix (Industry-Government-University) relations, but due to the scope of the research, the authors limited the model to the triple helix relationship. Finally, 20 selected indicators are classified into 4 groups: Industry performance, Government performance, University performance, and Industry-Government-University performance. After the selection of the indicators from Table 1, the authors classified them into the pillars (Fig. 1). Firstly, the authors calculated the two-step CIDI score for each pillar to generate weights and values of subindices. In order to calculate the final value of the TH performance indicator, the authors used the values of subindices as indicators and conducted the two-step CIDI for the final scores. The ranking was based on these final values.

4 Research Results

This section presents the second iteration results, the two-step CIDI scores (Tables 2 and 3). Table 2 shows the data-driven weights of the pillars and indicators. The results show that the most significant pillar is the triple-actor pillar, with the weight of almost 50% (49.60%—Table 2). The second is Industry (26.32%), then University (19.87%), and at last Government with only 4.21%. The table also illustrates the values of indicator weight within pillars. In the Industry pillar, there is almost similar distribution of weights, from 20 to 28%, while in the Government subindex, weights are distributed from 5 to 32%. University shows similar results with five indicators weighting from 7 to 36%, as the collaboration subindex from 5 to 33%. When it comes to the impact of the indicators on the final value, *Technology balance of payments: Receipts* indicator has the highest value of 16.37%, followed by *Business Enterprise researchers as a % of national total indicator being* 7.37%, and *% of GERD performed by the Higher education sector indicator* 7.15%.

Table 3 shows the final ranks and scores of the countries. The first 8 columns present values of the pillars and ranks obtained by these values. The highest score in Industry performance is registered for Japan, Korea, and Israel, while the lowest results are for Slovak Republic, Greece, and Latvia. For Government performance, the best seats are reserved for Mexico, Germany, and New Zealand, and the worse are registered for Israel, Denmark, and Switzerland. University performance is highest for United Kingdom, Latvia, and Portugal, and the lowest for Mexico, Hungary, and Luxemburg. However, the pillar of the collaboration of the three entities shows that Ireland, Japan and Germany are performing the best, while Portugal, Hungary, and the Slovak Republic achieve the lowest scores in this pillar. Finally, the best TH

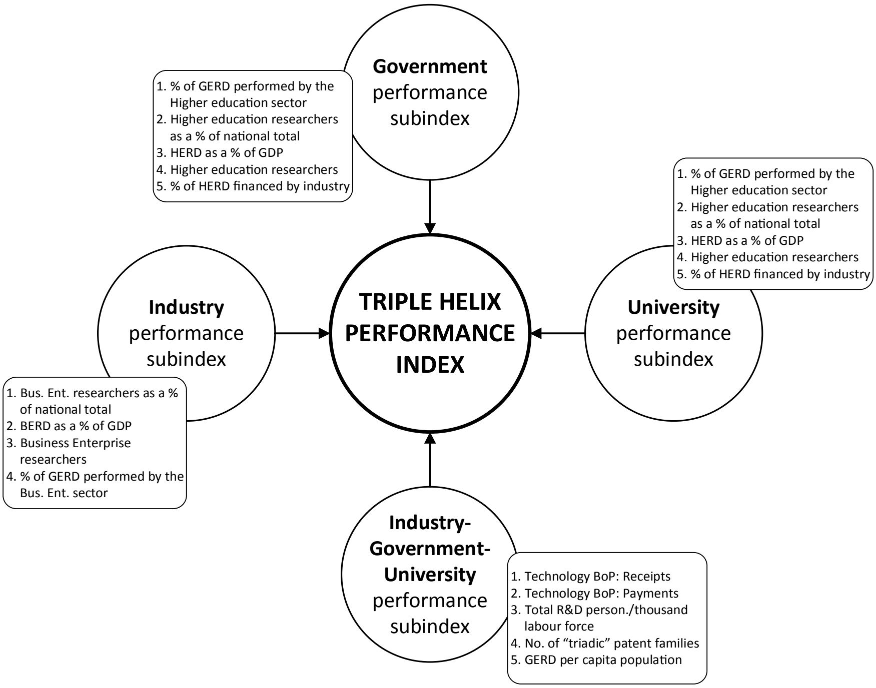

Fig. 1 Triple Helix performance model

Table 2 Weight values for pillars and indicators

Pillar	Pillar weight (%)	Indicator	r^2	Indicator weight (%)	Final weight* (%)
Industry subindex	26.32	Business Enterprise researchers as a % of national total	0.7564	28	7.37
		BERD as a % of GDP	0.7525	28	5.90
		Business Enterprise researchers (FTE)	0.6448	24	3.71
		% of GERD performed by the business enterprise sector	0.5531	20	2.21
Government subindex	4.21	% of GERD performed by the Government	0.6955	32	1.35
		Government researchers as a % of national total	0.5369	25	3.36
		GOVERD as a % of GDP	0.3809	18	1.23
		% of GERD financed by government	0.3119	14	0.61
		Government researchers (FTE)	0.1228	6	0.04
		% of GOVERD financed by industry	0.1012	5	0.03
University subindex	19.87	% of GERD performed by the Higher education sector	0.3356	36	7.15

(continued)

Table 2 (continued)

Pillar	Pillar weight (%)	Indicator	r^2	Indicator weight (%)	Final weight* (%)
		Higher education researchers as a % of national total	0.2206	23	1.17
		HERD as a % of GDP	0.2130	23	1.13
		Higher education researchers (FTE)	0.1070	11	0.13
		% of HERD financed by industry	0.0636	7	0.03
Ind-**G**ov-**U**ni subindex	49.60	Technology balance of payments: receipts	0.5731	33	16.37
		Technology balance of payments: payments	0.4559	26	3.08
		Total R&D person./thousand labour force	0.3656	21	1.61
		No. of "triadic" patent families	0.2565	15	0.58
		GERD per capita population	0.0773	5	0.02

*The final weights are calculated by multiplying pillar weights with indicator weights

performance is achieved in Germany, Japan, and Switzerland, while the strength of these pillars is lowest in Spain, Poland, and Hungary. It is important to emphasis that based on the obtained results, a country could have a disproportional development of the pillars (e.g. Japan) and score high if the pillar of collaboration, Industry-Government-University (IGU) is properly developed.

Table 3 Triple Helix performance index and subindices scores

Country	Industry subindex	Rank industry	Governm. subindex	Rank Governm.	University subindex	Rank University	Ind-Gov-Uni subindex	Rank Ind-Gov-Uni	TH index	Rank total
Germany	12.921	4	27.809	2	20.201	5	26.197	3	30.892	1
Japan	31.681	1	7.611	19	12.187	15	27.032	2	28.780	2
Switzerland	7.610	13	0.108	32	20.545	4	21.753	4	17.457	3
Mexico	0.345	29	38.991	1	5.367	30	5.892	25	17.451	4
Latvia	0.015	32	19.247	5	23.952	2	6.718	24	16.826	5
Ireland	5.024	17	0.418	29	6.113	27	29.834	1	16.332	6
United Kingdom	4.278	20	1.987	25	24.330	1	11.257	15	14.810	7
Republic of Korea	24.611	2	16.618	7	10.491	17	10.739	16	14.307	8
Israel	22.567	3	0.347	30	7.553	25	20.054	5	14.048	9
Denmark	8.425	9	0.201	31	19.281	7	16.940	7	13.150	10
Slovak Republic	0.094	30	17.964	6	17.670	9	1.181	32	9.709	11
Netherlands	8.062	11	10.731	14	13.208	14	16.168	8	9.487	12
Canada	7.367	15	1.538	26	20.159	6	5.408	27	9.368	13
Greece	0.074	31	15.321	8	16.550	10	9.823	17	9.301	14
Portugal	1.316	27	0.908	28	20.868	3	2.848	30	9.061	15
Estonia	1.053	28	3.551	24	18.729	8	9.235	18	8.423	16
Austria	11.134	6	3.810	23	9.662	18	17.499	6	8.247	17
Belgium	7.576	14	4.555	22	14.243	12	13.723	10	7.692	18

(continued)

Table 3 (continued)

Country	Industry subindex	Rank industry	Governm. subindex	Rank Governm.	University subindex	Rank University	Ind-Gov-Uni subindex	Rank Ind-Gov-Uni	TH index	Rank total
Sweden	12.349	5	1.357	27	13.276	13	12.056	14	7.391	19
Luxembourg	2.583	22	19.364	4	2.147	32	13.114	13	6.903	20
New Zealand	2.259	24	20.688	3	8.978	22	6.909	23	6.579	21
France	10.306	7	11.980	12	8.041	23	13.126	12	6.524	22
Australia	1.639	26	7.626	18	15.501	11	8.197	20	6.165	23
Finland	8.327	10	5.742	21	9.026	21	13.798	9	5.477	24
Iceland	4.362	19	10.034	15	11.164	16	7.879	21	4.271	25
Norway	4.769	18	9.595	17	9.558	20	9.166	19	3.907	26
Italy	3.427	21	6.943	20	5.830	28	13.207	11	3.764	27
Slovenia	7.933	12	9.606	16	7.725	24	7.279	22	3.309	28
Czech Republic	5.162	16	14.160	9	5.606	29	5.393	28	3.173	29
Spain	2.526	23	11.093	13	9.593	19	4.637	29	3.066	30
Poland	1.842	25	12.641	10	7.524	26	5.746	26	2.921	31
Hungary	8.854	8	12.320	11	3.695	31	2.153	31	2.735	32

5 Discussion—Implications, Limitations, and Future Research

The research results show that I-distance provides results in accordance with the theoretical framework of the TH. Collaboration has the leading role among the three entities, while the main role among indicators is reserved for the result of the patent activities—*Technology balance of payments: Receipts*. Also, the often-criticised subjective set of predefined weights is overcome in this methodology since it is based on data-driven values. However, this research has some limitations. It was based on a set of 32 OECD countries due to data availability. Putting more effort, systematic data collection should be performed to obtain more relevant results and conclusions. Secondly, the authors used the set of 20 indicators and classified them into four pillars shown in Fig. 1. Further efforts should deal with this issue and include various measures that describe the national eco-system in a more comprehensive way. Also, one of the limitations is that the double helix relations (Industry-University, Industry-Government, and Government-University) were not covered.

With a wider scope of indicators and new subindices (double relations), the creation of an improved model will be the subject of the future research. This is a pilot project aimed at testing the applicability of the I-distance method in this field. Additionally, in the literature review, previous research Lee and Park [33] proposed the DEA method as convenient for measuring the TH performance. This efficiency approach is interesting because it enables to detect the potential areas that could be improved for achieving higher performance. The efficiency approach is also important to give the estimation if the employed inputs are resulting in the expected outcomes since the practice shows that this is usually not the case (e.g. Swedish, European, and Serbian paradox) [34]. This method has already proven its effectiveness in combination with the proposed I-distance method [56] and will also be the subject of future research aimed at testing the alternative method of TH performance measurement.

6 Conclusion

Composite measures are emerging as important determinants of national development and guidelines for policymakers. TH model as an analytical tool for a systemic explanation of dynamic and complex university-industry-government relations could be beneficial, but concrete performance measures are a necessity.

Conclusion of the literature review

Despite numerous attempts and various approaches, there is still no a comprehensive methodology for measuring the TH performance. In this paper, the authors propose the two-step Composite I-distance (CIDI) approach, which has proven to be a reliable tool for creating composite measures in various research and fields. This approach enables categorisation of indicators into pillars (i.e. TH categories), analysis of each pillar's performance, as well as the further calculation of one composite measure which reflects the overall TH performance. R&D activities are marked as the catalysts of TH performance that foster and boost the third mission of the university. Thus, this research was based on the official data on R&D activities measured by the OECD. The set of selected indicators was classified into 4 pillars, that compound the Triple Helix Performance Index. Up to now, this is the first attempt to define a concrete model that measures the TH performance as a composite index. The model was applied and tested on the set of 32 OECD countries for 2015.

Conclusion of the research

The research results provided the data-based weights of the pillars. Industry-Government-University (IGU) collaborative pillar has the highest importance was weighting almost 50%. The most important indicator is *Technology balance of payments: Receipts,* which reflects the significant result of innovative activities of the country. The results emphasis that it is possible for a country to achieve high TH performance score even if two pillars are not equally developed in the case when IGU or Industry pillar score high.

This paper is a pilot research that proposes a fresh approach to measuring the TH performance. The research has shown that the model could be used as a tool for policy-makers. Still, it should be applied on a wider set of indicators and countries, which demands the systematic data collection. In this way, the potential of the TH concept as a systemic analytical tool for identifying the weak links and recognizing good practices in a national system could be fully exploited.

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Design Thinking Methods to Activate Co-creation Process Among Policymakers, Creative Industries and SMEs

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Abstract This paper is based on the exploration of how design approaches to innovation can be learnt and adopted by policymakers in order to enable SMEs to co-create with Creative Industries. More specifically it aims to research how design experts from the academic institution can effectively train policymaker and R&D department of companies in embracing design thinking methods as a way to support innovation. In order to comprehend this process, CILab (a departmental laboratory of research from the department of design of Politecnico di Milano) conducted a series of analysis based on an empirical research project that involved a panel of European policymakers, SMEs and Creative Industries, developing a set of tools implemented with different methods and activities. This process of investigation through workshops and user observation were implemented during the Co-Create European project. In this paper, design thinking is considered as an approach to innovation characterised by the implementation of methods and tools coming from the design discipline (Kolko in Design thinking comes of age, 2015, [11]). The reason why policymakers and SMEs in Europe could benefit from the implementation of design thinking approach refers to the growing recognition of the effectiveness of Design thinking approach in promoting innovation. Co-creation is intended as the practice of developing meaningful solutions (products, services, systems and business models) through a more participative process with engaged company stakeholders, involved in collective creativity environments (Galvagno and Dalli in Managing Service Quality 24:643–683, 2014, [7]). In addition to the explanation on the validity of this approaches to innovation, this paper illustrates how to approach design process and co-creation involving a variety of stakeholders: activities are triggered by the academic world that train policymakers from public administration in order to make industries, from the creative and manufacturing sectors, to benefit from the process of activating new path of innovation.

Keywords Design thinking · Co-creation · Training · SMEs · Creative industries · Policymaker

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1 Theoretical Background

1.1 Design Thinking as a Skill to Activate Condition of Innovation

The theoretical framework definition of this paper started from a reflection about the evolution of the **design as a discipline**. To roughly synthesise the steps from the origins, the focus of design started from the traditional tangible object including disciplines as graphics and industrial design passing to interaction design, then to design of services, design of systems, environments and most recently **organisations**. Nowadays the attention of design is progressively shifting toward ways of thinking and doing, oriented on designing solutions, intangible offerings addressing complex problems [22]. Designers can interact within complex organisational dynamics perceiving organisations as matter for projects: the product to be designed is not an artefact or a customer service anymore but the organisation, itself [3]; design experts nowadays operates on organisation's thoughts, beliefs and approach, through a set of interactive, collaborative and creative visual and physical artefacts [1].

This is one way of describing that approach to innovation named *design thinking*. The increasing interest among this topic (both from the business sector as for the public one) comes from the rising awareness on how design can foster innovation and generate competitive advantage in several sectors and typologies' of organisations.

The design thinking first appearance in the late 60's and was linked to the idea of design that deals with "the transformation of existing conditions into preferred ones" [21]. Later evolution of the definition of this approach was encompassed in the design practices, more closed to what is discussed in this paper, identifies the designer's task as providing appropriate solution by "organising complexity [and] finding clarity in chaos" through a process of patterned synthesis of aesthetic, cultural, and technology trends and consumer and business needs [6]. Furthermore, design thinking in the last 10 years has also been shaped as a general process structured on a series of tools and methods that helps manager and middle-manager as for social innovators to face and solve complex and many-sided problems. The most recent studies from scholars shown that design thinking approach could impact on firm performance in terms of growth [4] and on the capability to innovate [15].

Moreover, what is progressively arising in public and private sectors is the need of design thinking as a skill and approach for professional figure of managers [2]: the capability to combine decision-making process with a typical "design attitude" it's becoming crucial to face innovative paths. Therefore, design thinking is now considered not only as an approach to business objectives, it is indeed an attitude to deal with complex and uncommon subjects that have uncertain answers and solutions.

That is a typical designer's capability in solving wicked problems, coming from the human-centred approach that can enable multidisciplinary teams to create user-centred solutions (e.g. products, services, processes, organisational designs, and business models). Hence, this approach can influence innovation during the early stage through the involvement of various stakeholders in providing inputs to construct and **co-create** valuable solutions.

1.2 Co-creation Theories

Ultimately, the corporate interest has moved from offering products to offering experiences to customers, involving stakeholders in the value-creation process. This phenomenon required the development of new strategies to be adopted. In this context, was theorised co-creation, oriented to open up the traditional corporate business model. The adoption of this theory brings possible benefits to the companies that choose strategies such as open business models, higher customer involvement, better relationships with partners and cost savings. Nevertheless, adopting the co-creation strategy, companies need to analyse the relevance of the application and justify the investment that the strategy requires to be put in practice. The co-creation first appearance was in 2000, theorised by C. K. Prahalad and Venkat Ramaswamy and embracing a broader view of the value exchange process. Co-creation is a relevant topic in literature of design and innovation, defined as a process where firms' actors and other relevant stakeholders generate value through interaction in a collective creative environment [7]. Unlike the traditional view, co-creation is defined as the dynamic process where the actors do not play a pre-defined role and stakeholders have enough freedom to create value along with company. This perspective is driven by companies that want to cooperate with key suppliers and thereby co-create value, re-evaluating the classical roles, reducing the distance between them, interacting with each other for the development of new solutions [7, 16]. In order to be properly adopted, a change in the company's mind-set is required, passing from firm-centred to actor-centred.

The involvement of actors inside the co-creation process brings value to the company because they represent a "source of competence" to achieve the final result. This kind of involvement can produce not just innovative products, but it is about escaping from the product-centred thinking and focusing on creating novelty experiences. Co-creation is about building experiences along with the customers, not just offer them innovative products. For this reason, it is important to enable the user to co-create their own unique experience, embracing all the inputs generated from this process in the development of the solution [8, 16].

The co-creation phenomena have aroused considerable interest also in the design field. The design perspective, absorbing this theory evolved from a user-centred perspective to a collaboration with them in order to create something new.

1.3 Co-creation in Design Thinking Approach

From the perspective of design thinking, co-design is a term used to describe co-creation and can be considered a specific case of co-creation. Co-design refers to any act of collective creativity, among a diverse team of actors, with the designers' involvement, where is possible to obtain a new perspective in knowledge development, idea generation and idea development [14, 19].

The co-design approach goes to implement the formal idea about design thinking. The user is part of the process not just at the beginning, where is important to understand his need to produce the best result. He becomes an active actor, with an enlargement of the target and of his functions. Indeed, the involved actors represent not just the final users, but also other stakeholders that take part along all the process. In this way, the co-design can produce practical resolution to complex problems.

The co-design is placed in the early stage of innovation, usually characterised by high levels of uncertainty, and concerns idea generation, idea/concept development, and prototype. To facilitate this process, it is important that actors involved in co-design are supported by a comprehensive set of tools for ideation and expression in order to ensure close interaction with different stakeholders and provide collective creativity experiences, particularly when it is often not known what exactly the deliverable of the co-design process will be [9, 19]. Only if firms are able to absorb the characteristics of this methods, can they achieve the desired goals of co-creation, managing effectively these processes. Based on empirical research, the four principles of co-creation can be systemised as [17]:

1 Stakeholders are really participative in the process just if this will produce value for them;
2 Co-creation is considered successful if it provides rewarding experiences for all the actors involved in the process;
3 It is important to create a dialogue between multiple stakeholders;
4 Stakeholders have to constantly interact, using platforms, not only IT-based, to share their experiences and to understands problems and priorities coming from other actors. Above-mentioned principles of co-creation are supported by a set of building blocks. These principals are fundamental in the co-design process, where the best result can be just achieved if they work sequentially.

Companies should also understand the capabilities necessary to effectively work with customers. In this direction, the DART model [16] identify the four main building blocks or groups of competencies that companies should create in order to engage in value co-creation with customers.

The model is composed of four key building blocks: Dialogue; Access; Risk; Transparency. Dialogue means that an active dialogue between the company and the actors is required. A more informed, networked and empowered actor would be able to discuss and get involved in the creation of the experience [13]; Access means that company has to provide their actors with tools, with which they can use to interact with other users or "company listeners" [18]. In addition, [12] believes that actors need to use their accesses to existing tools as well as modify and extend them; Risk is related to "reflective learning" so the interactions can be used to improve the content and experience of the actors themselves [12]. The goal of this guideline is to manage the risks and benefits for the actor and the company, where conversations with actors could take place using the Internet and media available and the relationship is kept in this way; finally, transparency means that the company should look for information sharing with the actors involved. Keeping the actor informed would give them a feeling of trust, and trust is what will keep the actor engaged and "establish authenticity" [13, 18].

1.4 The Adoption of Design Thinking for Policymaker

In spite of the increase of acceptance of design thinking for co-creation among firms, the process of adoption of design into innovation process meets substantial difficulties that could block it to effectively generate valuable and innovative results [5]. The greatest barrier to the better use of design in the European context is a lack of awareness and understanding of design among policymakers.

Making the policymakers aware of the precious added-value that they can generate embedding design practices in policies and programs can be a crucial point for facilitating the innovation paths.

As theorised in this paper, based on the experiences of previous project, one of the solution in front of this situation, consists in the involvement of design and innovation actors, as academic design institution, in exchange best practices with policymakers and businesses: boosting new research and organising seminars or workshops addressed to policymakers and also managers focused on how to integrate design thinking and co-creation into their mainstream practices.

The co-creation among these three typologies of actors enable mutual learning testing the transferability of best practices between design experienced actors towards actors willing to become active providers of design innovation support services. All these processes of transferring and contamination of knowledge require a learning by doing approach, mostly because the design's role as a driver of innovation can often be a difficult concept for policymaker (and small business too) to grasp. This is the main reason why, as described in the following paragraphs, the "co-create" project is structured on hands-on workshops, providing the participants with practical experience of how design thinking methods and tools can add value.

2 The Empirical Research: CO-CREATE Project

In order to comprehend and develop the process of adoption of design thinking and co-creation approaches for non-design actor, a series of analysis based on an empirical research project has been conducted through different methods such as meetings and workshops. These studies were aimed to develop a set of guidelines and methods to be used from design experts, such as the University department of design, in training public and private actor in embracing design practices.

Theory-based propositions were investigated during the Co-Create project, conducted in Italy and co-financed by the European Regional Development Fund of the European Commission. The goal of this project was to support cross-fertilization processes between creative industries and traditional clusters of SMEs contributing to test co-design and design thinking methods applied to entrepreneurs and policymakers.

Co-create project was strongly in line with the aims of this research because, it involved a panel of European policymakers, SMEs and Creative Industries, and gave the research group the opportunity to develop and test a set of tools implemented in different contexts.

2.1 The Co-create Process

This paragraph summarises the activities, methods and research outcomes of the co-create project; the main research output of CO-CREATE was a toolkit as instrument to favour the training of policymakers and SMEs in adopting new approaches to innovation, bringing these actors close to the creative and cultural sector.

The project activity involved the 10 European regions, therefore the process is characterised by a shared methodology, developed by CILab (Department of design, Politecnico di Milano) applied at a local level in each of the area. In this paper, the matter of analysis is the activities run in Italy in the Lombardy region.

The process of the CO-CREATE projects that brings to the final results, was characterised by different activities; the main steps and their intermediate phases are the following:

1. Training activities—dedicate to the policymakers
2. Engagement phase
    a. Engagement of SMEs and dedicated training sessions
    b. Engagement of CCIs—Call for ideas
3. Pilot actions (Creative camps main events)
    a. Selection phase
4. Transnational event (International Creative Camp)

The first step of the transferring of knowledge adopted inside Co-Create was represented by the training activities. The training activities served as a bridge for preparing the co-creation among SME from manufacturing sectors and creative industries (CCIs). The policymakers involved in the project were mainly cluster managers i.e. public managers of innovation district or business networks, that are actors in strong relationship with SMEs. The goal of this phase was to transfer basic knowledge on design thinking and co-creation method in order to generate the ground of skills and competences necessary to develop innovation processes of cross-fertilization (mutual exchange of ideas from different fields for mutual benefit) with tangible results. At the end of this first phase, cluster managers got educated on the methodology to a level high enough, that was to adopt and share independently this knowledge.

The approach followed during the training activities was designed according to the co-creation theory. In order to better support the actors involved in the process of training, CILab designed a series of tools aimed to foster the innovation process among the different actors, through a hands-on workshop.

After a first phase during which cluster managers represented the main target involved and trained inside the project, the methodology has been applied to different actors. The same methodology and tools were also used in the second step of the Co-Create project, during which all the activities were addressed to SMEs and CCIs (so called pilot actions, creative camps).

Therefore, in between the training and the pilot actions it takes place the engagement phase made by trained policymaker that engage SMEs in order to make the companies ready to co-create with CCIs enabling them to produce effective briefs of project; than starting from the results of this step starts the process of involvement of CCIs through a "call for ideas" that generate the first match between SMEs and CCIs. The creative camps main events that describe the moments during which the meeting takes place and first co-creation activity between SMEs and CCIs and where the cross-innovative projects come to life. After a selection process based on shared qualitative criteria the 20 best cross-innovative projects coming from the 10 European pilot areas join the transnational event in Milan where the cross-fertilization process is extended at an international level.

The involvement of the actors in each step represented the distinctive element that can really impact on the final results of the cross-fertilization process between SMEs and CCIs: training and preparing the main actors before the co-creation meeting is fundamental in order to tune the expectation and point of view of the involved participants.

To validate the knowledge-transfer process inside these phases, businesses from different sectors were involved; the cluster manager and SMEs were specifically selected among those ones that never approach to design thinking and co-design methods as for the collaboration with cultural and creative industries (Table 1).

Table 1 Actors involved in the process

SMEs	CCIs	Cluster managers
44	30	15

2.2 The Co-create Training Methodology and Toolkit

The training sessions were organised merging frontal lecture, theoretical moments, with hands-on phase and workshops using the dedicate toolkit to practically apply the contents explained.

Specifically, training sessions were all organised with a specific structure, including:

- Introduction to CO-CREATE project and icebreaking session
- Focus on design thinking and co-design
- Explanation of Co-CREATE design toolkit
- Workshop phase (divided into 3 phases)
- Explanation of Brief generation canvas
- Presentation of the results and shared session

The session was organised with a precise key-point: to make all the participants aware of the potentials of joining CO-CREATE as a way to produce a concrete and meaningful approach to innovation, through the co-creation among different actors. Moreover, the theoretical focus was on the importance of the generation of brief of project through the brief generation canvas tool. A brief of project is the starting point for each new innovation project: a brief opens a design question that should include all the information to describe the area of intervention that a business actor wants to exploit. One of the aims of the training was to enable participants to include in a brief all the details useful for a design actor, in this case CCIs, to propose a project.

Theoretical knowledge about design thinking and co-design approaches was given inside the event, aiming to guide the actors to address a design question that could really impact on the innovation of their business. As described in the theoretical background in this phase, design thinking was considered an approach to innovation characterised by the implementation of methods and tools coming from the design discipline [11]; moreover, theoretical knowledge about Co-creation was presented, considering it as the practice of developing meaningful solutions (products, services, systems and business models) through a more participative process with engaged company stakeholders. Therefore, the theoretical content of the lectures moments described shortly the evolution of design and innovation, including some pills about the emerging trends (social and technological) passing by a series of case studies.

The learning process about these contents was supported by a design toolkit and a related methodology that was used in the workshop session for make policymakers first and than SMEs ready to practically approach the project objectives.

The adoption of a design thinking tools in organisations does not just regard the possibility to solve specific design and innovation problems. Adopting tools inside an organisation can influence its culture, affecting the norms, values, and underlying assumptions about the right way to work in those organizations. The different types of tools that can be generated inside the design thinking panorama can be classified into three categories [20]. It is possible to recognise (1) need-finding tools (i.e., tools such as ethnographic observations, in-depth contextual interviews, or customer journeys used to empathise with and understand the needs of end users), (2) idea-generation tools (i.e., tools such as brainstorming and cocreation/codesign used to generate possible solutions to problems), and (3) idea-testing tools (i.e., tools such as rapid prototyping and experimentation used to test ideas on a small scale to determine their desirability, technical feasibility, and business viability) [6].

The Co-Create project methodology embraced mostly the first two types of tools, creating a support for the actors in the program. Co-create design toolkit has been design with 4 main tools: *Look Inside, Look Outside, Look Beyond and Brief generation canvas.*

a. **Look inside**
   The first tool would enable each training participant to look inside their activity, understanding values, problems and other psychological points regarding their business. An in-depth analysis of what other persons think about them is vital, before knowing what other companies do.
   The concrete aim of this tool is to define a framework through a self-analysis process. Each of the three boxes of this tool (core qualities, Achille's heel, unexpressed feature) can be generators of different challenges. The final result is going to be small sentences, key words, or starting ideas which spring to mind from the three sections above (Fig. 1).
b. **Look outside**
   The second tool aims to make the training participant observe global future trends and analysing how competitors behave in order to help companies to

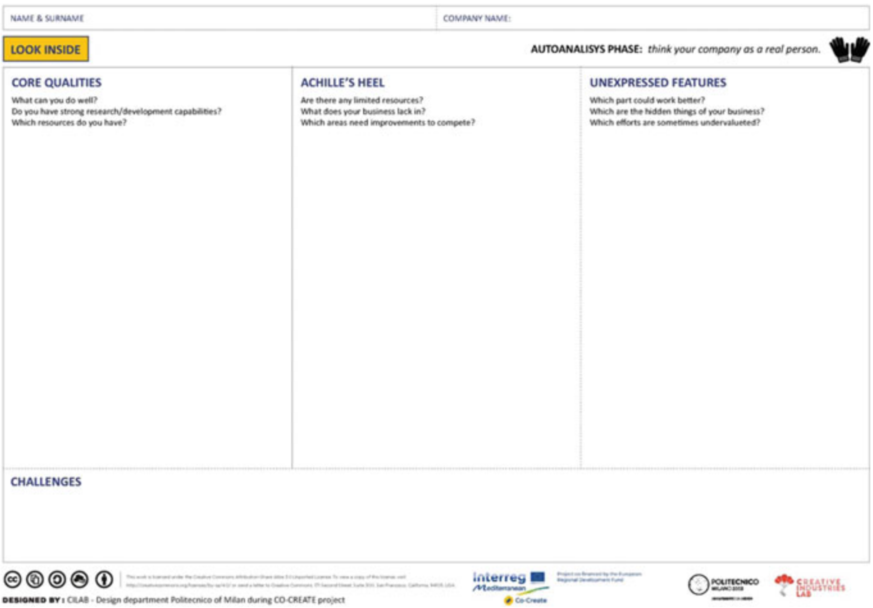

Fig. 1 Look inside tool

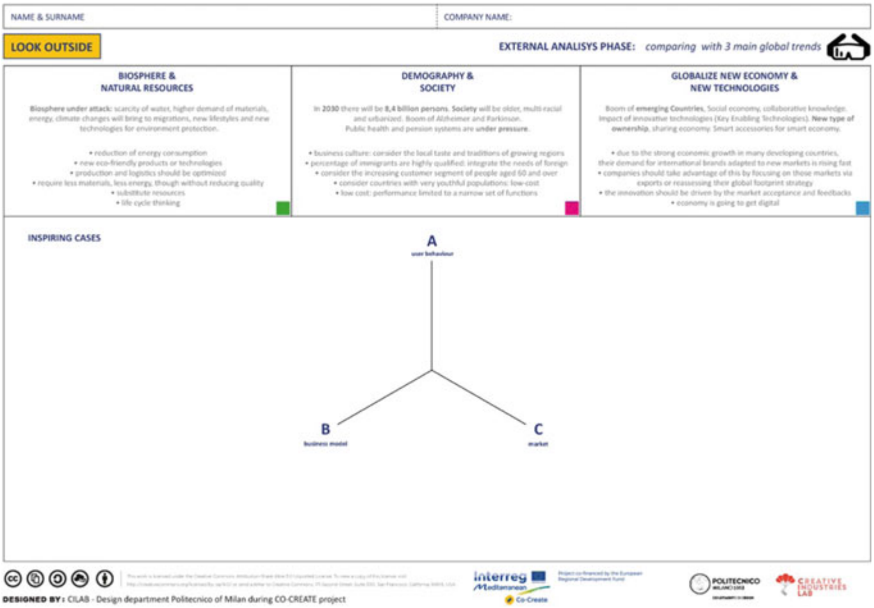

Fig. 2 Look outside tool

understand where the market is going and find promising signals. Biosphere and natural resources, globalise new economy and new technologies, demography and society are the three wide selected trends as a reference for guide possible innovation path.

The goal of this tool in the session was to define a trend maps: find cases, materials, thoughts or ideas, trying to compare the global trends with the 3 specific fields: user behaviour, business model and market (Fig. 2).

c. **Look beyond**

After an analysis of what is already existing, training participants have to focus on their wishes, possibilities and ideas. It is important that they deeply believe in what they want to become, without fears of failing.

The goal of this tool in the session is to boost the visioning potentials through a guided brainstorming session. Brainstorming is about setting a safe environment where everyone can say everything without being be judged—where ideas can rise. Starting from positive inputs collected using the two previous tools, mainly thinking at one of the 8 boxes (challenges and inspiring cases in particular), participants can shape some directions of innovation: comparing the different results, finding differences and similarities in order to get solid bases and a prolific foundation. The method in filling this last tool is based on a user centred approach, focusing on the user and his needs and thinking at every single step and actors of the supply chain, not only the final user (Fig. 3).

Fig. 3 Look beyond tool

d. **Brief generation canvas**
The last tool enables the process of synthesis of the content produced with the previous analysis and creative tools: the aim consists of concretising the content and the reflection produced through the application on the real framework of each participant's organisation involved in the process. This crucial phase consists of using the brief generation canvas that allows each participant to prepare a brief of project: as described before, a brief is intended as a design question from a company that includes all the information for enabling the creative actors to make a proposal.
The tool articulates the brief question in different content—boxes, as exposed in Fig. 4:

- WHY—the meaning that the proposal should embed (answering to questions as "What is the meaning behind? What is the value this idea might create?")
- WHAT—what is the proposal about (answering to questions as "what type of offering is it?")
- WHO—describe the target and profiling it (answering to question as "Who might be interested in it? Who would like to use it? Or pay for it?")
- WHEN—describe the time and plan of the project expected (answering to question as "Is this short-term or long-term? What is the time process expected?)
- WHERE—describe the market dimension and scale (answering to question as "Is it at local level, national level or international level? Why at this level?)

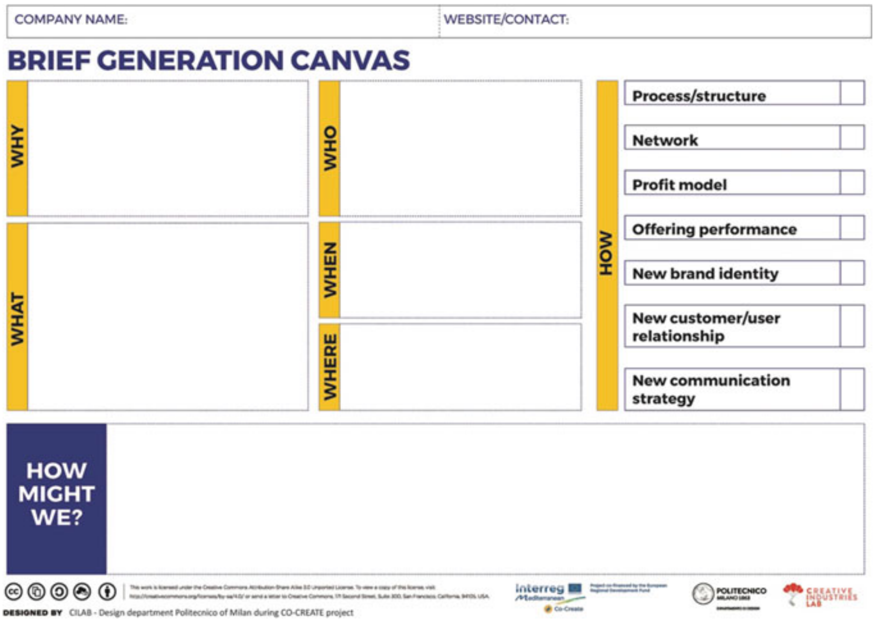

Fig. 4 Brief generation canvas tool

- HOW—this part is dedicated to specify how the company expects to realise the "WHAT" and "WHY" of the brief.
- This area consists in the identification of possible ways to realise the solutions expected and is presented using different categories based on on the 10 types of innovation theorised in DOBLIN model [10]. The Ten Types of Innovation is considered a diagnostic tool to understand how companies are approaching innovation internally, supporting them in analyse the competitive environment, giving the possibility to discover potential gaps present in the market and to identify potential opportunities for doing something different.
- The categories interpreted and used in this design toolkit are the following and stand for guidance to evaluate the project that answers to the brief:

  – Process/structure
  – Network
  – Profit model
  – Offering performance
  – New brand identity
  – New customer/user relationship
  – New communication strategy

The final and crucial box of this canvas is the "how might we" question that should summarise the design question and express promising opportunities to communicate the brief to creative communities.

Table 2 Results obtained during the co-create project

Briefs	Project delivered	Collaborations	Long-term contracts signed
31	32	15	2

Therefore, the general aim of these tools is to explain what is a brief, how does it work and how to write it in a correct way; but also, it is crucial to setup an effective communication of the brief in order to enable the Creative Industries to provide valuable ideas. The expected result of the training session dedicate to SMEs is the collection of the briefs of projects done and delivered by all the companies through the last tool explained.

At the end of these training activities, the project achieved a relevant sample of cases to be analysed in further researches in order to update and develop the theoretical knowledge about the topic. Moreover, it generates also valuable impact on the actors involved in the process: only in the region analysed the number of successful collaboration among different stakeholder involved (policymaker, SMEs and CCIs) were 15. Two of them are already stabilised with an official long term collaborations contract. These final results are the outcomes of the 31 different briefs and 32 co-created projects generated during the training activities (Table 2).

3 Conclusions

This paper shows a real-case approach in the context of the design thinking and co-creation applied to actors inexperienced in the design field. Moreover, there are several contributions about how support SMEs and CCIs, involved by policymakers through a training made by Academic Institutions coming from the design discipline: (a) the main drivers that should be respected in the co-creation process in order to generate an innovative result (b) a methodology aimed to create a cross-fertilization process (c) a toolkit aimed to the achievement of the final result by non-design-experts, in the development of new ideas.

The merging between design thinking and co-creation revealed the possibility to enlarge the active target, including the actors that participate in the process not just at the beginning, but during all the steps to achieve the final result.

The Co-Create project represented a fertile ground to test this formula of training and transferring of knowledge between different actors: only in this considered Italian area, Lombardy region, the number of successful collaboration among different stakeholder involved were 15 and starts from the positive engagement of more than 15 policymakers, 44 SMEs and 30 CCIs that generates 32 innovative projects.

The boundaries of this research study are clearly focused on the application of the design thinking on actors that are not familiar with the design logic and its results. The involvement of these actors was fundamental to generate innovative solutions, going beyond the classic boundaries of the organisation. The final result is oriented to a business perspective, that is the principal one where this study can be applied.

Nevertheless, there are some limitations that should be considered while discussing the findings. The introduction of this new method, should be supported inside organisations. The training itself is not enough if inside the organisations are presents standardised routines that then unable the real adoption for future development. The mind-set of some organisations can obstacles the adoption of the methodology that is not enough if it is not supported internally.

Another limitation could be the lack of financial instrument and support from the public authorities. Inside the Co-Create program, the first step of training was addressed to policymakers exactly to solve this kind of absence. Make the institutions aware about the importance of this topics was considered the first step to let them conscious about the need of support needed. One of the problems reported during the program was the need for companies about financial support in engaging figures and processes coming from the Creative and Cultural sector.

These limitations create the starting point for future research. The academic institutions from the design discipline can represent a valuable way to facilitate a partnership between industries and government actors.

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Managing Projects in the Public Sector: From Fragility to Agility and Innovation

Morad L. Taqateqah and Khalid Al Marri

Abstract Innovation for all organisations is the lifeblood that provides them with the strength to adopt market changes by creating innovative business opportunities. For the past decade, service providers in the public sector have faced the impact of the transformations caused by the emerge of "the Fourth Industrial Revolution", which led to almost make the followed Public Management processes and procedures obsolete. This study intends to provide insights into the relationship between innovation champions empowerment and innovation projects success. The aim of this study is to addresses the question: 'How does the empowerment of Innovation champions influence the success of the innovation projects within the public sector?'. As a lesson-learned from private sector empowerment, this study applies the adopted empowerment approaches in order to prove a significance of extent the innovation champions' empowerment in the public sector would encourage their line managers to perceive innovation risk as a viable one and become more innovative. The research method involves surveying 40 innovation champions from several public organisations. The outcomes show empowering innovation champions are contributing to making their organisations more innovative. However, there is a challenge caused by those line managers who are not accepting the innovation risk and just play a single role as supervisors, which grounds the fragility in innovation adoption through creating a resistance for innovation risk acceptance. Based on this study outcomes, it is suggested that public sector management should apply multiple managerial styles of sponsoring and supervising innovation project to facilitate innovation adoption and implementation. On the other hand, empowering innovation champions would support changes in the internal working environments and lead to encourage their line managers to accept innovation risk and play situational leadership (sponsor and supervisor); at the same time, such approach would make innovation champions

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more committed to the innovation success through a sense of ownership. Overall, innovation champions' empowerment and management style are both relevant and related to innovation projects success in the public sector. This result also offers an academic value through recognising the direct relation between innovation champions' empowerment, management role, and innovation project success in the public sector context.

Keywords Empowerment · Innovation champions · Public sector innovation

1 Introduction

Since the 1980s, the general trend in the public sector is following the New Public Management (NPM) style with minimal variations [15]. Such routine has created rigid metric methods of efficiency resulted in creating limitations to the management processes which may not fit in innovation context and flexibility [30]. For the past three decades, the NPM has led the public organization's management style and participated in their success and achievements. This type of the system was fit for that era and made most of the organisations in the public sector relaxed with minimal risk. However, for the past decade, all industry sectors have evolved to meet the impact of the Fourth industrial revolution which also required the public sector to evolve accordingly. There is no doubt that innovation carries a risk; the challenge is how to persuade organisations in the public sector to depart from their comfort zone and start accepting the innovation risk [36].

According to Quinn [31] the innovation champions, in general, belong to the middle management and possess extraordinary capabilities to develop innovative solutions and encourage their organisations to accept the assumed innovation risk. In addition, innovation champions can work with limited resources and management support using their ability in linking and utilising organisational resources to overcome innovation challenges [33]. On the other hand, innovation champions need organisational and supervisors' support to practice innovation [35]. The arguments in this study are focused on if the empowerment of innovation champions will contribute towards organisational innovativeness in the public sectors, and if the innovation champions will contribute towards persuading their line managers to accept innovation risk and become more innovative. Accordingly, argument extends on if the empowerment will lead to change in the internal organisational culture and in the supervisors' management style in order to create a better working environment for innovation adoption and implementation.

1.1 Study Problem Statement

The fourth industrial revolution is forcing dramatic and rapid changes in the whole systems within public and private sectors. Without effective empowerment of innovation champions, the public sector will continue to be markedly slow in perceiving innovation risk, which negatively affects innovation generating and adoption within this sector [29, 30, 36].

1.2 Study Questions

1 How does the innovation champions' empowerment influence organisational perception of innovation risk?
2 How does the innovation champions' empowerment influence the line managers to play both supervisor and sponsor role?
3 How does the innovation champions' empowerment influence the organisational innovativeness?

2 Literature Review

2.1 Project Management and Innovation

According to Filippov and Mooi [16], innovation and project management theoretically evolved as separated disciplines despite the fact that innovation itself is generated, adopted, and implemented as a project. Project management originally evolved from engineering field that is based on precision, accuracy, and resource usage optimisation. With reference to Maylor [26], there are three historical stages for project management; the first stage is unknown before the 1950s; the second stage is the introduction of numerical methods to support managing several projects from 1950s to 1990s. Stage three evolved from the nineties onward as the modern "projectification" where most of the organisations are using project management as a norm to manage their businesses.

Since the modern Project Management establishment, the scholars, project management journals, and project management body of knowledge started outlining directions and disciplines for the future of the organisational project management with a minimal focus on innovation [24]. It has been acknowledged to a certain extent that there is a positive correlation between project management and innovation levels in a linear fashion [22]. According to Fagerberg et al. [14] to clarify the link between innovation and project management systematically, the following illustration is offered: when an organisation faces a challenge in a certain area: Phase one:

starts as “the response” to a challenge where the invention starts at thinking, process, service, or product level. Phase two: defined as the “innovation phase” where the invention is carried out for the first time from theory into practices. Finally, Phase three: the “transfer” of invention and creativity into innovation and practices, which easily could be defined as a project management.

2.2 Public Sector Innovation

There are many definitions of innovation in the Public Sector in the reviewed literature. Some scholars like Meijer [28] are defining innovation in general based on individual innovators’ roles in the public sector as a standalone concept rather than organisational innovation. Also, Rogers [32] has defined innovation in the same context but added the organisational adoption by describing innovation as a newly adopted idea, practice, or object by an employee or firm. However, when it comes to defining organisational innovation as a concept, this study identifies some scholars such as Borins [4] who defined innovation as “the adoption of an existing idea for the first time by a given organization”. Other scholars like Bhatti et al. [3] defined organisational innovation as a novelty “innovation is to be understood as a policy, programme, or idea which is new to the organisation adopting it”. Based on the mentioned definitions above, Innovation in the Public Sector can be defined as the adoption of a new idea that results in the development of a strategy to renovate products, organisational practices, or both.

According to Damanpour [8], there are mainly four defined innovation dimensions for the public sector: “Process Innovation, Product or services Innovation, Governance Innovation, and Conceptual Innovation”. These dimensions as used to develop a new process, product, or paradigm for overcoming certain organisational challenges and create new approaches to address them. It is worth mentioning that despite the fact that innovation has four distinct dimensions, innovation is connecting one or more of these defined dimensions to create a new dimension as hybrid integration to meet organisational needs [12]. These innovation dimensions are targeting in general six-innovation outcomes in the public sector as defined by De Vries et al. [12] and shown in Fig. 1.

Damanpour and Aravind [9] and other scholars identify four main clusters of the antecedents of the Innovation process in the Public Sector that influence innovation:

1 **Employee Antecedents**

- At the employee level, employees should have the relevant job knowledge, competencies, skills, creativity, pledge, fulfilment, and innovation acceptance within their organisations. Borins [5] emphasised the necessity of having creative entrepreneurs to overcome the obstacles that have been created by the administrative culture and legacy practices.
- At the organisational level, the success of organisations that are adopting innovation relies on how they empower and support the innovation champions [23].

Fig. 1 Innovation targets in the public sector (De Vries et al. [12])

2 Organisation Culture Antecedents

- Public sector innovation relies on the availability of organisational resources. According to Bhatti et al. [3] organisational capital, size, and employee's capability are considered the main antecedents that influence the innovation process, in addition to a credible leader who has a vision along with strong administrative culture [6].
- Organisational learning and adoption are another important notions that should be taken into consideration when it comes to organisational professionalism that reflects managerial experience [38]. This concept might become an innovation barrier especially when experienced managers increase the boundary-spanning activities in a certain project.

3 External Environment Antecedents

- The external environment is related to public demand, political demand, and media pressure [1]. For example, in the UAE the government as a regulator has published the UAE innovation policy supported by the country's economic vision 2021. This type of the regulations is directing the service providers in the public sector to use innovation as a vehicle to meet governmental targets.
- Competition with other organisations is influencing the innovation process, especially those companies who are functioning in the surrounding environment [2].
- Media is creating innovation drivers or innovation barriers based on the way to a certain event communication with the public. With today's social media, corporation reputations improve or deteriorate in record time.
- The public, politics, and media are the external environment notions that are critically influencing the innovation process in the public sector.

4 **Innovation Antecedents related to attributes and adoption**

- Rogers [32] has identified five Innovation Intrinsic "attributes (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability" (p 232). In this context, other scholars like Damanpour and Schneider [10] described innovation attributes as ease-of-use, relative advantage, trialability, and compatibility which somehow fall into Rogers' definition.
- Rogers [32] stated, "individual perceptions of these characteristics predict the rate of adoption of innovation" (pp 221). Furthermore, he defined the rate of adoption based on the innovation adoption speed by the employees in the social system. Moreover, he reported that the five innovation attributes could explain the variance in the rate of adoption by 49–87%.
- For Rogers [32], the strongest predictor of the innovation rate of adoption is the relative advantage. When innovation is offering a significant benefit, it will be adopted more than innovations offering little benefits, which mainly become a victim of abandonment.

2.3 Innovation Risk Acceptance in the Public Sector

According to Townsend [36], it is crucial for organisations and individuals to perceive innovation risk to have a better understanding of the innovation process for a certain challenge. Public organisations, in general, tend to avoid risk and resists changes, which limits their flexibility to accommodate their environment needs [30]. Such resistance to change caused by innovation is increasingly making public organisation fragile [29].

The New Public Management (NPM) theory was developed between the 1980s and the 1990s and been characterised by "measurement, accountability, efficiency, rational planning and performance" [19]. The aim of NPM is to increase customer satisfaction, product enhancement, and cost efficiency through reduce complexity and greater resources utilisation. This sound of increasing efficiency in the NPM is creating a rigid metric that undertakes an explicit delivery framework, resources and methods that may contradict innovation motivation [30]. Organisations who adopted NPM as ingles management style have gradually created uniformity and standards that only accept what falls into the identified and approved frameworks, which again caused more limitations to the innovation process. On the other hand, there are many motivations for encouraging the public sector to adopt an innovation. "These motivations comprise a mixture of governmental, financial, legitimate rationalities in addition to increasing social welfare, and national awards" as cited in Townsend [36].

In summary, there is a need for changing the public organisations' current way of managing their businesses to help them break out of their rigid systems, frameworks, and performance metrics measures. They need to start accepting the risk of change caused by leaving their comfort zones through incremental innovation adoption.

Also, it is crucial for them to empower innovation champions by providing them with the right working environment, resources, space for experimentation, autonomy of decision-making, and rewarding system. Furthermore, the organisational culture in the public sector should be changed to accept failure as opportunities when it comes to the organisational interest.

2.4 Innovation Champions Management

Innovation champions—who are not always at senior levels—continually take the risk to create innovative ideas and at the same time have the capability to reduce the organisational resistance to realise their assumed objectives [31]. They also have the ability to scan the organisation and its resources to make decisions with limited information and build cross-sectional organisational relations at several levels with minimal management support. On the other hand, Innovation champions effectiveness differs from country to country based on the national culture [33]. Another challenge for innovation champions as a middle management is managerial support at the strategic level, senior executives, who rarely provide operational level oversight [13]. Hence innovation champions' empowerment relies on the national culture, organisational culture, and senior management support.

Despite the fact that innovation champions are granted considerable autonomy in general, they still need a level of assistance and oversight from their management [35]. Managers can play several roles to help innovation champion; they motivate them through widening the research areas, provide guidance, promote communication, keep the process within the organisational strategy, allocate resources, raise the effectiveness, and provide political support to overcome rigid organisational cultural. These roles are summarising the Project Sponsor roles who can ensure the legitimacy and provide support for innovation projects success [37]. In summary, innovation champions require empowerment from their organisation and line managers to overcome innovation project challenges through more resources allocation and greater self-autonomy. This empowerment depends on how organisations are willing to perceive innovation risk, and how innovation champions' supervisors are prepared to play the role of sponsor for their innovation projects. Based on this, the following three hypothesis are proposed:

2.5 Study Hypothesis

H1: The empowerment of innovation champions positively correlate with perceiving innovation risk at the organisation level.
H2: The empowerment of innovation champions would positively correlate with Perceiving risk in innovation projects at Manager Level.

H3: The empowerment of innovation champions positively correlate with organisational innovativeness.

3 Conceptual Framework

This study is focusing on investigating the influence of innovation champions empowerment on the level of accepting innovation risk in their organisations. By accepting innovation risk, organisations in the public sector will start adopting innovation toward improving their performance and enhancing their services or products. This type of risk acceptances requires incremental or in some cases radical changes in the organisational culture and management style. Innovation champions in this study are assumed the middle-management, knowledgeable and skilled employees who are willing to take the lead in their organisation's innovation projects. They should have the qualities of persuasiveness and qualifications to play the role of trustees in innovation generating, adapting, and implementations. The below literature funnel approach led to the argument of how the empowerment of the innovation champions will influence public sector organisation to accept innovation risk toward success (Fig. 2).

The following roadmap is developed for the suggested relations between the independent and dependent variables in the way to structure our conceptual framework (Fig. 3).

4 Methodology

This study is exploring the statistical relationship between the identified variables in the conceptual framework, and to test the study's hypothesises on this basis, a survey was adopted from Kelley and Lee [23] that has been conducted in the private sector within multinational companies in Korea. This research' authors have carefully adopted this survey with respect to research intention and common interests of the public sector within the United Arab Emirates. Two professionals from the educational sector have been consulted to enhance the survey content. Furthermore, informed consent was placed at the beginning of the survey to ensure that the responses are towards the communicated survey; also, the anonymity of participants in addition to responses confidentiality were guaranteed by not requesting for references, and researcher bias was eliminated by not interfering with the participants during the survey [34]. Accordingly, the online survey was communicated to a small but carefully selected group of fifty project champions from middle and senior management levels working in several public organisations who accepted to participate in this survey. Such probability-cluster sampling approach was chosen to deliberately select subject matter experts who have the specialist knowledge and practice in

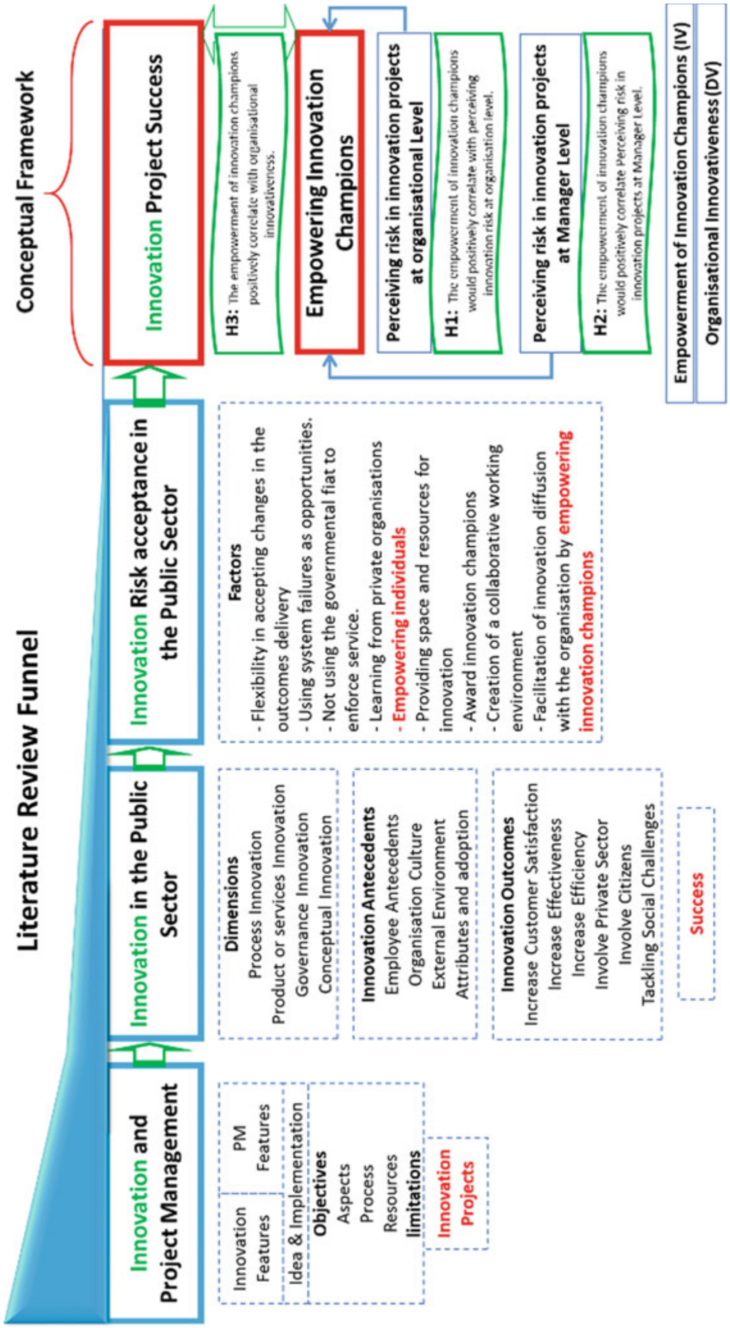

Fig. 2 Literature review funnel

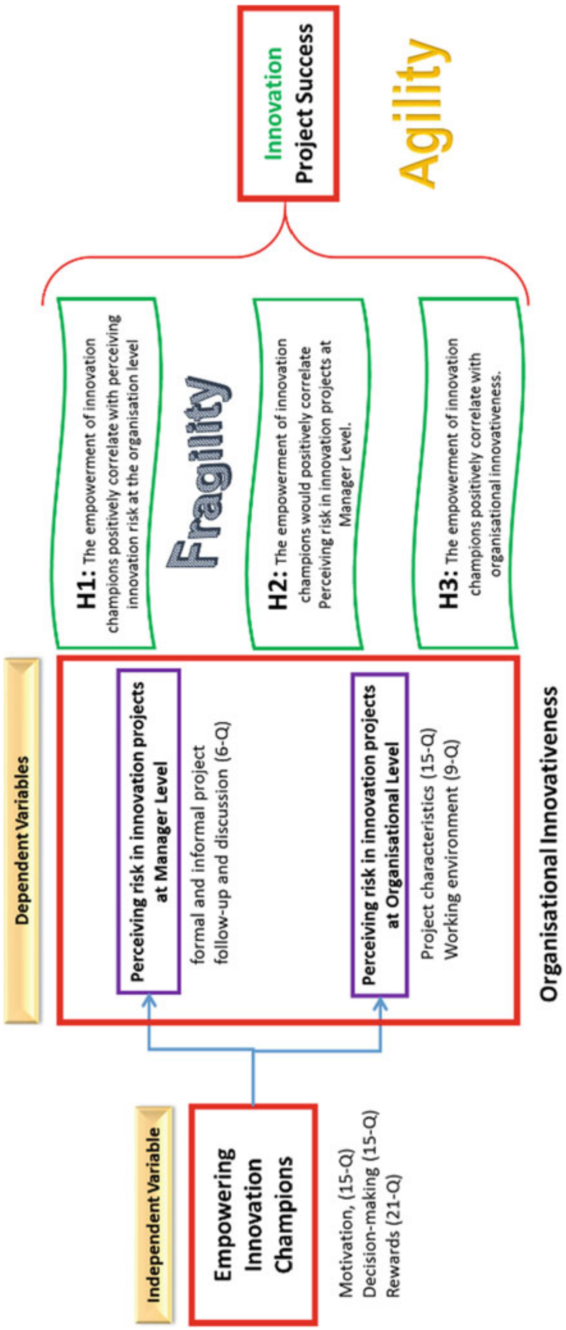

Fig. 3 Conceptual framework

innovation management. The duration of the survey was four weeks; conduction was planned carefully using a strict survey protocol and follow up to ensure acquiring the required response.

4.1 Measures: Independent and Dependent Variables

4.1.1 Independent Variable (*Empowerment of Innovation Champions*)

The study focus was on the project champions motivation, decision-making, and rewards of participating in an innovation project. For the first theme—motivation, there were fifteen questions, the second theme—decision-making with fifteen questions, the third theme—rewards with twenty-one questions [21] and [27] as cited in [23]. The three themes came with Likert scale consists of five-point, and respondents statement that is rated from one that reflects strongly disagree to five that reflects strongly agree.

4.1.2 Dependent Variables: (*Organisational Innovativeness*)

- ***Project Characteristics***:
  There were two main themes: the first one is project characteristics which consist of fifteen questions that describe innovativeness, strategic relatedness, level of newness, organisational risk, market unfamiliarity, market and technical uncertainty, and resources requirements as cited in [23]. The second theme consists of nine questions based on the working environment that supports the acceptance of project newness through organisational support. Both themes came with Likert scale consists of a five-point and respondents statement that is rated from one that reflects strongly disagree to five that reflects strongly agree.
- ***Line Manager Role* (*Supervisor*)**
  This part of questionnaire came with one theme addressing formal and informal project follow-up and discussion [18] as cited in [23]. This part consists of six questions that describe formal and informal meetings or discussions about the project during the process and came with the respondent's rated statement came with a five-point scale where one reflects low frequency and five reflects high frequency.

5 Data Analysis

This study is investigating the statistical relationships between the identified variable following quantitative research design to ensure the validity and the generalisation of results founded from the population selected sample [34]. A survey was designed in the format of online and its hyperlink has been generated to be shared with the fifty targeted participants. After four weeks of following up, 41 answers were received with 40 completed surveys. The completion rate of 80% out of the sent ones was considered as an acceptable percentage of participation in this study.

5.1 Validity Test

Reference to Foster [17] and in order to reduce the variables to certain dimensions, the authors decided to accept the entry of (0.3) onward. Based on the SPSS results, we have added the values to generate the factors as follows:

1. **Independent Variable**: Empowerment of Innovation Champions that consists of Motivation, Rewards, and Decision-Making
2. **Dependent Variable**: Organisational Innovativeness that consists of Project Characteristics and Working Environment. In addition to Line Manager Role through Evaluation and Meetings.

5.2 Reliability Test

The results in table show reliable results, which mean that the developed survey could measure our designed independent variable and dependent variables in the same way at different points in the future (Table 1).

Table 1 Cronbach's alpha

Variable	Value
Motivation	0.825
Rewards	0.807
Decision-making	0.812
Line manager role	0.852
Project characteristics	0.835
Working environment	0.838
Empowering innovation champions	0.835
Organisation accepting risk	0.810
Organisational innovativeness	0.846
All	0.904

5.3 Hypothesis Testing

5.3.1 Correlation Test

1 Empowering Innovation Champions (EIC) with Perceiving risk in innovation projects at Manager Level. We found a weak positive correlation (0.284) that is not significant (0.080) between the variables, which means that empowering innovation champions will not encourage the line manager to perceive the risk of innovation projects, and so, we initially reject the H2
2 Empowering Innovation Champions with Perceiving risk in innovation projects at Organisational Level. We found a significant positive correlation (0.539) between the variables, which means that empowering innovation champions will encourage the organisation to perceive innovation risk, and so, we initially accept the H1
3 Empowering Innovation Champions with Organisational Innovativeness: When we add perceiving risk at both organisation and line manager levels, we found a significant positive correlation (0.501) between Empowering Innovation Champions and Organisational Innovativeness, and so, we initially accept the H3.

5.3.2 Regression Test

1 Empowering Innovation Champions with Perceiving risk in innovation projects at Manager Level: the coefficient of R = 0.226 suggests a positive relationship between Empowering Innovation Champions and Perceiving risk in innovation projects at Manager Level. Also, $R^2 = 0.051$ which indicates a weakness in this model was only 5% of the variance of Perceiving risk in innovation projects at Manager Level could be explained by Empowering Innovation Champions. Furthermore, this model is not predicting the dependent variable well because F-Ratio = 1.995 at significant value $p > 0.01$. Finally, the Beta Value = 0.226 indicates that higher empowerment for innovation champions might increase perceiving risk at line manager level. Hence we reject H2, which shows that the fragility of innovation adoption comes from senior management minimal involvement in managing innovation projects.
2 Empowering Innovation Champions with Perceiving risk in innovation projects at Organisational Level: the coefficient of R = 0.578 suggests a positive relationship between Empowering Innovation Champions and Perceiving risk in innovation projects at Organisational Level. Also, R2 = 0.334 which indicates an acceptable level of goodness in this model were 33% of the variance of Perceiving risk in innovation projects at organisational Level could be explained by Empowering Innovation Champions. Furthermore, this model is predicting the dependent variable well because F-Ratio = 18.9589 at significant value $p < 0.01$. Finally, the Beta Value = 0.578 indicates that higher empowerment for innovation champions might increase perceiving risk at the organisational level. Hence we accept H1.

3 Empowering Innovation Champions with Organisational Innovativeness: the coefficient of R = 0.524 suggests a positive relationship between Empowering Innovation Champions and Organisational Innovativeness. Also, R2 = 0.274 which indicates an acceptable level of goodness in this model was 27% of the variance of Organisational Innovativeness could be explained by Empowering Innovation Champions. Furthermore, this model is predicting the dependent variable well because F-Ratio = 13.993 at significant value $p < 0.01$. Finally, the Beta Value = 0.524 indicates that higher empowerment for innovation champions will increase perceiving risk at the line manager and the organisational level. Hence the empowerment of Innovation Champions will increase organisational innovativeness in the public sector, and so, we accept H3.

The following step intends to investigate the influence of the independent variable factors (Motivation, Rewards, and Decision Making) on the dependent variables. Table illustrate the regression analysis for these factors.

6 Discussion

Based on the correlations and regressions tests, we have found that empowering innovation champions is positively influencing organisations to accept innovation risk. This result means that more empowerment for innovation champions will lead to better organisational innovativeness in general. However, when we test the relation between empowering innovation champions and line manager supervisory role, the result was not significant. Line managers should have more involvement in the project in order to make sure the innovation project still within the organisational capacity. Hence, the lack of line managers involvement will cause the fragility of the projects within the public sector. This conclusion is highlighting the fact that line managers should play the role of sponsor more than supervisor [7, 25], and this answers question 2.

The results in Table 2 show a fragility in innovation projects in the public sector caused by line managers lack of support [29]. The empowerment of Innovation champions requires line manager support in order to increase the innovation champions' autonomy [21]. This increase should come from more empowerment for innovation champions in decisions making along with keeping sponsor role for line managers besides more involvement in operations. This type of management will motivate innovation champions and increase their commitment towards innovation projects [20]. So, it is critical for line managers to play more sponsors role when it comes to high innovation champions empowerment [23].

On the other hand, the resistance to innovation is causing fragility in the public sector [29]. However, we have found that the empowering innovation champions are positively influencing organisations to perceive risk in innovation projects. This result leads to the fact that organisations in the public sector will be able to be more flexible in adopting an innovation. Here, innovation champions will have to play a

Table 2 Independent factors and dependent variables

Model	R	Variance explained (%)	F-ratio	Significance	Beta
Line manager role and motivation	0.330	10	4.670	0.037	0.331
Line manager role and rewards	0.000	0	0.001	0.981	0.004
Line manager role and decision-making	0.362	13	5.708	0.022	0.361
Project characteristics and motivation	0.313	10	4.118	0.049	0.313
Project characteristics and rewards	0.358	13	5.426	0.025	0.358
Project characteristics and decision-making	0.429	18	8.568	0.006	0.426
Working environment and motivation	0.481	23	11.40	0.002	0.480
Working environment and rewards	0.335	11	4.657	0.037	0.334
Working environment and decision-making	0.415	17	7.897	0.008	0.415
Organisation accepting risk and motivation	0.505	26	13.005	0.001	0.505
Organisation accepting risk and rewards	0.447	20	9.248	0.004	0.447
Organisation accepting risk and decision-making	0.546	30	16.126	0.000	0.546
Organisational innovativeness and motivation	0.505	26	12.988	0.001	0.505
Organisational innovativeness and rewards	0.344	12	4.953	0.032	0.344
Organisational innovativeness and decision-making	0.547	30	16.218	0.000	0.547
Line manager and empowering innovation champions	0.226	5	1.995	0.166	0.226
Project characteristics and empowering innovation champions	0.434	19	8.588	0.006	0.434
Working environment and empowering innovation champions	0.465	22	10.194	0.003	0.465

(continued)

Table 2 (continued)

Model	R	Variance explained (%)	F-ratio	Significance	Beta
Organisation accepting risk and empowering innovation champions	0.578	33	18.589	0.000	0.578
Organisational innovativeness and empowering innovation champions	0.523	27	13.993	0.01	0.524

major role in persuading their organisations to change the internal culture and accept the innovation risk. Also, innovation champions should persuade their line managers to play the role of sponsor and supervisor where they can have more involvement at operations level [23]. Finally, innovation champions are responsible for creating innovate ideas and translate them into reality through on ground implementations [9]. According to Townsend [36], this type of innovation adoption through accepting innovation risk will create and facilitate the innovation diffusion within the organisation through the collaborative working environment. In this way, organisations in the public sector will perceive risk and accept changes, which make them more flexible to accommodate their internal and external environment needs [30], and this answers question 1.

Empowering Innovation Champions will positively influence organisations innovativeness by accepting market unfamiliarity and technical uncertainty [11]. As provided in Table 2, we found a significant positive relation between empowerment of innovation champions and Project Characteristics (Level of newness, organisational risk, market unfamiliarity, market and technical uncertainty). This result means that motivation, rewards, and especially decision-making will encourage innovation champions to generate and adopt innovation despite the organisational and line managers risk acceptance. On the other hand, Innovation Champions will positively influence organisations innovativeness through creating a better internal working environment as they will work collaboratively with their line manager and persuade them to accept innovation risk. Also, they will persuade their organisations to accept innovation risk and will work towards generating and adopting an innovation. Finally, they will develop creative ideas to innovate their rigid systems, frameworks, and performance metrics measures, and this answers question 3.

7 Conclusions and Recommendations

Organisations in the public sector are facing challenges for innovation adoption at many levels. Mainly, they resist accepting the innovation risk which makes them more fragile [29]. This study provides insights into the link between empowering innovation champions and organisational innovativeness. The results we have found in this study show a positive and significant relation between organisational innovativeness and empowering innovation champions. First, by empowering innovation champions, organisations will have better working environments were senior management and middle management would work collaboratively. Second, empowering innovation champions will contribute towards organisation accepting innovation risk, which leads to generating and adopt an innovation. Third, empowering innovation champions will, in general, support in making organisations in the public sector agiler through innovation adoption.

The fragility of innovation adoption in the public sector organisations as concluded from this study comes from the line managers who do not perceive innovation risk and playing only a supervisory role. Their management style is more into supervisory rather than a balance between supervisory and sponsors role with minimal operations involvement, which leads to less empowerment for innovation champions and failure in innovation adoption. This result has also been concluded by Kelley and Lee [23], where they suggested that line managers should play multi managerial roles and support their organisation to determine the appropriate empowerment level for innovation champions. Line managers in the public sector organizations need to improve their managerial skills and effectiveness in order to facilitate innovation in their organisations.

These conclusions are opening the door for further research on how to improve internal organisational management in the way to facilitate innovation. It is hoped that these research findings will contribute to support organisations in the public sector to build a better understanding of their internal innovation restrictions and where they should focus to overcome these challenges. It is important to recognise this study limitation like the representative sample that is creating a questionable ground for generalising the results at this time. Also, there was a challenge to "access" some organisations and some managerial positions in the public sector that require more effort to grant access. Finally, this study longitudinal effects are limited and this is considered as an opportunity for furthering the investigations of the changes over the time.

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Clinical Performance Improvement in Diabetes: Adapting a Proven Model in Dubai

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Abstract The Dubai Performance Improvement (P.I.) project in Diabetes (Dubai-PID) will replicate the 6-phase process used in the European Performance Improvement in Diabetes Demonstration project (EPIDD), an initiative deployed in the region of Cantabria, Spain. Dubai-PID will aim to improve clinical practice of primary care teams treating and managing Type 2 Diabetes (T2D) patients in Dubai. The project will begin with the formation of a Triple Helix collaborative between a private P.I. organisation (AXDEV), academia (Mohammed Bin Rashid University), and industry and local governmental health authorities. Phase 1 will include the development of a collaborative agreement, defining the roles and responsibilities of each organisation, ensuring a common understanding of the project. In Phase 2, potential practice challenges will be identified from a literature review. In Phase 3, a consultation group of local healthcare providers (HCP) and decision-makers will prioritise the locally relevant challenges, which will be further validated during semi-structured interviews with HCPs. Confirmed challenges will inform case-based educational interventions designed and deployed in selected Dubai clinics during Phase 4. The ethics-approved evaluation (Phase 5) will include online surveys and qualitative interviews with learners, clinic administrators and T2D patients. The initiative will also include a dissemination plan (Phase 6), to ensure sharing of lessons learned to the professional educator and healthcare provider communities. This case will use the results and learnings from EPIDD to inform each phase, to ensure success of the initiative.

Keywords Collaboration · Interprofessional continuing education · Performance improvement · Triple helix · Type 2 diabetes

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Geographic Coverage United Arab Emirates (UAE)/Emirate of Dubai/Dubai.

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1 Strategic Aims

The Dubai Performance Improvement in Diabetes project (Dubai-PID) will be a Triple Helix collaboration between a private performance improvement (P.I.) organisation (AXDEV), academia (Mohammed Bin Rashid University of Medicine and Healthcare Sciences, MBRU) and local governmental health authorities.

The main aim of the Dubai-PID will be to improve the clinical practice of primary care teams treating and managing Type 2 Diabetes (T2D) patients in Dubai. To achieve that aim, it will use a six-phase P.I. approach, which was proven successful through the European Performance Improvement in Diabetes Demonstration project, or EPIDD [1–4].

The EPIDD concept originated from the minds of Suzanne Murray (AXDEV CEO and Founder) and the AXDEV research team. It is based on adult learning principles and years of accumulated evidence in educational and behavioral research, created to optimise performance improvement in the field of healthcare. The EPIDD project received the inaugural Global CME Impact Award, awarded by Global Education Group and the Global Alliance for Medical Education (GAME) at the 42nd Annual Conference of the Alliance for Continuing Education in the Health Professions (San Francisco, California, United States, January 27, 2017). The EPIDD initiative was the first step in demonstrating the value of this approach and AXDEV's commitment using this method in other regions and therapeutic areas.

2 Case Overview and Track Record

One of the keys to ensuring success of the 6-phase process is to dedicate proper time and energy on the development of the collaboration itself, to ensure a common understanding of the project's objectives (Phase 1) and a clearly established process that guarantees an unbiased and evidence-based educational and clinical performance intervention. This will lead to the development of a collaborative agreement, defining the roles and responsibilities of each organisation.

The Dubai-PID project will include, two phases of identification (Phase 2) and prioritisation (Phase 3) of practice challenges, before confirmed challenges are used to inform live case-based educational interventions designed and deployed in selected Dubai clinics. More precisely, in Phase 2, potential challenges will be identified from a literature review. In Phase 3, to prioritise the most locally relevant challenges, a consultation group will be formed, involving local healthcare providers (HCP) and decision-makers. The prioritised challenges will be further validated during semi-structured interviews with HCPs.

During the EPIDD project, the literature review led to the identification of 47 challenges which were grouped and prioritised by educational experts into 9 addressable challenging areas, from which 4 (with 27 underlying causalities) were retained by the local working group: A) diagnostic and patient uptake of diagnosis; B) insulin therapy and therapeutic inertia; C) empowerment of patients to make lifestyle changes; and D) pro-active management of T2D complications.

The Dubai-PID project will use the confirmed challenges from phase 3 to inform the development and design of case-based educational interventions to be deployed in the participating Dubai clinics during Phase 4. The content of the interventions will include cases based on difficult clinical scenarios provided by the learners themselves during Phase 3 interviews, ensuring that the healthcare providers discuss and learn from situations that are realistic to their current clinical context. The impact of Dubai-PID will be assessed by an ethics-approved evaluation (Phase 5) which will include online surveys and qualitative interviews with learners, clinic administrators and T2D patients. Finally, in Phase 6, results and learning of the Dubai-PID initiative will be disseminated to different audiences, such as healthcare providers and health educators. The dissemination plan will include submission of one or more manuscript(s) to peer-review journals, as well as submissions of abstracts to scientific conferences.

The Dubai-PID project could potentially achieve clinical impact similar to the EPIDD project, which it will attempt to replicate the process. As shown in Table 1 (next page), increased knowledge and skill were reported, as well as changes in practice.

3 Triple Helix Champions

The EPIDD initiative included three champions from two of the three helixes, with two representatives from the private sector (one pharmaceutical industry and one performance improvement organisation), and one from the government. Two champions were required from the industry because of the differing natures and roles of the two organisations involved. In comparison, the Dubai-PID initiative will include a fourth champion, from the academia sector, effectively completing the triple helix model.

4 Tangible Impact

It is expected that the clinical performance improvement experienced by Dubai-PID participants will impact patient outcomes, overall clinic efficiencies and contribute to lowering healthcare costs. The Dubai-PID initiative will include a dissemination plan, to ensure sharing of lessons learned to the professional educator and healthcare provider communities, multiplying the potential impacts (see above references for EPIDD).

For the collaborators, the main tangible impacts may include visibility and credibility. These two aspects are especially important for the private collaborators. The

Table 1 Impacts of the EPIDD project identified by challenging area

Challenging area	Impacts identified
(A) Diagnostic and patient uptake of diagnosis	• Low levels of knowledge gained • No changes in clinical practice reported • Enhanced patient-provider communication (should help providers in uptake of diagnosis)
(B) Insulin therapy and therapeutic inertia	• Decreased therapeutic inertia • Increased confidence using different types of insulin/mixtures • Increased knowledge of communication strategies to alleviate patient fears • Enhanced skills and confidence in patient-provider communication to discuss insulinisation with patients • More complex cases kept in primary care, reducing referrals to specialists
(C) Empowerment of patients to make lifestyle changes	• Increased confidence discussing lifestyle changes with patients • Enhanced patient-provider communication (should help providers optimise patient support)
(D) Pro-active management of T2D complications	• Improved awareness of importance of annual check-up for diabetic foot • Increased knowledge, confidence and skills in management of hypoglycemia and diabetic foot • Implementation of patient group on diabetic foot in one of the clinics

EPIDD initiative for example contributed to positioning both Eli Lilly, the pharmaceutical industry involved, and AXDEV Group, the performance improvement organisation leading the project, as leaders and key stakeholders that provide innovative and evidence-based education to healthcare providers, and also as organisations who are willing to openly collaborate in public-private partnerships in order to develop and deploy rigorous and credible education for the benefits of the healthcare community. For government stakeholders, the main tangible impact could include enhanced clinical efficiency that contributes to the improvement of healthcare services and to lowering healthcare costs. Finally, for academia, expected benefits include advancement of knowledge in continuing education, implementation science and performance improvement research.

5 Intangible Impact

It is expected that Dubai-PID participants will improve their knowledge, skills and competence, and will demonstrate improved clinical performance, as the clinical gaps identified at the beginning of the project will be addressed. Notably, participants will improve their team efficiency and inter-professional collaboration skills. This improvement could directly impact the care received by patients of Dubai-PID participants.

During the EPIDD project, healthcare providers reported enhanced skills and confidence in relation to patient-provider communication, including increased confidence discussing lifestyle changes with their patients. They also reported increased motivation and willingness to manage more complex cases (thus reducing referrals to speciality care), as well as adoption of proactive behaviours with patients at-risk for complications, and in the on-going adjustment of treatment with patients. Participants, on the other hand, reported improved awareness of the importance of annual check-ups for diabetic foot, as well as an increase in knowledge, confidence and skills managing hypoglycemia and diabetic foot. In addition, the creation of a patient group on diabetic foot was reported in one clinic.

6 Transferability and Lessons Learned in Triple Helix Cooperation

The outcomes evaluation of the EPIDD project suggested that the 6-phase process used in this P.I. demonstration project can be replicated in other clinical settings in Spain or other countries, to identify, validate and successfully address clinical gaps in type 2 diabetes, in addition to other therapeutic areas. The Dubai-PID initiative will replicate this 6-phase process to improve clinical performance and efficiencies of healthcare providers and teams involved in type 2 diabetes care in Dubai.

Lessons learned/take-aways in Triple Helix cooperation:

1. Based on the experience acquired with the EPIDD initiative, it appears essential for the success of any collaborative initiative, including Triple Helix collaborations, to provide sufficient time and importance to the process to engage all targeted stakeholders and collaborators. In the model used during the EPIDD initiative, the developed collaboration was considered a distinct phase, and included a signed collaborative agreement: a document that defined the roles and responsibilities of each organisation and facilitated a common understanding of the project's objectives. In addition, collaborators agreed on clear processes to guarantee respect of each collaborator's contribution and an unbiased, evidence-based educational and clinical performance intervention.
2. An important lesson of the EPIDD initiative, which is also being considered in the Dubai-PID project, is the inclusion of administrators and patients, who,

although not the primary audience of learners, are key stakeholders and informers of clinical practice challenges that should be addressed by the educational intervention. It is crucial for the success of any Triple Helix initiative to consider all stakeholders that should be involved, both as short-term information sources, and as long-term key facilitators of the project's sustainability.
3. Another key factor of success is to not minimise the importance of using the right methods and measures throughout the project, from needs assessment to implementation of the educational intervention and evaluation of the project's impact.
4. The Dubai-PID initiative should contribute to the validation of the 6-phase process used in EPIDD as replicable and sustainable in other clinical settings, countries and therapeutic areas. Replication of the clinical impacts of EPIDD via its successful integration of the Academia helix should provide healthcare providers and educational experts with a solid method to improve clinical performance and efficiency.

To increase the probability that the changes observed throughout the initiative are maintained after completion of the program, the model will involve local champions at three different levels: clinical team leaders, clinic administrators and representatives of the local health authorities. The involvement of local clinical champions will increase the probability that the necessary steps be put in place locally, in each targeted clinic. These steps will include: monitoring how the solutions applied throughout the program will evolve in the months and years to follow, as well as implementation of formal procedures and processes to standardise application of the identified solutions and to define how continuous clinical performance improvement will be an integral part of the clinic's evolution. From our experience, however, sustainability cannot be guaranteed, as changes in leadership and management eventually occur and often transfers are not conducted optimally.

7 Conclusions

The Dubai-PID initiative will integrate the academia helix (MBRU) into its existing model to establish a strong Triple Helix collaboration, that will provide healthcare teams from selected Dubai clinics with educational activities tailored to their needs. This case will replicate and aim to validate the 6-phase process used in Spain during the EPIDD project. A validation of this process will provide evidence that the model can be applied in other clinical settings, countries and therapeutic areas, and can provide healthcare providers and educational experts with a solid method to improve clinical performance and efficiency.

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The Influence of Soft and Hard Quality Management on Innovation Performance in UAE Service Sector

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Abstract The purpose of this research is to examine the controversial nature of the relation between quality management (QM) practices and innovation performance in the service sector in the UAE. Quality management was examined from multi-dimensional perspective, namely Soft QM and Hard QM, which adds another aim for this study that is to examine the relation between soft QM and Hard QM practices in the service sector. Quantitative research methodology was followed, while regression analysis and ANOVA tests were conducted to test the hypotheses. The main finding was that soft QM practices are supporting the implementation of hard QM practices in the service sector in the UAE. In addition, both soft and hard QM practices are directly related to the innovation performance with a relatively higher influence of soft QM than hard QM on innovation performance of service organization in the UAE. The main limitation of this study was the number of service sector organizations included in the study, which three in this research are banking, education and telecommunication. Furthermore, the number of participants was not statistically strong enough to generalize the study results. The most important implication of this study for top management in the service sector is that they should concentrate more on the soft QM practices identified in this research (problem solving groups, employees' suggestion system, and employees' job-related training) since these practices are essential to implement hard QM practices and support the overall innovation performance of the organization.

Keywords Service innovation · Innovation performance · Soft quality management · Hard quality management

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1 Introduction

In today's competitive market, quality management and innovation management are two core managerial concepts for running a successful business [37]. The relation between the two managerial concepts has been explored extensively in literature from many different perspectives; most of these research studies have a debatable nature about the type of relation between the two concepts [37]. Some researchers found that quality management hinder creativity hence innovation [17, 21, 22, 28, 34, 44]. The rationale in these studies was based on the opinion that standards and conformity rules usually block employees' creativity and shift their thinking to only produce the same with no errors or mistakes rather than finding new and creative ways to perform their tasks. In the academic literature, a clear distinction between creativity and innovation was presented since they are not synonyms. Creativity stands for new ideas and ways of doing things, whereas innovation stands for the implementation of new ideas and concepts in organizations [4]. However, "When creativity is under the gun, it usually ends up getting killed" [5]. Obviously, creativity is the core of innovation. So a trade-off or a competition between innovation and quality might occur [40].

Other researchers [25, 32, 50] found that quality and innovation can simply coexist and support each other such as these articles that argued that quality management may foster innovation if the management team starts to change its perspective of quality management practices. For example, instead of dealing with customer complaints (Quality management) they should start thinking of meeting customer expectations that make them move towards innovation management rather than quality management [25].

This study attempts to investigate the relationship between quality and innovation in the service sector. It will look at quality as a multidimensional concept that consists of soft quality management that refers to the humanistic aspects of quality management such as customer awareness, problem solving and training, and hard quality management that refers to quality management tools and systems such as statistical process control and QFD (Quality Function Deployment) [49].

Many research studies have already investigated the relation between quality management and innovation, but further research is needed to clarify the debatable relation between the two [37]. Most of these studies have been conducted in regions like USA, Europe, Brazil, Japan and China. However, limited research has been done in the Middle East which is considered as a developing region rather than a developed one. As clearly stated by [26], the innovation process in developing countries might follow a different pattern than developed countries. So, the United Arab Emirates has been chosen as the site for data collection from the service sector organizations. In addition to the future research suggestion made by Zeng et al. [50] who tested the relation between soft QM and hard QM with innovation performance in the manufacturing sector in developed countries, namely Austria, Finland, Germany, Italy, Japan, Korea, Sweden, and USA to explore the same in the service sector, the aim of this research is to study the relation between the two dimensions of quality management - soft and hard QM and innovation performance in a developing country (UAE) service sector. The study seeks to answer the following questions:

1. Does soft quality management relate to hard quality management?
2. Does soft quality management relate to innovation performance?
3. Does hard quality management relate to innovation performance?

2 Literature Review

This study's literature review is composed of three main parts in which we explore the service innovation in the first section and then we move to understand the concepts of soft quality management and hard quality management, and finally we will explore the relation between soft QM and hard QM with innovation performance.

2.1 Service Innovation

Service is usually a process and an experience based in which the human aspect generally plays an important role in delivering the services. The best way to define the meaning of service is that it is a process that involves an interface with a customer through human or technological interactions [8]. Unlike tangible goods, services have a dynamic nature and they are usually seen as a set of activities that create value for both the customers and the service providers. These activities create a clear characteristic of services process [16].

Service innovation is an important aspect of an organisation's success and its ability to compete in the market [23]. One of the essential characteristics of service innovation is the interaction with the customer [48]. Service innovation usually concentrates on service weaknesses or defaults in order to find innovative solutions and win more customers [30], since the main goal of service innovation is to provide innovative solutions for customers [10]. Service innovation has been seen from different perspectives in literature. For example researchers like [14, 45] have agreed that service innovation is usually related to employees' behaviors and organizations rather than technological improvements, whereas researchers like [6, 24] have stressed the importance of technology in service innovation. One of the main challenges in service innovation is that it is not hard to be imitated by other competitors since it is tough to get a patent on service innovation as in the case of products and goods innovation [47]. Innovation in the service sector usually concentrates on customers' needs and expectations as the source of service or process innovation [10]. Some researchers criticise the customer focus approach as a source of innovation since this will limit the innovation to the current services rather than taking the innovation to the next curve of the innovation cycle to unlock new or even unknown needs for customers [43, 46].

2.2 Soft QM and Hard QM

Quality management is the key for performance improvement as clearly stated by the quality gurus such as: [9, 19]. Many studies have been conducted on quality management and its relation to innovation performance. Some studies dealt with quality as a single concept, while others presented it as a set of principles. Other researchers have distinguished two main dimensions out of these principles, namely soft quality management and hard quality management [13, 41, 50]. Hard QM practices usually refers to tools and techniques that we use in quality management, such as process control and quality information systems, whereas soft QM refers to people management, leadership and relationships [1]. The practices of soft quality management usually help in creating the continuous improvement of culture in organizations, while hard quality management practices influence the organizational performance [27]. Unlike the manufacturing sector, the service sector focuses more on soft QM rather than hard QM because of the employee-customer interaction nature of the service sector [27].

So this study adopts the two dimensions of quality management—soft and hard quality management—that are adopted by [49]. The construct that identifies each dimension has been chosen from many studies in literature about soft and hard QM. One of the main constructs of hard QM that is discussed in literature is process control that guarantees the standardisation of the process outcomes to meet customers' requirements and expectations [13]. The main aim of process control practice is to monitor the processes in order to reduce the variation and eliminate service breakdowns.

Quality information is the other hard QM practice that we select in this study that has been discussed in many research studies in literature such as [18], and the main aim of quality information practice is to provide employees with the necessary information about their quality performance and their service processes.

Soft QM practices have been identified with the human management and leadership mainly in literature and since this study focuses on the service sector the best representation of soft QM will be the employees-related factors. [3] has identified three main employee- related factors to be precise—involvement, empowerment, and training. In a similar way, [29] has studied the relationship among employees through training, suggestion and team improvement. This study adopts the identification of [50] of soft QM practices because it suits our study purpose since they identify soft QM practices by: Problem solving technique, employee's suggestion, and job-related training.

In literature, the relationship between soft and hard quality management and their influence in organizational performance was indecisive, since some studies found that hard QM is not significantly related to performance [18], while others founds that some aspects of soft and hard QM are either directly or indirectly related to organizational performance, or that hard quality usually plays the role of mediator [42]. Others have clearly stated that soft QM practices facilitate the implementation of hard QM, and both are very important for successful implementation of quality management in any organization [1]. Based on the previous literature review about soft QM and hard QM, further investigation is needed, especially to identify the relation between soft QM and hard QM with innovation performance, and even this study will try to identify the relation between soft QM and hard QM. In other words, one of this research aims is to identify the type of relation between soft and hard QM practices, which leads us to our first hypothesis:

H1: Soft QM has a positive relation with hard QM practices in the service sector.

2.3 The Relationship Between Soft QM, Hard QM, and Innovation Performance

The relationship between quality management and innovation has been explored deeply in the last three decades, even though there are still contradicting findings about the nature of this relation [37]. Some researchers found that there is no clear evidence that quality management practices are related to innovation [33, 39], since quality management main focus is to establish standardization in work procedures and processes, So it will become the main aim of quality management is to produce the same output of these processes or procedures with no mistakes or defaults, which will not create the right culture to support new ideas or generate new products/services [15]. Other researchers have found that quality management usually supports innovation through eliminating waste and enhancing efficiency [43], while [11] has found that quality management practices are positively related to product/service innovation and also related to process innovation. Similarly, [20] has found that a set of quality management principles is related to product/service innovation and process innovation. Hence, many researchers have recommended to investigate more in identifying the nature of the relation between quality management and innovation [20, 39, 50]. One of the important principles in quality management is focusing on customers in order to achieve customers' satisfaction and meet their expectations, so companies might be motivated to be creative and search for new customers or even new needs for the current customers rather than just apply the standards [37]. Quality management practices can also support the speed of product innovation in organizations; such a relation has been explored and supported by Flynn [12]. Since quality management can be considered a two-dimensional concept that consists of soft and hard QM, as the case in this study, results might be contradicting between the two dimensions and their relation to innovation in organizations. So, Abrunhosa and Sá [2] have debated that the overall influence of quality management is hard to identify since it is complex and multidimensional. Many other empirical studies have found a positive relation between quality management and innovation types [12, 20, 43] all of these studies have found that quality management practices have a positive relation with product and process innovation.

Peng et al. [35] has studied the influence of process management and innovation and has found a direct relation between the two. Quality information management has been identified as one of the most valuable quality practices that can support innovation practices in companies [31].

People management and leadership have been found as a related concept to product innovation [37]. Soft quality management supports team work and endorses effective communication among employees, which facilitates collecting creative and new ideas from employees and supports product innovation in companies [12].

All of the above literature has led us to the following hypothesis:

H2: Soft Quality Management has a positive relation with innovation performance.
H3: Hard Quality Management has a positive relation with innovation performance.

2.4 Conceptual Framework

The conceptual model of this study is based on the previous literature review, and the study's hypothesis is represented by Fig. 1.

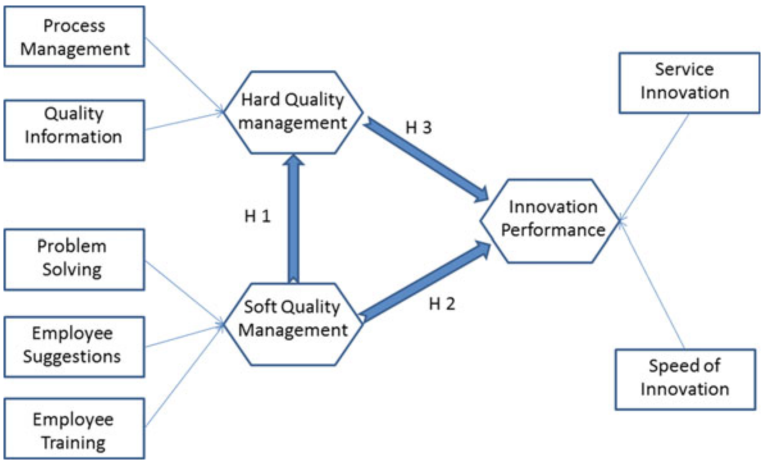

Fig. 1 Conceptual model

3 Research Methodology

In this section, a detailed explanation about the sample and the research methodology and test applied to test the study hypotheses will be provided.

3.1 Sampling and Research Techniques

The aim of this study is to examine the relation between soft QM and hard QM with innovation performance in the service sector in the UAE. So, this study has basically targeted employees working in the quality departments or innovation-related tasks in their organisations. We have mainly targeted banking, education, telecommunication and other service providers. The study collected its data through a literature-based survey from 50 participants in 2017 who are working in different organisation from the service sector in the UAE. As per the size of the organisations that the data was collected from, we have classified them into four main groups—less than 50 employees, 50–100 employees, 101–300 employees, and more than 300 employees.

Since the main aim of this research is to study a statistical relation among the research variables, a quantitative research methodology was followed to test the study's hypotheses and a range of tests was applied to identify the type of relation among the variables such as regression analysis, ANOVA test, and reliability and validity tests (Cronbach's alpha).

3.2 Measures

Based on the study's literature review done in the previous section, a set of scales of measures has been adopted and modified from [50] to test the research hypotheses. For hard quality management, two measurement scales were chosen: process management and quality information. Whereas for measuring soft quality management, three constructs were selected: small group problem solving, employees' suggestion and employees' training. All of these five constructs are measured through 25 perceptual questions over five points on the Likert scale (1 very unlikely, 2 unlikely, 3 not sure, 4 likely, 5 very likely).

Innovation has been introduced in literature in many typologies, and innovation performance has been measured in different ways by researchers. Three main typologies can be identified by previous literature that focused usually on a pair of types—product and process innovation, administrative and technological innovation and incremental and radical innovation [50]. In this research, the focus will be on product/service innovation. The service innovation performance will be measured by two constructs, namely the speed of service innovation and the service innovativeness. These two measurement scales are adopted from [50] with a minor modification to suit the nature of this study which is the service sector rather than the manufacturing sector in Zeng study. These two constructs are measured by using five points on the Likert scale, in which employees are comparing their companies' innovation performance with their competitors in the market. All the previous questions have been answered by more than three participants at least from the same organisation, with participants working in the quality department or in innovation-related jobs.

3.3 Data Analysis

In order to test the research hypotheses, we start by testing the validity and reliability of the research constructs to be able to test the relation among the variables. In terms of construct validity and based on the study's literature review, a well-tested scale from previous literature was adopted to ensure the validity of the survey questions used to collect the data in this study. Reliability is mainly defined as the degree to which scales are error-free so we can consider it consistent [7]. Cronbach's alpha reliability test was adopted to test the reliability of the scales in this research, starting from our dependent variable which is innovation performance. We have then tested the independent variables of soft QM represented by three constructs, namely small group problem solving, employees' suggestions, employees' training. A similar test was applied to hard QM variables—process management and quality information. (0.7) is the value set for accepted Cronbach's alpha results. All of these tests are represented in Table 1.

Based on Table 1 results we can accept all the constructs values, and we can clearly see that all of the research scales are highly reliable.

ANOVA analysis was conducted by using SPSS software with a significance level of (0.05) to test the research hypotheses, so in the first hypothesis we assumed that

Table 1 Constructs Cronbach's alpha Test

Name of constructs	Number of items	Cronbach's alpha value
Process management	5	0.936
Quality information	5	0.924
Small group problem solving	6	0.848
Employees' suggestions	5	0.831
Job-related employees' training	4	0.877
Innovation performance	2	0.920

Table 2 ANOVA tests

		Sum of squares	df	Mean square	F	Sig.
Hard quality * Soft quality	Between groups (Combined)	61.461	24	2.561	8.970	0.000
	Within groups	7.138	25	0.286		
	Total	68.599	49			
Innovation performance * Soft quality	Between groups (Combined)	51.155	24	2.131	4.584	0.000
	Within groups	11.625	25	0.465		
	Total	62.780	49			
Innovation performance * Hard quality	Between groups (Combined)	47.976	24	1.919	3.111	0.003
	Within groups	14.804	25	0.617		
	Total	62.780	49			

there is relation between soft QM and Hard QM practices in the service sector and the result of the ANOVA test is represented in Table 2.

From Table 2 results of ANOVA test done to examine the relation between soft QM and hard QM, we have found that the F value is (8.970) and the ($P > 0.01$), so we can reject the null hypothesis and accept that there is a statistical relation between soft QM and hard QM.

ANOVA test was applied to test the relation between soft QM and innovation performance and the results are represented in Table 2. Since the ANOVA analysis gives us F value of (4.584) and ($P > 0.01$), we can reject the null hypothesis and accept that there is a statistical relation between soft QM and innovation performance. This is the research's second hypothesis.

A similar test was applied to examine the relation between hard QM and innovation performance, and the results of the ANOVA test illustrated in Table 2 shows us that the F value is (3.111) and ($P > 0.01$). So, we can reject the null hypothesis and accept that there is a statistical relation between hard QM and innovation performance. This is the research's third hypothesis.

To further test the relation between soft QM and hard QM practices, a regression test was conducted using SPSS program. The results are illustrated in Table 3.

Based on Table 3, the results of the regression indicated that soft QM explained (70%) of the variance ($R^2 = 0.704$), F (114.005) and ($P > 0.001$), which means that soft quality significantly predicted hard QM (Beta 0.839 and $p < 0.001$).

Multiple regression analyses were used to test if soft QM and hard QM can predict innovation performance in the service sector. The results of the regression indicated that the two predictors explained (63%) of the variance ($R^2 = 0.627$), F (39.565) and ($P > 0.001$). It was found that soft quality significantly predicted innovation performance (Beta 0.649 and $p < 0.001$). The results of the regression analysis are illustrated in Table 4.

Table 3 Soft QM and Hard QM regression analysis

Model summary

Model	R	R square	Adjusted R square	Std. error of the estimate	R square change	F change	df1	df2	Sig. F change
1	0.839[a]	0.704	0.698	0.65072	0.704	114.005	1	48	0.000

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	48.274	1	48.274	114.005	0.000[b]
	Residual	20.325	48	0.423		
	Total	68.599	49			

Model		Unstandardised coefficients		Standardised coefficients	t	Sig.	95.0% confidence interval for B	
		B	Std. error	Beta			Lower bound	Upper bound
1	(Constant)	−0.806	0.423		−1.905	0.063	−1.657	0.045
	SoftQuality	1.152	0.108	0.839	10.677	0.000	0.935	1.369

[a]Predictors: (Constant), SoftQuality
[b]Dependent variable: HardQuality

Table 4 Soft QM and Hard QM with innovation performance regression analysis

Model summary

Model	R	R square	Adjusted R square	Std. error of the estimate
1	0.792[a]	0.627	0.612	0.70551

ANOVA[b]

Model		Sum of squares	df	Mean square	F	Sig.
1	Regression	39.386	2	19.693	39.565	0.000[a]
	Residual	23.394	47	0.498		
	Total	62.780	49			

Coefficients[a]

Model		Unstandardised coefficients		Standardised coefficients	t	Sig.	95.0% confidence interval for B	
		B	Std. error	Beta			Lower bound	Upper bound
1	(Constant)	0.049	0.476		0.103	0.918	−0.908	1.006
	SoftQuality	0.853	0.215	0.649	3.967	0.000	0.420	1.285
	HardQuality	0.157	0.156	0.165	1.006	0.320	−0.157	0.472

[a]Dependent variable: Innovation performance
[b]Predictors: (Constant), HardQuality, SoftQuality

4 Findings and Discussion

In this research, we tried to investigate the controversial relation between quality management and innovation. The research will add to the existing knowledge of the relation between quality management and innovation performance since it has two main distinctive features than the previous research studies. First, this study tried to examine the nature of relation between quality and innovation by looking at quality management as multi-dimensional concept in which we identify soft QM practices and hard QM practices and their relation with innovation performance a similar study has been done in literature [50], however Zeng study was on manufacturing sector and mainly in developed countries. Secondly, this study examines the relation between quality and innovation in the service sector in a developing country.

An interesting finding of this study was the nature of relation between QM dimensions (soft and hard) with innovation performance in the service sector. In previous literature, the type of relation between the two dimensions of quality management and innovation was not consistent, some researchers such as [11, 38] have found that only soft quality management practices can nurture innovation, while other researcher have found that both soft and hard QM contribute to enhancing the organisation's innovation performance [36]. For their part, [20, 50] have found that hard QM practices have a stronger impact on innovation performance than soft QM practices in organisations.

However, the results of this study are rather different from this perspective, since our results indicate that both soft and hard QM practices are influencing innovation performance, but to some extent soft quality has a higher influence than hard quality. We can contribute this different result to the nature of the scope of our study, since this study is investigating the service sector, whereas Zeng and Kim have examined the manufacturing sector.

The human aspect is very vital in the service sector [8], so employee involvement is very important to find creative and new ideas to solve current problems or even create new and innovative service to meet their customer expectations, which is the main aim of service innovation [10]. This result can be supported by the findings of [14, 45] since they relate service innovation to employees' behaviors rather than technology- related activities.

5 Conclusions and Recommendations

The aim of this study is to shed light on the debatable relation between quality management and innovation in the service sector in the UAE. The study has adopted a multi-dimensional perspective towards quality management that is soft and hard QM and how each dimension is related to innovation performance in service providers. The main findings of this study reveal that soft QM practices have a positive relation with hard QM practices. In addition, soft QM practices have a higher influence on innovation performance than hard QM practices.

Many important implications of the study results can be recommended for mangers in the service sector. First, quality mangers in the service sector in UAE should be focusing on the soft QM practices identified in this research (small group problem solving, employees' suggestions, and job-related employees' training) in order to facilitate the practices of hard QM. Second, mangers need to establish the proper practices of soft QM and hard QM in order to enhance the overall innovation performance in their company.

A few limitations should be taken into consideration in this study. First, the number of the participants in the study's survey (50 participants) is not statistically sufficient enough to generalise the findings of this study. So, a future research might include a bigger number of participants with other service providers than the ones included in this study (banks, education, and telecommunications companies) to support the generalization of the study findings. Second, the data used in this study was a cross-sectional data, so a longitude survey might reveal more accurate results especially since quality management practices might have a long-term influence on innovation performance rather than a direct influence. Finally, the study used a survey- based subjective data. Even though we tried to overcome the common method bias by having more than one respondent from the same company, it still depends on the participants' own judgment and perception of the questions used in the survey, which might create an issue in generalising the findings of this research.

In summary, quality management and innovation have a conversational relation in literature based on the sector and the nature of the study itself, but both concepts are still very important to enable companies to compete, be successful and achieve sustainability. The relation between the two is not a tradeoff relation since they can coexist and support each other in achieving the organisational strategic objectives.

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From R&D to Innovation and Economic Growth: An Empirical-Based Analysis from Top Five Most Innovative Countries of the World

Naveed Ul Haq, Rahmat Ullah and Emanuela Todeva

Abstract This study aims to explore the relationship between research and development, innovation and economic growth of most innovative countries of the world, where innovation and economic growth are dependent variables and R&D, skills, technological innovation and economic structure are the independent variables. The data analysis is conducted using GMM dynamic panel estimations for finding the relationships among variable of the study for the period of 1990–2016 of the top five most innovative countries of the world. The findings of this study show that larger spending in research and developments, more skilled labour, the efficient economic structure of a country having more employment in industry and services sectors, a rapid increase in the technological innovation are the key factors that boost the innovation and economic growth of these countries. The existence of the strength of the relationship is however contingent country-specific socio-economic characteristics, which affect overall capacity of the country to transform research and development investments into innovation and ultimately into the economic growth of a country. The findings of this study are helpful for other countries which are on the way of innovation. The factors identified by this study are very helpful for governments, researchers and policymakers to pay attention to it for the purpose of creating a country innovative and eventually boosting the economic growth of a country.

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Keywords R&D · Innovation · Economic growth · GMM · Innovative countries of the world

1 Introduction

The contribution of research and development to innovation and economic growth of a country is well established in the literature of economic theoretically and practically [7, 11]. Over the last few decades, governments of developed countries have pursued remarkable research and development policies with the aim of fostering the innovation and economic growth in their countries. The question arises that whether these innovation policies are paying off. In this regard, technological spillovers, the increasing trend of return to scale in research and development, the unavailability of socio-economic conditions and innovation culture seems to cast doubt on the returns of these innovation policies.

The linkage between innovation and economic growth of a country largely depends on the technology and technological advances of a country, for instance, Grossman and Helpman [4] observed that technology has been the real force behind the rising living standards. Generally, investment in research and development has been considered as one of the strategic keys to boosting the innovation and ultimately the economic growth of a country [15]. Similarly, Bilbao-Osorio and Rodríguez-Pose [2] have shown the relationship between research and development, innovation and economic growth, seems to show the path for the policymakers in order to boost the innovation in a country. The recent developments in the theoretical role of innovation and economic growth considered four kinds of innovation (learning by dong, human capital, research and development and public infrastructure) [1, 6, 10]. It becomes difficult to generalize about the empirical approaches to the innovation taken by the studies to test the new growth theories.

The present study undertakes the world's most innovative countries for finding the relationship between R&D, innovation and economic growth. According to the Global Innovative Index 2016 rankings, Switzerland is the most innovative country. Its capacity for innovation and quality of its research institutions are the two factors that have enabled this small alpine country to hold on the first position of being most innovative country. The major research area of Switzerland is "Robotics", that's why Forbes recently called it as the "Silicon Valley of Robotics". Many multinational companies and emerging startups are conducting their researchers in Switzerland, such as Amazon, Microsoft, Apple, Google, IBM, Bosch etc.

Sweden is the second world's most innovative country. A century ago, Sweden was among the poorest nations in Europe. But despite being a small country today, it is the world leader in innovation. There are several innovations which set the example of Sweden country to being an innovative country. The invention of the pacemaker was a great innovation of Sweden because millions of hearts around the world beat with the help of a pacemaker. Another one is candles that are lit with the help of safety matches. And finally the three-point seat belt, which can save innumerable lives. These are some examples of Swedish innovation that have made a difference [14]. Because innovation is closely linked with the research and development, one of the major reasons for being an innovative country is that Sweden is one of Europe top three spenders in research and development area. Sweden has strengths in terms of both input and output. The strong output of the country is demonstrated in many new published papers and registered patents. On the other hand, Sweden is also seen to have a good input basis, characterized by the stable political environment and high-quality education.

The United Kingdom is the third world's most innovative country. The United Kingdom is the leader in scientific research, great ideas and innovativeness. The larger tendency in spending R&D leads the UK towards the innovative country. There are many examples of innovations of this country which are remarkable for example, surgical forceps, clinical thermometer, first blood pressure measurement and first cardiac catheterization, a battle tank and hydraulic press etc. The United States is the fourth most innovative country in the world and is prized for its history of individual creativity. The US has been and still at the forefront of cutting-edge science, technology and innovation. The culture of US that has graced this nation since encourages risk-taking. The US innovation is followed by risk-taking and thus got handsomely rewarded and failure if any is viewed properly as a tool for learning. The greatest innovations of US include hearing aid, traffic lights, microwave oven, laser, led lights and global navigation etc. Finally, Finland is the fifth most innovative country in the world. Finland is considered as modern West Country and achieves the economic miracle. The major reasons behind this change were investing in educations with free universities and other egalitarian educational policies. One of the massive consequences is the number of technologies Finns have created. According to the Finnish Invention Foundation, the population of six million people make around 15,000 inventions every year. The major inventions of Finns include Nokia mobile phone, SSH the universal tool for secure computer administration, Linux operating system, Erwise the first available graphical web browser etc.

Figure 1 shows the graphical presentation of research and development, innovation and economic growth of top five innovative countries as whole over the period from 1990 to 2016. We can see that the trend of spending in R&D activities in innovative countries is very high. They initially spend more in R&D and as a result of this innovation of these countries increases and ultimately economic growth also increases. The graph clearly shows that when spending in R&D decreases it suddenly effects the innovation and economic growth of these countries. Similarly, Figs. 2, 3, 4, 5 and 6 shows the trend of R&D, innovation and economic growth of innovative countries separately for the period of 1990–2016.

The technological change is a very important factor for the economic growth of a country. But in recent years after neglecting the study of technological change, many economists have shown a great interest in examining the relationship between research and development, innovation and economic growth. In this study, we have developed a dynamic panel data model of top five most innovative countries in the world to test the linkage between the research and development, innovation and economic growth. The present study is conducted to answer the following questions:

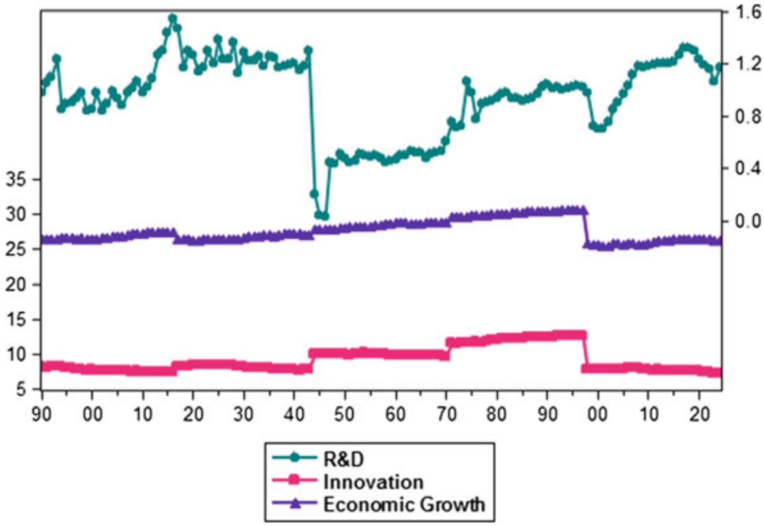

Fig. 1 Trend of R&D, innovation and economic growth of innovative countries for the period of 1990–2016

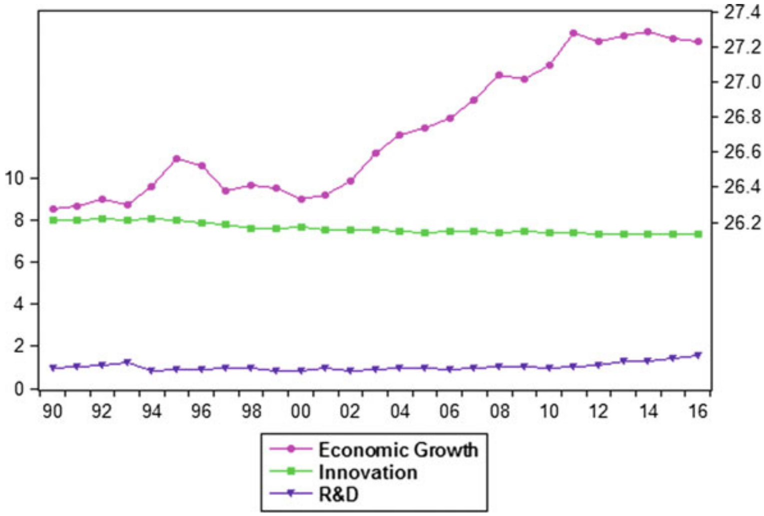

Fig. 2 Trend of R&D, innovation and economic growth of Switzerland for the period of 1990–2016

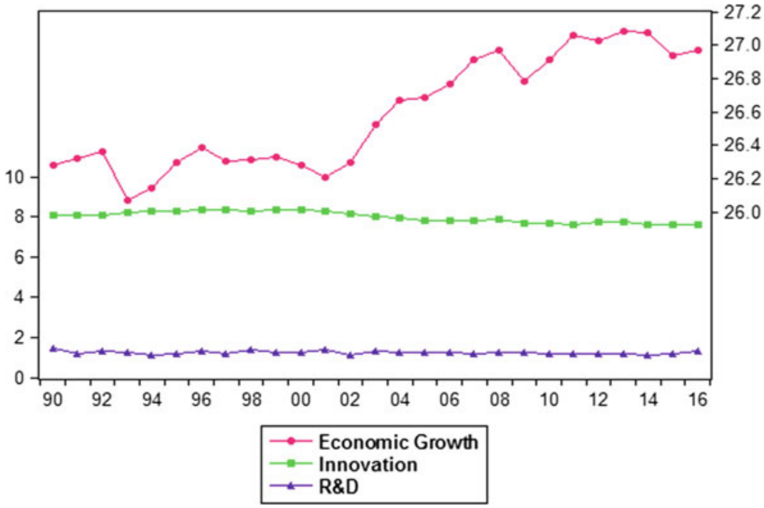

Fig. 3 Trend of R&D, innovation and economic growth of Sweden for the period of 1990–2016

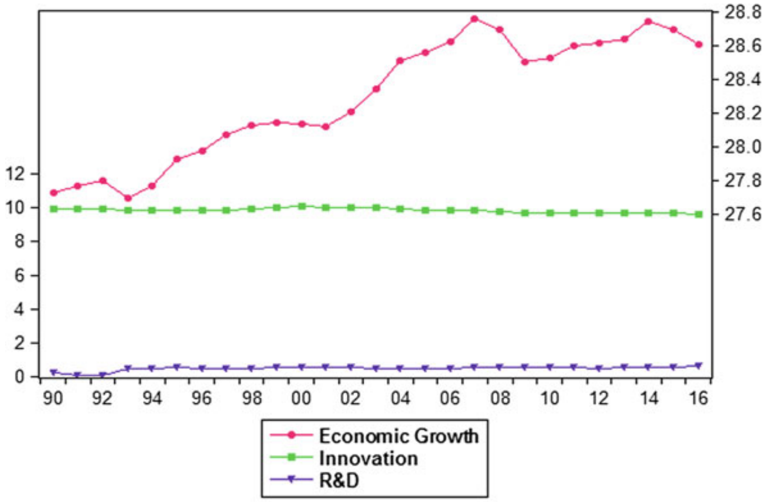

Fig. 4 Trend of R&D, innovation and economic growth of UK for the period of 1990–2016

Q1: What is the relationship between research and development and innovation of most innovative countries of the world?
Q2: What is the relationship between innovation and economic growth of most innovative countries of the world?

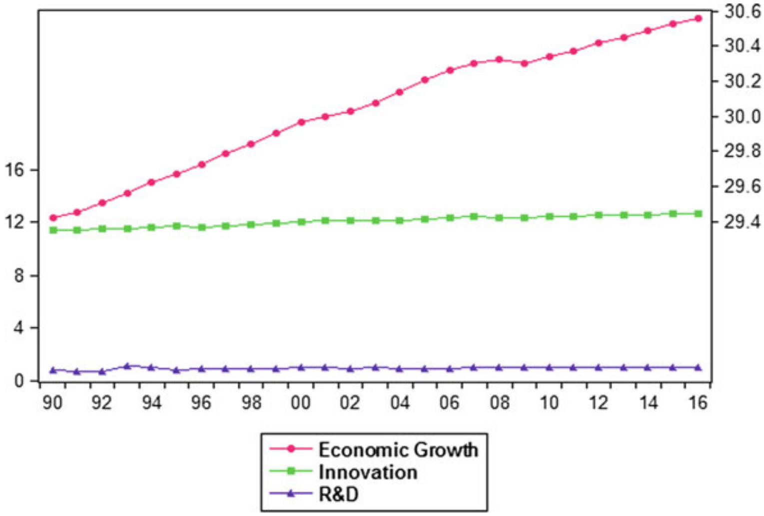

Fig. 5 Trend of R&D, innovation and economic growth of US for the period of 1990–2016

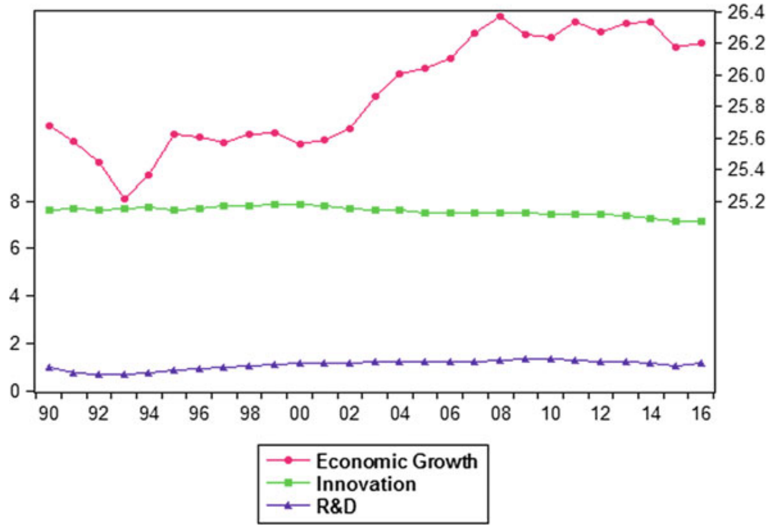

Fig. 6 Trend of R&D, innovation and economic growth of Finland for the period of 1990–2016

To answer the research questions, we developed following research objectives:

1. To investigate the linkage between research and development and innovation of most innovative countries of the world.
2. To investigate the linkage between innovation and economic growth of most innovative countries of the world.

Section 2 of the study sheds lights on the literature of the research and development, innovation and economic growth of a country. The first part of the literature describes the studies that explore the relationship and contribution of the research and development to innovation and economic growth of a country. The second part of the literature theoretical and empirical literature linking to the innovation and economic growth of a country and consists of the development of a hypothesis. In Sect. 3, we describe the methodology and operational model of the study. The results and discussions are discussed in Sect. 4, and finally, Sect. 5 describes the conclusion and Sect. 6 presents the practical implications of the study for policy makers.

2 Background of the Study

The neoclassical growth theory developed by Solow [13] presents the model in which the series of neoclassical assumptions are given for the growth path of any country. These neoclassical models assume the existence of perfect competition, no externalities, constant returns to scale, diminishing returns to inputs and maximizing behaviour. As a result of these assumptions, the growth path theory model predicts productivity growth as a result of it increases the amount of capital each worker is set to operate. Under these assumptions, the investments in developed countries become increasingly inefficient making the investment in a more attractive option. The growth path theory is challenged by the researchers such as Lucas Jr. [6]. They highlighted the need to introduce technology because technology is an endogenous factor affecting economic growth of a country.

The investments in research and development have a number of characteristics that make it different from the ordinary investments. One of the important features if investment in R&D is the degree of uncertainty which is associated with its output. This uncertainty has a tendency to be most noteworthy toward the start of an exploration program or venture, which suggests that an ideal R&D technique has alternatives like character and ought not by any means be examined in a static structure. Research and development ventures with little probabilities of extraordinary accomplishment, later on, might be worth proceeding regardless of whether they don't pass a normal rate of return test. The vulnerability here can be outrageous and not a basic matter of an all-around determined circulation with a mean and variance.

The importance of skill in the way to innovation process can never be denied. Pavitt [8] explained that technological and scientific knowledge requires an extensive learning process. The labour market is another factor that may influence on the innovation process of a country because the low-level activities and employment in the country are the key characteristics of the innovation averse societies [9]. The economic structure of a country also plays a vital role in the genesis and assimilation of innovation [12]. A transcendently agricultural region is more averse to produce expansive quantities of patents, as agriculture and particularly traditional agriculture does not have a tendency to be as creative as different sectors. Alternately, certain sub-divisions inside the manufacturing and service sectors might be more inclined to foster the innovation. Specifically, the countries which rely on the technology their sub-sectors have greater tendency to achieve the higher rate of innovation.

The greater increase in the technological innovation intensity leads to the economic growth of a country. The neoclassical and endogenous growth models of economic growth acknowledge the importance of the technological innovation in the way of economic growth of a country [10]. A large body of researchers has explained the rationale behind technological progress and innovation [3]. These studies have contributed significantly the economic growth of a country. The high technology exports of a country increase due to the increase in technological innovation. The general findings in the developed countries are that the larger exporting firms have higher productivity than non-exporters because the tendency of innovation seems to be higher in exporters firms.

Figure 7 the conceptual framework of this study. The study is estimated the linkage between R&D, innovation and economic growth with some economic factors. In first step the innovation is dependent variable and R&D, skill and technological innovation intensity are the independent variables followed by first four hypotheses. Then in second step for finding the linkage between innovation and economic growth we us economic growth as dependent variable and innovation, growth in innovation, skills and economic structure are the independent variables followed by hypotheses 4–7.

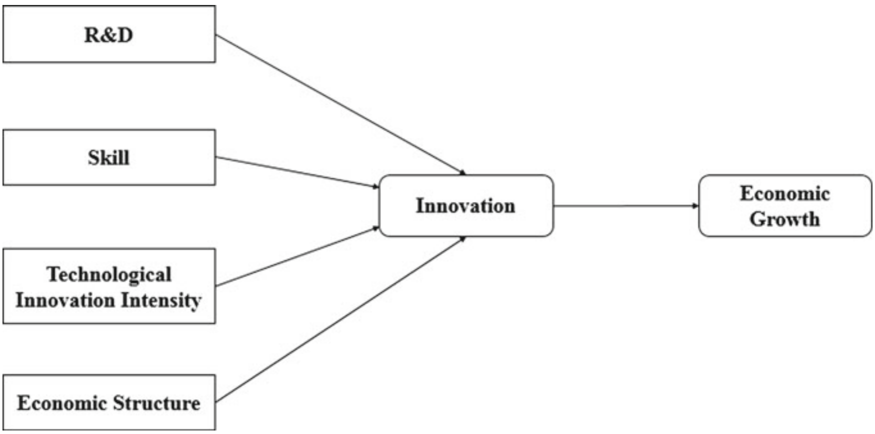

Fig. 7 Conceptual framework of R&D and innovation

The present study has following research hypothesis:

H_1: There is a relationship exists between research and development and innovation
H_2: There is a relationship exists between skills and innovation
H_3: There is a relationship exists between technological innovation intensity and innovation
H_4: There is a relationship exists between innovation and economic growth
H_5: There is a relationship exists between growth in innovation and economic growth
H_6: There is a relationship exists between skills and economic growth
H_7: There is a relationship exists between economic structure and economic growth.

3 Data and Methodology

This study uses an international sample of top five most innovative countries in the world. Top five most innovative countries are according to the Global Innovative Index 2016. Table 1 shows the ranking of top five most innovative countries in the world. Global Innovative Index provides matrices about the innovative performance of 127 countries and economies from all over the world. The index has 81 indicators for exploring the broad vision of innovation of a country. The data used in this research is the secondary type and collected from World Bank Database for the period of 1990–2016.

The study uses dynamic panel data model, GMM (Generalized Methods of Movements) estimations for the purpose of achieving the objectives of the study. Generally, in panel data, we have to face some econometric issues i.e. unobserved heterogeneity, omitted variables bias and the problem of endogeneity. The GMM estimations developed by Hansen [5], provides most accurate estimations of panel data and deals with endogeneity and unobserved heterogeneity. The dependent variables of the study such as innovation and economic growth of a country, are dependent on the various factors and also effects from its past performance, so the problem of endogeneity might occur [16].

Equations (1) and (2) are the operational model of the study under GMM estimations. In the first equation innovation is the dependent variable and research and development, skills and technological innovation intensity are the independent variables. Whereas, in the second equation, economic growth is dependent and innovation,

Table 1 Global innovative index 2016 rankings

Country/economy	Score	Rank	Income
Switzerland	66.28	1	HI
Sweden	63.57	2	HI
United Kingdom	61.93	3	HI
United States	61.4	4	HI
Finland	59.9	5	HI

Table 2 Variables explanation

Variable name	Abbreviation	Measurement
Innovation	INNOV	No. of patent application
Growth in innovation	G_INNOV	Percentage change in innovation
Research and development	R&D	Research and development expenditure as a percentage of GDP
Skill	Skill	Total labour force
Economic structure	ECO_STR	Percentage of employees working in industry + Percentage of employees working in the services sector
Technological innovation intensity	TECH_INNO_INT	No. of patent applications/GDP
Economic growth	EG	Measured as gross domestic product (GDP) current US $

growth in innovation, skills and economic structure are the independent variables. In the dynamic panel data model where i is the country at time t. $INNOV_{i,t}$ is explained by its lagged values and a set of exogenous explanatory variables. Here α_i is individual specific effects and λ_t represents the time-specific effects. Table 2 presents the measurement of the variables used in the study.

$$\begin{aligned} LN\_INNOV_{i,t} = {} & \gamma LN\_INNOV_{i,t-1} + \alpha_i + \beta_i LN\_R\&D_{i,t} + \beta_i LN\_SKILL_{i,t} \\ & + \beta_i LN\_TECH\_INNO\_INT_{i,t} + \beta_i COUNTRY_{i,t} \\ & + \beta_i YEAR_{i,t} + \lambda_t + \varepsilon_{i,t} \end{aligned} \tag{1}$$

$$\begin{aligned} LN\_EG_{i,t} = {} & \gamma LN\_EG_{i,t-1} + \alpha_i + \beta_i LN\_INNOV_{i,t} + \beta_i LN\_G\_INNOV_{i,t\,i} \\ & + \beta_i LN\_SKILL_{i,t} + {}_i + \beta_i ECO\_STR_{i,t} + \beta_i COUNTRY_{i,t} \\ & + \beta_i YEAR_{i,t} + \lambda_t + \varepsilon_{i,t} \end{aligned} \tag{2}$$

4 Results and Discussions

Table 3 shows the results of descriptive statistics of the whole sample data. The sample size is 135 observations. Descriptive statistics analysis is used to describe the various features of the dataset. In general, as compared to inferential statistics, the descriptive statistics are not based on the probability theory. These types of analysis are normally presented to describe the central tendency and variability of the dataset. Measures of central tendency include mean, median and mode whereas measures of variability include standard deviation, range, variance, maximum and

Table 3 Summary statistics of the whole sample

Variables	Mean	Std. dev	Minimum	Maximum	N
R&D	0.946	0.305	0.023	1.543	135
INNOV	8.998	1.765	7.139	12.596	135
G_INNOV	7.995	1.775	5.979	11.598	135
EG	27.505	1.539	25.215	30.555	135
SKILL	16.288	1.519	14.715	18.907	135
TECH_INNO_INT	1.078	5.405	2.090	2.430	135
ECO_STR	4.572	0.020	4.478	4.594	135

minimum values in the data. Using this type of analysis is necessary before running any econometrics model because it provides the overall first look at the data and also the extreme values that are included in the dataset.

The mean value of R&D expenditures is 0.946 with a standard deviation of 0.305, minimum value 0.023 and a maximum value of 1.543. Similarly, innovation has a mean value of 8.998 and a standard deviation of 1.765. Similarly, all variables show normality of the data. The technological innovation intensity has a larger variation in the dataset which is 5.405 with a minimum value of 2.090 and a maximum value of 2.430.

Tables 4 and 5 shows the correlation matrix of our operational models. Correlation analysis is also called the bivariate analysis. It measures the strength of the association among variables of the study. The correlation matrix provides the correlation

Table 4 Correlation matrix of model 1

Variables	R&D	SKILL	TECH_INNO_INT	COUNTRY	YEAR
R&D	1	–	–	–	–
SKILL	0.526	1	–	–	–
TECH_INNO_INT	−0.281	−0.492	1	–	–
COUNTRY	0.161	0.163	−0.627	1	–
YEAR	−0.395	−0.469	−0.566	−0.472	1

Table 5 Correlation matrix of model 2

Variables	INNOV	G_INNOV	SKILL	ECO_STR	COUNTRY	YEAR
INNOV	1	–	–	–	–	–
G_INNOV	−0.665	1	–	–	–	–
SKILL	−0.233	0.044	1	–	–	–
ECO_STR	0.388	−0.378	−0.261	1	–	–
COUNTRY	0.069	−0.146	0.238	0.552	1	–
YEAR	−0.145	0.202	−0.168	−0.562	−0.445	1

information about dependent variable with each independent variable and among each independent variable also. The value of correlation computed by the correlation matrix ranges from −1 to +1. The positive correlation shows that when two variables move in the same direction, on the other hand, an inverse relationship is shown by negative correlation. The correlation matrix provides us information about the multicollinearity in the variables. The problem of multicollinearity occurs when the correlation between two variables is high. The correlated variables generate biased results or insignificant estimations. In order to run a regression analysis, we have to ensure that there is multicollinearity among variables. Both tables confirm that there is no such problem of multicollinearity among independent variables in the models. All variables in the model have correlation values less than 0.7 which confirms that model is free from multicollinearity.

5 Results of GMM Dynamic Panel Estimation

Table 6 shows the results of the model 1 of the study under Generalized Methods of Movements (GMM) estimations of the whole sample. The overall results of the model show a clear picture of innovation and economic growth of innovative countries having significant relationships. The model 1 of the study captures the relationship between research and development and innovation with other economic variables of the country. The dependent variable is innovation and independent variables are research and development, skills, technological innovation intensity. To measure the country effect and time effect we use country and year dummies in our operational models. The GMM estimations include the lagged value of the dependent variable as the independent variable and also the country dummy for measuring the country effect. The model results indicate that lagged innovation has a positive significant impact on the innovation of years ahead.

To test the hypothesis from H_1 to H_3 we run model 1 under GMM dynamic panel estimations. The first hypothesis of the study states the relationship between

Table 6 Model 1 results of GMM estimations on R&D and innovation of the whole sample

Dependent variable: INNOV			
Independent variables	Coefficient	Std. error	Prob.
LAG_INNOV	0.8499	0.0250	0.000***
R&D	0.0695	0.0327	0.034**
SKILL	0.1695	0.0274	0.000***
TECH_INNO_INT	1.2707	0.2177	0.000***
COUNTRY_DUMMY	0.0115	0.0096	0.231
YEAR_DUMMY	0.0010	0.0955	0.303
CONSTANT	−1.6681	0.2545	0.000***

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

Table 7 Results of GMM estimations on innovation and economic growth of whole sample

Dependent variable: EG			
Independent variables	Coefficient	Std. error	Prob.
LAG_EG	0.8129	0.0368	0.000***
INNOV	1.1885	0.6808	0.081*
G_INNOV	1.1780	0.6787	0.083*
SKILL	0.1764	0.0420	0.000***
ECO_STR	0.5936	0.6053	0.049**
COUNTRY_DUMMY	−0.0126	0.0072	0.083*
YEAR_DUMMY	0.0059	0.0017	0.001***
CONSTANT	−1.7319	2.8305	0.541

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

R&D and innovation. We find the evidence in support of this hypothesis and that are; H_1 ($\beta = 0.0695$, $p < 0.05$), states that there is a positive significant relationship exists between R&D and innovation of innovative countries of the world. The more a country invests in the R&D activities the greater the innovation will be. The Skill; H_2 ($\beta = 0.1696$, $p < 0.01$), states that there is positive significant relationship exists between skills and innovation of innovative countries, leading to accept the second hypothesis of the study. Similarly H_3 ($\beta = 1.2707$, $p < 0.01$), states that technological innovation intensity has a positive significant impact on the innovation of innovative countries, thus leading to accept the third hypothesis of the study. Moreover country and year do not have a significant impact on the dependent variable innovation.

Table 7 shows the results of model 2 of the study to explain the linkage between innovation and economic growth of innovation countries. To the hypothesis H_4 to H_7, we run Eq. (2) under GMM estimation. The H_4 of the study states the relationship between innovation and economic growth. The H_4 ($\beta = 1.1885$, $p < 0.1$), proves the existence of a positive relationship between growth in innovation and economic growth of innovative countries. The H_5 ($\beta = 1.1780$, $p > 0.1$), states that there is a significant positive relationship between growth in innovation and economic growth of innovative countries. This states that when the country achieves significant growth in innovation activities then it has a significant impact on its economic growth. The H_6 ($\beta = 0.1764$, $p < 0.01$) and H_7 ($\beta = 0.5936$, $p < 0.05$), provides the evidence that there is significant positive relationship between skills, economic structure and economic growth of innovative counties.

6 Conclusion

This study is an attempt to shed some lights on the importance of research and development in innovation and innovation ultimately on economic growth of most innovative countries of the world. The study begins with the importance of R&D in innovation and economic growth of the country, then discussed the top five innovative countries of the world. The primary objective of this study is to find the linkage between R&D, innovation and economic growth of innovative countries with the support of some socio-economic variables of the economy so that we can find out the characteristics of the innovative countries. We also observed the linkage between R&D, innovation and economic growth of innovative countries individually.

We began by estimating model 1 of the study for finding the dynamic relationship between research and development and innovation using GMM estimations and found a significant positive relationship in innovative countries as a whole. The reason for a positive linear relationship because these countries have larger tendency to invest in R&D activities. Furthermore, other factors such as labour skills, the economic structure of a country and technological innovation also found to be significant and show a positive relationship with the innovation of innovative countries of the world. Most of the variables found to significant in innovative counties individually such as R&D expenditures, skills, economic structure and technological innovation. In Switzerland and the strength of the relationship between technological innovation and innovation is strong. The findings of the study are consistent with [2]. The model 2 of the study estimated the linkage between innovation and economic growth of innovative countries and results supports the literature on innovation and economic growth. The significant and positive relationship states that innovation leads to the ultimate economic growth of a country. The other economic factors found to be positive and significant such as growth in innovation, skills and technological innovation. The individual country-wise results show that economic structure of Switzerland and Finland is supportive for innovation and shows a higher value of coefficient thus states the strong relationship between them. This might be the reason that Switzerland holds a top position as an innovative country in the world.

7 Proposals for Policy Makers

As a whole, this study has emphasized the multifaceted relationship between R&D, innovation and economic growth of innovative countries of the world. The R&D, skills and technological innovation are the significant factors that we found in the innovative countries that leads them towards the direction from R&D to innovation and economic growth. The policymakers must focus on the R&D based strategies to generate the innovation and consequently the economic growth of a country. Although research and development is the base for innovation, the economic structure of a country is very much essential to implement the R&D strategies in that country. The governments of developing countries must put efforts for increasing the percentage of employment in industry and service sectors for strengthening its economic structure. The findings of the study provide useful guidelines for policymakers of the less innovative countries to invest in R&D activities, strengthen their economic structures and consider other significant factors to increase the innovation and for securing the position for being innovative countries of the world.

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Innovation and Risk Mitigation Measures for the Successful Implementation of Smart Government in Dubai

H. Dali and Khalid Al Marri

Abstract The world is witnessing a rapid development in every aspect of life that puts unprecedented pressure on businesses, especially the ones involving cutting-edge products, services and programs such as SMART Governments, whereas the problem with this virtual style of Government has always been escorted with high risk due to the vulnerability nature of cyber space. Before launching new products or introducing new programs, organisations must be heedful of market analysis, and the identification and assessment of risks occurrences and severities. This research will emphasis on the risk management plans and framework in the innovation arena besides exploring the relation between Risk management and Innovation, to set the bar for the recent SMART government in Dubai which uses technology to enhance plans, decision making, public services and democracy. The vision of Dubai Government to employ innovation to achieve happiness, that is why a number of interviews has been conducted with important names in the field to discover the relationship between the innovation and risk management to be able to choose the right risk management plan for this new project. The study will have a great impact on the SMART Government decision making process to be able to benefit the most from innovation and will enhance smart plans which has to be sit in this very early stage of the initiative. SMART government project is a pioneering hub that should set a great example for other countries to follow, and only by the right management team, suitable risk management plans such as Lee Mortimer's 1995, and professional framework that aim could be fulfilled. Further studies should be conducted in the future investigating this arena.

Keywords Smart plans · Risk management frameworks · Smart government · Leadership · Innovation ecosystem · Innovation theory

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1 Introduction

As the demands of the audience becoming difficult to satisfy everyday, the need for new products and new technologies is growing bolder. Companies should focus on hiring managers with new ways of thinking, innovators, and leaders, where they can innovate and in the meantime, identify the risk to be able control it before it is too late.

There has been many frameworks for managing risk in the innovative programs, this paper will identify the framework of Andrew Lee-Mortimer and others, as Lee-Mortimer suggested there are three important steps for any company to be able to manage the risk, which is to identify the risk by doing brainstorming meetings and conducting interviews along with sorting process, after that the team with external stakeholders and involvers should asses the risk that comes out from these kinds of external deals or stakeholders then study the effects of this risk and how it will impact the work. Finally, every company or establishment should have its own risk management plan, emphasising on the high risks, high likelihoods, and high impacts. This plan should aim at identifying the risk and its impact before it happens, in order to be able to reduce its likelihood and high impact when it occur [1].

Nevertheless, innovation and risk management should work in alliance to reach the maximum success potentials within an organisation [2]. A professional and well-educated team with a good experience in leadership should direct and manage the development processes and should study the risk from the very beginning. Only then, companies can achieve high-quality services, and satisfy the growing demands of the customers with a minimum amount of risk [3].

In this paper, the researcher will identify the different frameworks of risk management frameworks for innovation, starting with Lee-Mortimer framework, to determine which framework can work the best for the new project of SMART government in Dubai.

Interview instrument will be adopted from an interview with Ron Adner by Brian Leavy (20xx) about "Managing the interdependency and risks of an innovation of ecosystems", with simple changes to fit the SMART government project [4].

The rationale behind the research is that the SMART government project is taking place online, as The Governor of Dubai has declared shifting to a paperless government community by the end of 2020. What is more, the cyberspace or internet and its vulnerability to risk can pose a formidable threat to a sensitive project such as SMART government, which includes sensitive documentation and files that are in high risk of hack by the terrorists and different enemies or hijackers targeting Dubai. This could raise the need for risk management plan before launching the new SMART government in 2020. As discussed above the risks should be identified and assessed in the very early stages of any program or product launching, to spare the companies from a high risk impact which might occur in the future [3].

The problems and risks of the SMART government new programs are addressed in the work of Hyslip [5], who talked about how the new style of government lead to many online issues such as cyber-crimes along with administrative and political issues that escort this virtual system due to the vulnerability of the cyber space nature. As most of the new projects are struggling with Risk management whenever they try to launch a new program [6], the Smart government is facing new challenges trying to deal with that risk. The problem lies beneath the Innovation right or wrong process [7] within one organisation or project; where some ideas are being innovative but carries a huge amount of risk when brought to reality. That's why the Innovation and Risk needs a systematic framework [1] from within an organisation that provided and innovation ecosystem while being aware of the risks from the start [4]. The above issues are addressed in this research paper in details, while number of solutions has been set to avoid high impact in the future implementation stage of SMART Government.

One of the effective solutions is to put a risk management plan from the beginning, to make sure that risks are well defined and assessed to dodge bullets in the future [8]. Risk Frameworks for innovation studies are presented well in the literature but studies about defining the relationship between the two notions are rather limited [9], this research will try to fill the gap in this particular area; for the new initiatives such as SMART government to take place well-prepared in order to succeed.

Despite the new technologies and all the innovative programs, the cyberspace and internet remain vulnerable to risk, its nature of being virtual is making it more difficult to handle every day. Some would agree that traditional form of governmental services is safer and more resilient to risk, on the other hand, governments are trying to cope with the new trends of the new century to satisfy market/customer needs, in terms of cutting edge services that saves time, effort as well as money [10].

Hyslip [5] suggested on a managerial level that organisations should focus on the risk of external parties or stakeholders that are involved in the work flews or work processes should have been avoid to minimise the potential attacks of the system and to reduce the outside risk, and the crucial need for a closed work flaw within one organisation is raised.

The study highlights the issues of SMART government innovation due to the vulnerability of the new online system and suggests a risk management plan to reduce the likelihood of risk when this project will be completed in 2020. One of the successful solutions to the issue is the work of Lee-Mortimer framework, who suggested a scientific and effective framework that prepares the team of SMART government and enhance the protection of the new virtual system.

The aim of this research will be to find the best Risk management plan for the innovative initiative of SMART government in Dubai. This study will highlight the different risk frameworks for innovation in the field of management. Two main questions will guide this study: what are the risks of innovation in the SMART government system? And what is the best risk management plan for the SMART government in Dubai? The objectives that will be pursued to answer the above questions are:

1. Determining the best risk management plan that will suit the SMART government system.
2. Identify the risks inherent in the innovation process that impinge the success of innovation in SMART government project.

3. Studying different available frameworks of risk, to identify the main aspects and steps towards a sound risk management plan and fill the gap in the innovation and risk area.
4. Determining the attributes of teams and managers that should be hired in SMART government to carry on the process of innovation with minimum exposure to risk.

2 Theoretical Framework

This study will use the framework of Lee-Mortimer [1] to examine the risk management for innovation in SMART government. The reason for this selection is that this particular framework focuses on managing risks in terms of their identification and assessment, and studying the likelihood of their occurrence, for the preparation of a resilient course of actions for the management team to respond to viable threats.

Lee-Mortimer discussed the development of the three steps of risk management by AP Consulting, these three steps are:

1. Identify the risk through interviews and brainstorming meetings. He argued that one should carries out this action in the very early stages of designing new product or launching new program.
2. The assessment of risk especially for teams that are using external involvement, to assess the likelihood and the impact of the potential risk.
3. To build a risk management framework or plan; to be able to control high risk and high likelihood to reduce the risk impact in the future.

This study will focus on the above steps, especially when it comes to SMART government innovative system. The different risks of the new virtual system will be identified and assessed to come up with the right risk management plan for the Government of Dubai to adopt. The team of SMART government will have to follow scientific framework to deal with these kinds of risks and should be selected accordingly.

3 Literature Review

Gurd and Helliar [3] conducted a study about how the leaders in an organisation balance between the innovation of creating a product against managerial aspects such as the notion of risk management. The researchers had a case study on two different companies which are struggling with innovation process, one of these company could not ignore the risk and the second one is still stuck in the same old system. They discussed how administrative processes or plans such as risk management plans will always reduce or bottleneck the creativity and innovation activities, but if the right team handle that or create some kind of balance between the two aspects, then the innovation plan will go in the right direction. Their study discussed the notion of leadership as an institutional work, starting from the role of the leaders to maintain the values and to be able to balance innovation activities against risk management plans. Such kind of leaders and leadership are recommended to SMART government project to be able to manoeuvre between different kinds of innovative activities while maintaining the same level of risk management framework.

Euchner [11] conducted a study about innovation and risks, the researcher also highlighted the role of leaders and senior managers in an organisation in managing risk of innovation. He argued that it is a difficult task for these managers to determine the risks that could appears from a new product, whether customers will embrace the new change and whether any competitive companies will come along and at which time. He added that companies avoid investing in a bad idea but the miss the risk that comes out of not investing in a good idea which competitors can produce suddenly, so in this case companies should invest in a good executive success teams and plans instead of wasting time in finding better products. Euchner discussed that its better to develop the best tool to be able to confront risk inherent in innovation: by trying to study product with practical tools focusing on risks, taking in consideration other ways to bring the innovation in, and learning from the in-market trials, and discovering new ways of monetising investments in innovation. In the case SMART government there was a previous trial or experiment with the Dubai E-government where the Government of Dubai has tried some online services and product in the cyber space field and decided to take t to the next level where customers might be more satisfied with the new version of SMART government.

Biais et al. [12] conducted a study about the dynamics of innovation and risks. They argued that both investors and managers should have been studied to determine their believes about the innovation itself whether it is a strong one or not, that could affect the success and failure of the product, to determine whether there is a negative shock or not. The investment at the end will depend on the amount of effort given by the managers and investors; that is, if they apply the right dynamic plan for innovation and risk they will avoid any kinds of negative shocks in the future when it hits the market. They added "First, the strongest growth episodes of the innovative sector are fueled by the entry of managers exerting low risk prevention effort – and therefore correspond to a decline in risk prevention standards. Second, under moral hazard, there is excessive entry of managers exerting low effort and earning informational rents, so that the innovative sector is larger and riskier than in the first best" (p. 1377).

Maynard [13] conducted a research about the need of risk innovation. He argued that our approach to risk should be altered to suit the new needs of technological developments such as nanotechnology; which needs to reach its full potential nowadays. He discussed the urgent need of new approach of risk management to cope with the rapid development of technology and its nature of introducing new aspects and visions to all arenas. The need for new insights, roles, aspects and tools of risk is increased; and without risk innovation organisations such as Google will not be able to continue growing. The traditional risk roles will slow the business processes down especially in the big innovative and cutting edge organisations.

Latham and Braun [14] conducted a study about managerial risks, innovation, and organisational decline. They suggest that agency-based considerations of the managers risk profiles, contributes in changing the dynamics between innovation, organisation outcome and organisational declines or rejects; whereas managers and leaders should balance between different factors when responding to the organisational rejects or declines by choosing innovation. This could lead to the understanding of the importance of managers and leaders which can take effective decisions, and know how to weigh a multitude of factors when they decide to go ahead with the innovation process.

Fernandes and Paunov [9] conducted a study a bout innovative firms. They asked if such kind of firms are unlikely to die compared to other firms. They argued that risk has a strong impact on innovation, they call it "exit relationship". The framework they provided helps rationalise the innovation decisions despite the potential risk, in order for the firms to get more involved in the competitive nature of the market. They argued that innovation will help to extend the life of plants in the actual market, despite all risks and potential risks against this theory. One can notice that all the above studies are asking for merging between innovation and risk with some alteration in risk management insights to suit the latest innovation processes and activities.

After studying the most relevant models that conceptualised Innovation and risk mitigation measures for the successful implementation of innovative organisations such as Smart government in Dubai, the researcher comes up with one model that sums up all the elements that could be employed and deployed in the process of innovation process with minimum risk potentiality and likelihood. The illustration shows how the relationship between Innovation and Risk is becomes Inverse when using the right smart plan or the right plan for risk management (Fig. 1).

The illustration shows how the relationship between innovation and risk is not necessarily symbiotic. In order for the innovation to take place safely one should apply the right risk plan in a very early. Technically as shown in the illustration, if

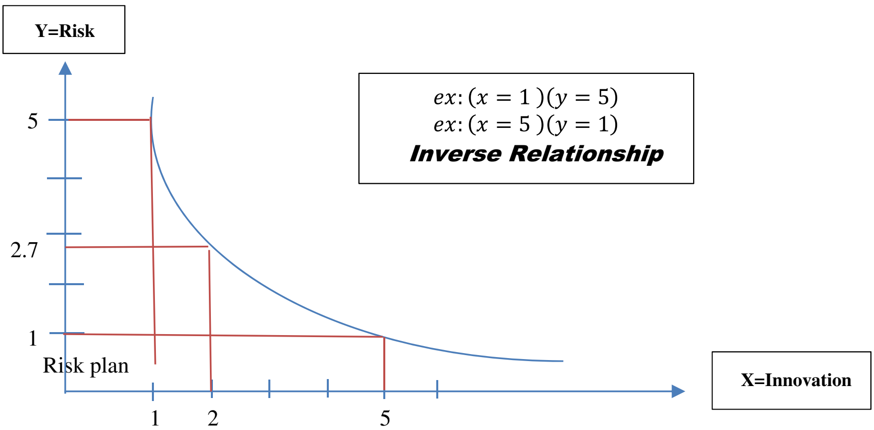

Fig. 1 Innovation and risk measures

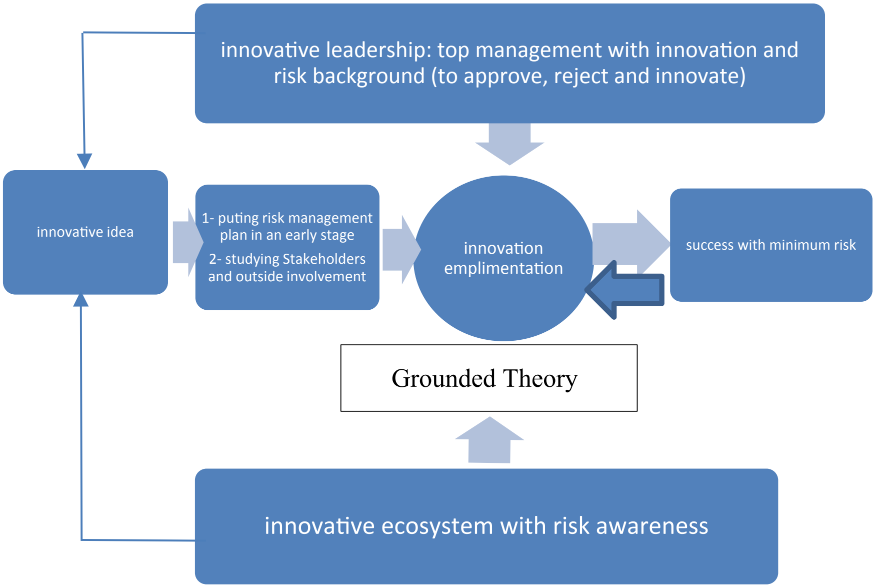

Fig. 2 Innovation and risk model

the risk will be mitigated, the innovation will have its maximum success taking in consideration other factors of a successful innovation.

The model that will sum up all the frameworks in the lit consists of 6 stages shows how the culture of both innovation and risk frameworks is crucial for innovative organisations such as SMART government. The innovation ability and the sense of risk along with experience should be in the background of the top management team of the SMART government project. What is more the innovative organisation should have and innovation ecosystem that work in alliance with risk plans, as the future of one should lead to another. The diagram shows how the late risk management framework or plan might result in a failure of an innovative idea or program and vice versa (Fig. 2).

4 Methodology

4.1 Qualitative Research

After reviewing the literature and frameworks of previous studies it has been found that a qualitative study will serve the purpose of this study [7] and conducting interviews with the specialists and managers in this field is the best way to do this research in both levels, technically and managerially.

4.2 Instruments

An interview was held in Dubai with three Doctors of Risk Management and IT in prestigious departments in the field, the interview instrument was adopted from an interview done by Brian Leavy with Ron Adner about "Managing the interdependency and risks of an innovation of ecosystems", with simple changes to suit the new topic of SMART system [4].

This interview was held in British university in Dubai with a Professor at the Engineering and IT department at the British University in Dubai for both (technically and managerially) aspects of risk management, and another Doctor of the same faculty (technically) along with a Doctor who work for the Government of Dubai under the umbrella of the SMART Government project (managerially).

Theme 1: "Wider lens" is a very important notion that we need in the process of innovation, especially when we are taking all kinds of Risks into consideration.

Q1: Ron Adner stated in his latest book called "A wider lens" that even companies that have excellent plans and very good creative implementation schemes, fail massively at the end of the day. If you can give us an idea about what do you think they are missing or what they are NOT taking in consideration when it comes to their execution of plans or even innovation process in general?
Q2: If companies try to succeed and avoid failure in the market, why should they has a wider lens or a wider vision, can you tell us why do you think this new way is important nowadays and what is different lately in the market to make this method so crucial?
Q3: Some companies tend to think that treating innovation as an implementation of new Ecosystem can give importance to which source or which kind of Risk? What do you think for this matter?
Q4: There is a notion called "co-innovation risk", how do you think this notion undermined the efforts of the innovation processes back in the days when companies who tend to use it especially when they asses and manage the risk in their innovation strategies?
Q5: How different do you think is adopting Risk chain than other methods, and how do think companies or firms should asses and deal with this method in their strategies of innovation. And if you can give us an idea about the important elements of co-innovation and the process of adopting risk strategies.

Theme 2: The importance of time and positioning when using Ecosystem plan or strategy, main frameworks, main schemes and main plans.

Q6: Some argued that creating a value first drafts of a design or a plan which is called value blueprint is important for any project, why do think that is important or beneficial? And why do think that its different from value proposition?
Q7: Do you think that taking the lead role is important in the innovation plans and companies should take it in consideration or not? In your point of view, how companies should determine whether to take that decision or not? And is this

decision is up to the leaders of Ecosystems? Is it in their hands? Do you think that it has Risk underneath it?
Q8: In the innovation context we talk about the timing, do you it is more important for companies is to be the first mover (FMA) or the right mover? What are the advantages? And which one is more important and crucial lately especially in the current circumstances?

Theme 3: Forming, developing smart plans.

Q9: In your point of view, when a company or planners face problem in the blue print stage, how can they use the Risk management plans in solving this problem, what do you recommend as a process in this very early stage of blue print?
Q10: Finally, can you give an idea about your recommendation for Dubai, and what they should take in consideration when it comes to forming, developing and enhancing the new smart system and Risk Management system, technically and managerially?

The researcher will use the grounded theory to analyse the interview and the answers.

4.3 Sampling

The interviewees were selected managerially and technically related to the subject; in order to be able to cover the angles of the subjects in every aspect, since this topic is discussing online and offline risks of innovative SMART government. All the interviewees were provided with a interview Consent Form which is included in the appendices of this research, everything was clear in the form the time, the rights and recording reserved, for them to be able to decide about some points regarding the interview and to install trust in the researcher in the meantime.

4.4 Analysis

This research analysis is based on the grounded theory and consists of main elements and factors regarding innovation and risk. The researcher analysed the context and the literature review along with the answer of the interview assigned to this topic then tried to come up with a theory that sums up the innovation and risk relationships between each other. The reason behind choosing the grounded theory is in this qualitative research the kind of the strong relationship between innovation and risk that the researcher believes its already there according to a number of studies and data. Depending on the researcher philosophical background, methodological tools and the theoretical outcomes, the study will fulfill what it aims at [15].

5 Results and Analyses

Professor Iansiti and doctor Levien at Harvard University argued in 2004 that the battle and the competition is not between the people of any company or organisation but between the network of their firms and that the strategy notion has changed to be the way any firm handles their assets that they do not own in reality. Also in this book the author argued about how to create a good networked environment in terms of strategy and positioning.

Ron Adner [4] highlights in "The Wide Lens" the book he wrote in 2012, that companies nowadays if they wish to stay in the market and survive in the competition they must rethink their strategies and networking along with innovation which form a very important element in the business industry.

The innovation notion when put in the ecosystem context creates some kind of risk and challenges for the company especially when it comes to standing-alone among other services and products but on the hand this might give the company more opportunities and sustainability and a longer-term growth especially those who does in a right way.

To stand on the main issues of this topic and to discuss all these opportunities provided by the innovation and in the meanwhile discussing the risks that follow its execution, besides discussing some basics and principles and new notions, tools and programs in the SMART government this study has held to help develop companies' strategies to become more successful in this very new and cutting edged context.

After holding those interviews, the research came to conclusion that the innovation contains some kinds of risk, on the hand it plays a vital role in many ways and its almost a must for every company to survive in the revival market. The analyses will discuss the main concern of the population and will discuss how this concern will be resolved and processed, five main elements of the theory and three subs:

5.1 Innovation and Top Management

In this point, this study found out that most of the interviewed persons talked not only about the top management when it comes to innovation; it has been discovered that innovation process could be processed and evolved from both sides the head board and the middle-ranked employees in the company. So it is not an exclusive for top management. One of the interviewees made it clear that it is not unpredicted process, he explained that you never know when the idea is innovative or not and sometimes it take you 10 year to discover that, so it happens regardless of your position but the point here is sometimes the top managers will be the ones who stopped or kill it in the very early stages which one of the interviews explained that its some kind of sensor or responsibility that it contains some risk. According to literature review of this research top managers could be the bottleneck in the innovation process if they don't have the right awareness of the whole idea of innovation and how to deal with risks associated with it.

5.2 Innovation Ecosystem

When it comes to innovative ecosystem one must notice that in order to create such an atmosphere in your company, brain storming and special creative meeting should be held according to the interviews that has been done for this study. Almost all the interviewees agreed that this the best ways to enhance the innovation in your company but technically one of the doctors interviewed added the purchase of new technologies and new systems will encourage the employees to create and innovate new things and will contribute in the born of new ideas. He added, despite the risk that will come out of new systems, technology, and programs, companies must always carry on and keep purchasing those new systems and programs especially in the case of SMART government, to stay in the competition among the world advanced countries. According to the literature review the innovative ecosystem is a crucial need for today's companies to be able to have an existing in the field otherwise the company will die eventually if it does keep up with the needs of the consumers.

5.3 Risk Management Frameworks

As the analyses of the interviews and the literature review showed that there is no certain framework that associate innovation and risk management, we just need to follow by the roles of normal risk management. One doctor out of three interviewees agreed on not having any specific framework to deal will innovation, he added you can just be prepared and adopt the new innovation especially when it is a great idea regardless of the risk and let the risk management team does their work as usual without exaggerating. According to the literature review every company has its own circumstances and roles and possibilities so it does depend on the company itself not on specific framework for all companies. The idea of assessing and identifying risk of any new innovation is the most important before taking this step or taking a new idea into consideration. Companies should be aware of the results or at least most of it before executing any innovative project and its ecosystem should all be full of the idea of embracing innovative ideas and programs.

5.4 Managing Risk in SMART Government

In the case of Dubai SMART government when talking on a local level, it has been found that Dubai SMART should adopt new systems and programs and should install new technologies in order to carry on with march of development in this new style of SMART government. Of course, some issues will appear on the surface because of the new government system, in this matter all the interviewees agreed on the leadership and the process of hiring top managers in the new government.

The suggested features when choosing SMART government managers is awareness, good experience, creativity, leadership, open minded and well education. According to the literature review the leadership and the top managers are the main elements in the innovation process who some time sabotage it or contribute in killing it in the very early stages because they can say no to a very innovative idea that could create a jump for the company.

5.5 Risk Management and Innovation Theory

The researcher came up with this theory about innovation and risk after reviewing the literature and conducting interviews as follow:

Innovation process contains of three main issues: (1) innovative leadership (which contains all the mangers and top managers and middle managers who can contribute in the innovation process), (2) innovative ecosystem (which consists of the policies and the innovative ideas and brainstorming within the company that urge new ideas to be born and encourage employees to be innovative), (3) risk management (including all the risk management frameworks and the innovation frameworks and roles which works in alliance to innovate in a safe way and take the company to the next level).

6 Conclusions and Recommendations

The aim of this study is to determine the best risk management plan that will suit the SMART government system and Identify the risks inherent in the innovation process that impinge the success of innovation in SMART government project. By studying different available frameworks of risk, the researcher was able to identify the main aspects and steps towards a sound risk management plan and fill the gap in the innovation and risk area. One important aim as well for this study is to determine the attributes of teams and managers that should be hired in SMART government to carry on the process of innovation with minimum exposure to risk. So the overarching goal for this study is to discover the relationship between the Innovation and Risk and how could it be conceptualised. The researcher concluded that all the innovation is a must process for recent companies in order to stay in the market and to cope with the fast-growing needs of the consumers, despite all the risk lies beneath this innovation process. Same case in the SMART government project which is an innovative initiative that demands both managerial and technical frameworks to be able to achieve its aims and overarching goal with minimum risk. The recommendation where mostly about keeping up with the market needs and carrying on with the SMART government regardless of the risk but in the meantime some rules and risk management basics should be followed to minimise the risk in the future without slowing down in the innovation process. The key is to set a risk management plan in a very early stage of the innovation process. Another element innovative organisation should consider from the start: the outside involvement and the stakeholders who can form a danger on the system if they do not apply close ended work flows. By giving a third party the access to the system, organisations are exposing their system to an unforeseen danger.

Nevertheless, choosing managers and leaders for the new innovative project should happen carefully to serve the overarching goal of the SMART government; new managers with good potentials and way of thinking will lead the new style of the Government to its success and will take Dubai to new places among not only the advanced world but among the first-class countries around the world. Leadership and top management should have the background of both innovation and risk with long experience in the field; because they have the privilege to stop, reject and enhance the innovation and risk plans and frameworks. For the Dubai SMART Government assigning a manager acquires two elements in his background: innovation culture and risk frameworks.

Nevertheless, a good leader will create an innovative ecosystem, with a culture of risk management seeking for smart plans that applied only where needed and in the right stage timing. What is more, the need for blueprints and initial designs for every innovative project is important also, it stimulate the project in real life before it happens, also it will give a clearer idea of the potential risk that might occur in the future to help define it and assess it to be able to minimise it or even eliminate it.

The most important is the right innovation not the first innovation; as doctors in the interview explained that it is about the smart innovation which already take first place regardless of the timing and each one leads to the other. So the way innovation ecosystem is work is unpredicted and an innovative idea or a great innovation could happen to every single employee in the company regardless of his position, even great inventors no one cared about them at their century but nowadays it appears that their innovative inventions is rolling on whole life such as internet and zero one technologies.

Last but not least, in term of risk of the smart systems, if we built a fence they will built a tunnel and systems tends to be less than 100% safe from external attacks and hijacks that is why SMART government should be aware of that kind of risk since all its work processes are taking place online, and Dubai SMART team should be proactive not reactive through the right risk management team and frameworks. This study has an implication on choosing the smart plans and right managers for SMART Government and will help the scholars in defining the relationship between innovation and risk and how to conceptualise. Finally, more studies should be conducted in the same area to measure the different risks kinds and potentials of innovation process.

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Shaping Gateway Cities in GPNs: The São José Dos Campos' Science and Technology Park

Patricia Alencar Silva Mello

Abstract In this paper, science and technology parks (STPs) as policy for local and global development, is associated to the phenomenon of gateway cities' formation. With the theoretical lens of gateway cities studies, the Global Production Networks (GPN) approach and regional development analyses, we sought to answer the following research question in a strategic coupling perspective: how the São José dos Campos Science and Technology Park is impacting the region consolidation as a gateway city of aerospace and correlated sectors? To answer it we performed a longitudinal case study with five different unities of analysis and interviewed 32 multiple players operating in and out this specific STP. Our purpose was to investigate whether this innovative arrangement may or may not be facilitating the access of other regions and sectors to the global economy. We argue, by promoting local, global and inclusive development, STPs could be operating not as an isolated island, but as a gateway city developer by acting as an articulator of GPNs of multiple sectors. They would permit productive knowledge flows and would allow the access of other Global South regions to the organizationally fragmented and spatially dispersed world economy. In fact, interviews confirmed that the more than 60 years of aerospace industry history in São José dos Campos, recently redeemed and strengthened by the STP operation, where the three global leader companies develop research and development: Boeing, Airbus and the national Embraer, the gateway city phenomenon is evident there. This environment, because of many incentives towards capacitation, has also helped many technology-based enterprises not only from the STP to better position themselves in GPNs of many sectors and to retain more value in their local operation.

Keywords São josé dos campos · Science and technology park · Gateway city · Global production network · Strategic coupling · Public policy

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1 Introduction

As the two major airplane manufacturers, Boeing Co. and Embraer SA, get closer to a pact to forge a huge global alliance,[1] São José dos Campos, Embraer's homeland "with its high concentration of research companies in the aerospace sector, ended up in first in fDi's Aerospace Cities of the Future 2018/19—FDI Strategy ranking".[2] Such outcomes have been massively explored in the worldwide media and have caused great proud to the town's citizens but also lots of different critics.

However, regardless the results themselves, what motives lie behind such aftermath have been barely explained. In Brazil, the success of Embraer, a former state-owned company and the world's third-largest plane maker, is often taken for granted. So as the high score of indicators achieved by São José dos Campos' city. Studies either replicate the history of both this company and city or investigate the sector performance without questioning the non-economic actors strategies and broader dynamics that may be affecting such results.

We miss a wider understanding of how the current global organizationally fragmented and spatially dispersed and complex economy, structured in many networks deeply interconnected, is impacting the city's institutional reframing in order to keep up with the leadership in such high competitive sector. How value is created, enhanced and captured to generate development there? Which strategic coupling undergone by economic players, policies and institutions are influencing this course? Are they powerful enough? How other cities, actors and sectors have benefited or not from this process?

Along years, many institutions were created in the city to foster the aerospace sector. Starting in the 1950's when the Federal Government chose São José dos Campos to be transformed into an innovative city in the aerospace sector. Since then the state played a crucial role in transmuting the city. More recently, however, one specific arrangement was conceived as policy to face the challenges imposed by the knowledge and interconnected global economy: The Science and Technology Park of São José dos Campos (PqTec).

Being the first one implemented in the Federal State of São Paulo program under the São Paulo Science and Technology Parks System, the PqTec, regardless many juridical difficulties and several obstacles, has ever since exponentially grown. So as its global impact, one of the seven types of effects expected by science and technology parks (STP) operation, according to MELLO (2018, in press).

In this paper, we argue that STPs might be transforming regions into gateway cities of multiple sectors' global production networks. This is because of the features of the nowadays' Global Production Networks (GPN) that pattern the global economy [1] and affect or are affected by gateway cities and its STPs, whose mission is to

[1]In https://embraer.com/br/pt/noticias/?slug=1206397-boeing-e-embraer-devem-estabelecer-parceria-estrategica-para-acelerar-crescimento-aeroespacial-global Visited on July 5, 2018.

[2]In https://www.fdiintelligence.com/Locations/Americas/Canada/fDi-s-Aerospace-Cities-of-the-Future-2018-19-FDI-Strategy. Visited on June 14, 2018.

promote local and global development by means of common and shared innovative solutions established and operated in science and technology based activities.

Our hypothesis is that STPs of emerging economies have been used by cities to be better integrated in GPNs, due to the global leaders' attractive effect and stakeholders' internationalization incentives, the ability to foster the local buzz and global pipelines of the knowledge economy, the value capture stimuli and the ability to allow or not the access of other regions, actors and sectors to the global economy. The final result being: the gateway cities' advent.

In order to deeply investigate this proposition, we formulate the following research question: **how the São José dos Campos Science and Technology Park is impacting the region consolidation as a gateway city of aerospace and correlated sectors**?

To answer it, with the theoretical lens of gateway cities' investigations add to the Global Production Networks (GPN) approach and regional development studies, we performed a qualitative analysis, investigated documents, observed relations and interviewed 32 multiple players operating in and out this specific STP. We, then, performed a qualitative inquiry applying longitudinal case study' strategy based on five unities of analysis with Atlas Ti software support.

At the end we were able to confirm our thesis concluding that the PqTec is acting as a genuine gateway to various flows, integrating or obstructing the access of other regions of the Global South to the aerospace and correlated sectors' global economy. Interviews confirmed that beginning with the more than 60 years of the aerospace industry history in São José dos Campos, recently redeemed and strengthened by the PqTec operation where the three global leaders develop today research and development: Boeing, Airbus and the national Embraer, which was itself a spin off of the city's innovative system, and more than 300 selected stakeholders forming a vibrant innovative complex also used as an internationalization platform of many other actors, the gateway city phenomenon is evident there.

This environment has also helped many technology-based enterprises to better position themselves in GPNs of many sectors and to retain more value in the city, although complaints also revealed a better management could be implemented. In any case iterviewees acknowledged if it weren't for this STP, the city would not have been able to articulate itself in the nowadays global economy, which compels complex and strategic policies. Moreover, because of its expertise and its lab infrastructures, many companies from other cities explore the STP facilities and certification capacity to access the global market. Further investigation is necessary in other cities located in the global south with STPs operating in strategic sectors so as to compare effects toward other gateway cities formation.

The theoretical contribution of this paper consists on associating science and technology parks (STPs) as policies for local and global development of emergent countries to the consequent externalities on gateway cities' formation in today's global production networks.

It is structure in five different parts. First we present the theoretical background, followed by the theoretical contribution and methodological design where we contextualize the PqTec and the city trajectory to emphasize de case option. Then the major results are presented and discussed to finally conclude highlighting the major findings and future possible investigations.

2 Theoretical Background

The study herein proposed requires some theoretical perspectives, such as: the Global Production Networks (GPN), the Regional Development studies and the Gateway Cities' approach and the way each of them consider in their analysis innovative environments, from which STPs derive.

2.1 Innovative Environments and Global Production Networks

The rapid and profound changes experienced by the global economy [2] challenge the capacity for theorizing the world today. Organizationally fragmented and spatially dispersed production networks reflect the complex global scenario and the uneven results in terms of development [3].

The GPN approach seeks to observe this phenomenon, highlighting the dynamic and the strategic rationale of the main actors involved in this new global economic logic where complex networks structure relations and constitute organizational arrangements formed by actors (not only economic) who interconnect and interact systemically. GPN's researchers focus on actors rather than products and in regions instead of nations. Contrary to GVC that encompasses sectorial and linear strategies,[3] ignoring local institutional strategies, these authors are concerned with how networks of companies connect and how they comprise different institutional and social structures and development outcomes [1].

Causal dynamics reflected in local organizational strategies, such as innovative environments direct the formation and evolution of GPNs. They connect the local network to the global one and capture values by facilitating strategic couplings which are: (i) intentional and dependent on active intervention by regional institutions and the power of GPN actors; (ii) contingent to time-space and geographically transcend, dependent, thus, on policies strategically designed in this sense [1].

In fact, innovative environments are indicated by these authors as an example of indigenous coupling, which contrarily to the other ones, functional and structural, involves inside-out process and more autonomous local networks able to capture more value and even to create new GPNs [1]. Nevertheless, empirical studies depend on to be formulated associating this phenomenon to the gateway city formation as a spill over effect.

[3]For a better understanding on GVS studies see Gereffi and Korzeniewics (1990, 1994), Gereffi (1994, 1995, 1999, 2005) and Blair (2009).

2.2 *Innovative Environments and Regional Development*

Recent researches have spawned a wide variety of attempts to blend innovative environment insights from 'global' and 'local' perspectives on regional development. They identified a large number of clusters and agglomerations within a globalizing economy and explained that, although global economy is increasingly organized through global regions, a concentrated number of specialized agglomerations of activity tied together through corporate networks of production and innovation stand out [4].

Following this line many analyses highlight the local buzz and global pipelines aspects of innovative environments [5], deriving it manly from studies on weak and strong ties [6]. According to them collaboration of firms in the same geographical region (local buzz) induces technological spillovers and value creation if these activities are combined with international collaboration (global pipelines), and vice versa [7].

Local buzz refers to the idea that local connections in embedded contexts induce trust, reduce transaction costs, create technological spillovers, and provide more precise information and the sharing of combining ideas. Global pipelines, in contrast, bridges organizations and facilitate the access to novel and non-superfluous information, which also foster technological spillovers and innovation [7].

In fact, in this era of economic globalization, no innovative environment can exclusively rely on assets and development strategies inherent territorially only. There is no such thing as choosing between global networks and regional territories strategies. The two dimensions are to be mobilized at the same time to capture the multi-scale nature of regional economic development. And these territory-global articulations in GPNs nurtured by actors from different places and various strategic policies for development require continual interactions in many tiers.

This approach is crucial in innovative environments' analysis because, while on the one hand studies focused on global chains tend to ignore local contexts, on the other, researches and policy-making concentrated on local development by means of implanting innovative environments in developing countries tend to over emphasize local connections formed by the actors they attract to operate on the cutting edge knowledge in different chains, ignoring how much they impact and are impacted by the global dynamics.

This perspective requires these policies to incorporate the "local x global" dilemma recognized by many as the "globalization paradox", which comes from the idea that the greater the ease of global knowledge exchange, the greater the reliance on local resources. It is the opposite processes of dissemination and concentration of knowledge that reveal the success of innovative environments [8].

To incorporate such dilemma depend, from on hand, on the innovative environment capacity to form internal networks (local buzzes) that require face-to-face relations, local atmosphere, personal encounters, the process of joint learning, but on the other hand, to identify and further global pipelines connections [8, 9] The combination of these two dimensions potentiates the process of knowledge production and determines the performance of innovative environments [5].

In fact, the fate of a region is defined not only by what happens in it, but also by various relations of control and dependence, competition, market access, and the intersection of vertical and horizontal dimensions. GPNs depend on the articulation of networks with the territorial relations. It is not about choosing between global networks and regional territories, the two dimensions need to be mobilized at the same time to capture the multi-scalar nature of regional economic development [10].

Therefore the globalizing process implies increasing multiplication of local, national, regional, and global scales overlapping and interpenetrating in increasingly complex ways. This happens because knowledge can be either codified and expressed explicitly in documents, software and hardware or tacit, no formally communicated for being deeply personalized [3]

Hence, the basis of localized innovative environments such as STPs lies in this process highly sensitive to geographical distance and proximity. Their local assets can become an advantage for regional development and thus to the gateway city formation only if they fit the strategic needs of the global economy. It must then simultaneously promote regional advantages and enhance the region's articulation into GPNs [1].

2.3 Innovative Environments and the Knowledge Function of Gateway Cities

Since the late 1990s, cities have been considered nodal points in global commodity chains [10, 11]. Among them, global cities stand out as the top level of the global economy hierarchy and together they shape a world system of production control and market expansion [12].

They are also claimed to act as production and innovation sites, as well as markets for the circulation of innovative products from which global economic processes are controlled or at least managed [13]. The network standpoint was also focused to comprehend such cities as drivers of innovative processes that depend on systems equally connected by different agents [14].

Among these global cities we highlight the ones located in the so-called Global South, the Gateway Cities, whose function is to connect their respective regions of influence in the global economy. According to Scholvin et al. [10], some studies tried to map the way cities from developing countries are standing out in the global economy. Some of them emphasized their command centers' feature, but present vague concepts to explain it, others are concerned with services these cities deliver, such as the relational cities studies, but they only deal with advanced producer services provided in these cities, ignoring other features. Globalizing centers and world cities in commodity chains would deal with connections of regional systems and advanced producer services that connect the hinterland globally, but ignorers how and why globalizing centers function [10, 15].

However, a much older, but apparently better grasp of the Gateway Cities essence was made by Burghardt in 1971. He defined them as an entrance into (and necessarily an outlet for) some area. It suggests that gateway cities serve as channels of transmission between their respective regions of influence and the outside world. It highlights the interconnection function of gateway cities in the form of control of economic processes and a territorial hierarchy. He states that the city [gateway] is in charge of the connections between its region and the outside world (Burghardt, 1971).

Scholvin et al. [10] rescued this idea and inserted it in the current context of GPNs advancing studies that simply replicate global cities' functions into cities of emerging countries. They differentiate global from gateway cities not only considering the geographical location. They focus primarily on their ability to act strategically in the GPNs with a view to connecting globally the undeveloped regions of their influence in the global economy. This function of intermediation is what differentiates Scholvin's [10] studies from others that also tried to investigate the global cities of the global south, but did not enter into the intermediation function that they play [16–18].

This effect is best apprehended by examining how cities and their strategic couplings in GPNs integrate the periphery with the global economy in a given network that begins in the global south countries, but which necessarily passes through the gateway cities. However, not only in one sector, but in many others by taking advantage of specific assets of a locally embedded sector, and by adding technological capabilities in a process of joint learning that reinforces positions in different GPNs. This is because innovation and knowledge generation that mark gateway cities is understood as cooperative processes that may involve local and non-local companies from different sectors. Together they seek to adapt existing technologies to local particularities or commercialize locally knowledge developed globally [19, 20]. And the places where this knowledge is produced serve as intellectual articulations at different local and global scales [10].

Thus, it is necessary to examine developing countries' innovative environments, such as STPs, physically located in specific regions to observe how they strategically interacting local networks with GPNs in a way they assume a format of gateway city.

2.4 Science and Technology Parks and a Theoretical Contribution

According to the literature above, in the current globalized world, characterized by organizationally dispersed and spatially fragmented production networks, cities stand out as a result of several actors' performance and policies implementation. Both this actors and policies would ensure, by performing strategic couplings in GPNs, the local and global capture of value generated and enhanced inside these cities [1, 21–23].

However, studies are still needed to investigate who these actors and what these strategic policies are, especially in less developed regions, located in the so-called global south, and especially in some of their cities that have gained prominence in certain GPNs.

As discussed above, first studies recently arose, seeking to understand the strategic role in specific GPNs of some cities form developing countries identified as gateway cities, an intermediary player linking local regions to the global economy [10, 15]. Nevertheless, deep investigations are still necessary to better understand the knowledge factor that seems to indicate the great differential of gateway cities. This is because the current world is not only fragmented, dispersed, and structured in local and global networks of many actors and institutions. It is characterized by a productive knowledge economy, by economic complexity dictating development and by cross-sector technological solutions.

Physical innovative environments, such as STPs, would act in this vector of knowledge generation. Their institutional designed tend to be structured in a way leading companies sense the pressure to be involved with their R&D centers inside them. STPs would also export their local and regional companies, functioning as a channel through which various resources, like knowledge, pass by. Due to the degree of institutionalization they offer, the economic complexity they provide, the collective learning inter and intra sectors they foster, and the availability of talents and high quality research and teaching institutes available in there, they are able to capture values created and enhanced in both local and global networks they participate (Mello, 2018, in press).

Even though it is true that cities where these STPs are located previously counted on necessary conditions such as, the operation in a GPN of a sector embedded for a long time in the region, this fact seems not to be enough to transform them into gateway cities. This is a path dependent process, meaning that the relational nature of regional development can constrain or promote future possibilities in a given region. Even if it counts on a previous successful history, it will still need to perform competences to absorb the existent capacities by means of capturing knowledge generated and cumulated locally [2, 24, 25].

In fact, whether the past trajectory enables successful connections in GPNs, this circumstance itself does not imply the subsequent couplings needed to sustain and improve the region conditions. This is especially true in such a global network economy, which increasingly requires technological complex capacitation and productive knowledge to maintain regions, as the gateway cities, in good positions in GPNs [1]. And STPs have been used as a tool to address these exact purposes.

STPs, as we conceive here, are one kind of innovative environment, implanted as a real state project, that presupposes the interaction of the elements of the so-called triple helix theory[4]: entrepreneurial academia, academic productive sector and a mission-oriented government. This last one approximates the first two to develop activities based on science, technology and innovation. Legally speaking it is a kind of hybrid arrangement which is not public or private, but it counts on market incentives combined with public control and on a strategic center where all the decision are shared.

They aim at facilitating the more strategic positioning of its stakeholders and regional actors in GPNs, by enhancing the buzz, both local, through co-location and face-to-face relationships, and global, promoting international events. They would also function in GPNs encouraging collective learning locally, in their R&D centers and laboratories, and internationally through its global pipeline policies [28]. This means they would act as an intermediary point that connects the local network to the global economy, and consequently they would catalyse the knowledge gateway city function in the region where they are located.

This article intends, therefore, to evolve in the discussion about gateway cities and GPN dynamics and strategies of emerging countries, putting more emphasis on the knowledge function by means of investigating the role of STPs in gateway cities outcome. To do so, we consider STP both as an active player and a policy for strategic coupling for local and global development, and a promoter of the gateway city function through its productive knowledge it indorses.

3 Methodological Design

In order to answer our research question from the above literature perspective and in an attempt to theoretically contribute to them, we chose The Science and Technology Park of São José dos Campos (PqTec). Many motives lie behind this choice, among them:

1. STPs have been fostered since 2000 by Brazilian policies as a way to promote local and global strategic development. It was understood that although the country is increasing its scientific publications and, thus, outstanding in knowledge production, this is not being transformed into development because of the non synergistic interaction with the productive sector [29]. Thus, to correct such system failure, physical innovative spaces were stimulated to proximate the so-called elements of the triple helix.[5]

[4]Concept presented by Etzkowitz and Leydesdorff in 1995, borrowing from biology the concept of "double helix" of DNA. It assumes innovation process depend on the interaction of Government, Productive Sector and Academia [26, 27].

[5]Concept presented by Etzkowitz and Leydesdorff in 1995, borrowing from biology the concept of "double helix" of DNA. It assumes innovation process depend on the interaction of Government, Productive Sector and Academia [26, 27].

2. São José dos Campos has a history of more than 70 years of innovative culture initially transplanted by the Massachusetts Institute of Technology—MIT from which derived the creation of the Technical Aerospace Center (CTA), which includes the Technical Institute of Aeronautics (ITA) and where the Compania Brasileira de Aeronáutica S/A—Embraer spinoff in the 1950's and 1960's. This history was crucial for the success of the PqTec.
3. The aerospace sector is one of the most important within the productive structure of the advanced economies, due to its strategic nature in the field of sensitive technologies and the production of defense equipment and its economic aspects: commercial balances, high added value and high qualification jobs. Intensive in technology industries this sector needs high investments in R&D. Their products involve highly complex integrated systems with continuous and incremental incorporation of technological innovations from other industries. Also, the high requirements imposed by the aerospace industry allow a high level of diffusion of technological innovations to other sectors of the economy, but requires an elevated degree of technical standards. It tends to be organized in a concentrate oligopoly in a global level, despite efforts to strengthen national conglomerates competitively. The state is the great coordinating agent of the aerospace industry, not only in sectors where it controls directly, such as military and space, but also in the commercial segments. Governmental policies for the aeronautical industry are responsible for the historical innovation and increased competitiveness of most developed countries [30, 31].
4. Indeed, deveral state strategic decisions surround this city's trajectory. The Federal Government was responsible for choosing this city to receive that national aerospace institutional design in the 1950s. It was also the Federal Government who formulated the first policy to foster STPs in Brazil in 2002. The federal state of São Paulo, inspired by this federal policy, created the first regional state policy called the São Paulo System of Technology Parks (SPPTec), and also chose, in 2006, São José dos Campos to be one of the five cities to benefit financially and technically with the program. In fact this city was the first to meet a range of requirements imposed, at which time it ended up pioneeringly certified by the program. Finally the PqTec was juridically and institutionally constituted according to objectives designed in municipal programs that financially support it until now;
5. The PqTec shows very promising results and a significant volume of investments. Is the house of the three largest aerospace companies in the world, including the national Embraer. It also deals with more than 300 stakeholders, including large and small companies, national and international, from different sectors. Besides it the PqTec manages nowadays the Aerospace Local Productive Arrangement and another one related to information technology and communication;
6. It is also considered as an ideal model to be replicated in other regions, reason why the current institution that manages the PqTec is been called to present guidelines to implement other STPs in Brazil and for the formulation of future public policies that intend to disseminate innovative environments.

Based on this reasoning we understood the PqTec experience could reveal us recurrent patterns of strategic couplings grounded on local and global development stratagems that would help the city to be transformed into a gateway city in the aerospace and correlated sectors' GPN.

Our methodological design was influenced by Pettigrew [32] and its longitudinal and contextualized method of conducting longitudinal field research on change in which the concern with the way thing evolve over time and why they evolve in that way is always present. We formulate then a longitudinal case study analyzing stakeholders from the PqTec in a way we seek to recognize patterns of events to learn how and why things evolve in a certain way [32–34].

Our first step was to identify actors and groups of actors both inside and outside the PqTec. Initially we though on exploring only the aerospace sector following studies on chain tendency, but soon we realized that the STP differential in transforming the city's economy relies on its ability to capture value from different sectors, to add productive capacity and in a joint learning process to generate development in science, technology and innovation in a cross-sector way. We decided to interview enterprises from different sectors and to investigate the STP in all its operation. We tried to interview representatives of the triple helice's studies: government, productive sector and academia. All of them were recorded but kept anonymous.

Even though the main source of data collection were from the aerospace sector and most of them operating inside the PqTec.

The analysis involved initial data exploration and the identification of possible unities of investigation trying to sort what was more relevant for the gateway city formation and how. All data collected were integrated into Atlas.Ti software for qualitative analysis. Then an inductive coding was implemented and information was labeled and interpreted.

The unites of analysis chosen for interpreting the results regard the different strategies applied to the capture of values in the city and the gateway city consolidation. Each one of the interviewees would provide some information regarding these five axes:

Finally, this study follows high rigor criteria of credibility, constructed manly over interview recorded and public documents. It is also based on transferability, dependability and confirmability features, since it can be replicated in other places or reapplied following the same methodology herein designed.

4 Main Results

To better organize the data collected to comprehend if, why and how PqTec are influencing the São José dos Campos gateway city formation, we focus on five units of analysis (Tables 1 and 2):

Table 1 Data collected

Data sources	Description	Period	Role
PqTec official documents	16 documents (contracts, institution's statute, other documents)	January 2006–2018	Source of additive data coded
Interviews	32 in-depth interviews: *Large companies: 8 *Small companies: 6 *APL: 3 *Incubator: 1 *State institution: 1 *Academia: 4 *STP developers: 3 *State: 3 *PqTec: 3	May to July 2018	Important for building the history of the STP formation and the way it has been capturing value
Participant observation	Field notes of the day-by-day STP operation	May to July 2018	Necessary to comprehend the dynamics inside the PqTec
Public documents	News, websites, articles, etc.	May to July 2018	These documents completed the information on the STP action

Table 2 Units of analysis

Axis	Category	Specific question
1	State strategies, institutions and Embraer	How state strategies, the creation of governmental institutions over the years in the city, the national global leading company (Embraer), and the Local Productive Arrangements were necessary but not enough to determine value capture regionally and the consequent gateway city consolidation by the PqTec?
2	International leading companies	How international leading companies attracted by the PqTec to the city operate in a way to conform the Gateway City materialization?
3	National small and medium size technology enterprises	How the PqTec support to their small and medium size technology enterprises contributes to the Gateway City formation?
4	Super cluster and diversification	How the sector's diversification promoted by the PqTec by means of adding technology capacities to the aerospace segment benefits the gateway city characteristic?
5	Regions and other actor's GPN inclusion	How other regions and actor's access the global economy trough the PqTec?

Elaborated by the authors

4.1 PqTec as Sufficient Condition for the Gateway City Characterization

Previous institutions and the embedded aerospace 70 years history were necessary conditions for the PqTec to be created. Without them this new initiative would have not been feasible, but they by themselves were not enough for the Gateway City configuration.

> Embraer and CTA have their value but their action is limited. They employ people and generate revenues for the city, but PqTec acts beyond that. It represents continuity and also opportunities opening caused by the environment it creates, for instance, the universities and talents it form and retain locally.[6]

Some other interviewees also stated "… *contrary to other institutions, it [PqTec] is the only one concerned with capturing values in the city*".[7] Among these other players we could identify some, like:

(1) The Department of Aerospacial Science and Technology (DCTA) and the National Institute for Space Research (INPE): interviewees claimed because of their government structure they are not flexible as the PqTec is. They don't have the private perspective to solve technological problem. "*Not even Embraer uses it anymore, other entities even less. People cannot access these places…"*.[8] Although the importance they had over the years to form a technological culture in the city, they are not able to deal with all demands of the current global interconnected economy.
(2) The national global leading company, Embraer and all its national suppliers from the aero APL—if the first institutions above are too public to deal with the nowadays global demands, this other companies are too private to capture value and focus on promoting local development. "*Clusters and APLs are not concerned with capturing values. They have business vision. They focus on what is more profitable for them"*.[9] Thus, a flexible institution, like STP, is crucial to return to the city the public investments made over the years, besides the jobs created by Embraer, because "*the whole city would be held hostage to the financial situation of this company.*[10]
(3) Embraer also recognize during the interviews that it depends on the PqTec to be more competitive. Indeed it was one of the main responsible for the creation of the PqTec. It has many different companies there created in the last years, a R&D center and the Research Laboratory for Light Structures (LEL) which serves many different sectors. And Embraer keeps inside the PqTec its whole defense and security systems' operation, which couldn't be developed inside its

[6]A representative of a company located outside the PqTec, but in the city. It operates with different information technologies most of them directed to space and defense IT solutions.

[7]Report provided by the director responsible for administrating the APLs.

[8]Information given by the PqTec directory.

[9]Says people from the PqTec responsible for coordinating the APL.

[10]This was the report of interview that operates inside Embraer.

huge fabric district for safety reasons. Besides it promotes training, workshops, helps to rise public funding, invest on start ups and is trying to use the PqTec to better capacitate its suppliers to innovate. *"We never thought on a gateway function, but we had this rationale always in mind and that is why the PqTec is capable of implementing in the city programs we never did before.*[11]

In fact, even though some complaints regarding the way more or less political the PqTec acts or some accusation on its inclination toward some players' protection the benefits derived from its hybrid nature and the consequent ability to configure a gateway city transformation, which the region never experienced before, are uncontroversial in all interviewees' reports. According to them, this is due to the cooperative environment full of students, small, medium and big size companies, and also because of the above institutions that in a way or another also operate there together with other similar institutions from other regions, such as the Technological Research Institute (IPT) from São Paulo and the National Disaster Operation Centre (CEMADEN) that moved its whole operation together with its 200 employees to the PqTec.[12]

4.2 The PqTec Power to Attract International Players to the Gateway City

PqTec attracts leading global companies and other international players encouraging them to bring their R&D centers and to cooperate with other stakeholders residing in the PqTec.

> The PqTec is the one who attracts them [leading global companies] not the APLs. Boeing and Airbus could operate in the APL without moving its R&D operation to Brazil. They were interested on coming because of the connections the PqTec promotes and the talents the it retains there.[13]

In fact the three largest companies in the aerospace sector, including Embraer are there and do not intend to move out:

1. The American Boeing could not record interview because of the new enterprise under construction with Embraer, but it operates for a long time inside the PqTec in the Joint Research for Biofuels created there. There were many comments on this company operation in the PqTec by the interviewees. Mostly they consider this company to be interested on learning interactively and to access the innovation process under course in the PqTec.
2. The European Airbus, that although closing many important operations in Brazil, due to the biggest economic crisis Brazil faces and that hit in particular some

[11] This was the report of interview that operates inside Embraer.

[12] More information on the PqTec website: http://www.pqtec.org.br/quem-esta-aqui/instituicoes-de-ciencia-tecnologia-e-inovacao. Visited on July 22, 2018.

[13] Say people from the PqTec responsible for coordinating the APL.

> of its partners, decided to keep its office in the PqTec. Representatives of this company confided that because of its relevance, and the capacity to establish networks everyday the company would not leave this place.

Besides those, an interesting information gathered in this research regards the Swedish company: SAAB. It moved to Brazil to construct the fighter aircraft after winning an international bid over Boeing and Airbus. Political reasons make SAAB to open its fabric in another city (São Bernardo dos Campos), but their R&D center and all its intelligence is in the PqTec. This is because this company bought a national company (Akaer), which transferred its whole operation to a huge lab existent in the PqTec. So the less complex operation is in São Bernardo dos Campos, but the technological intelligence is in the PqTec.

There are other international big companies also composing the group of global leading enterprises presented there, like Ericsson. This is also a Swedish company, one of the leading providers of Information and Communication Technology (ICT) to service providers, that opened an R&D center for ICT in the PqTec. Representatives of this company stated that it was contracted by the São José dos Campos municipality to come up with solutions regarding smart cities. This initiative was so successful that many other cities want to contract the PqTec to replicate the same technological solutions, focused on safety, mobility and digital interactions.

4.3 PqTec Capacitates and Internationalizes National Small and Median-Size Enterprises

PqTec encourages their resident companies to internationalize their operation and gives the support to better position them in GPNs, including the Embraer supply chain. Many interviewees stated that although the design authority that Embraer holds which gives it, besides other advantages, the power to choose its own suppliers, 80% of its aircrafts are composed by import components. The most sophisticated part of this chain is occupied by international companies and the PqTec believes it is its duty to change this situation by capacitating and make more internationally competitive the aero APL.

> The PqTec responsibility is to help companies to internationalize, to transform this cultural position to be waiting for the government to provide everything, to develop a new market vision.[14]

The PqTec also stimulate the aero APL's industries to contract services from its residents. Because of many interactions small resident companies have opportunities to come up collectively with new technological solutions. For instance, representative of a medium-size company of the aero APL stated that because of the PqTec intervention it contracted some small companies to develop different digital services,

[14] Information given by the PqTec directory.

which helped the company to make a wide use of 3D design software integrating management and the industrial infrastructure.

> These services would not be contract by a APL industry if it weren't for the PqTec's EBTs. These same solutions can be developed by big companies, but it is too costly for us.[15]

On the other side, although some SMEs complaints on concerning the not enough help provided by Embraer and the Government, they realize the PqTec positive effect on their business capacitation to close big contracts, including the internationalization of their operation.

4.4 PqTec Diversifies Aerospace Technological Applications and Incentivize Economic Complexity

Another evidence of the PqTec's capacity to capture values and upgrade the whole city is its competence to be structured as a super cluster, which derives from one specific sector, but by adding technological capacities, it operates in transversal way, involving different sectors.

> To be a gateway city its STP has to open the door for all technologies and foster new ones. It cannot be limited to one sector. It has to focus on an innovative development model. It has also to form an intelligence nucleus and consider it a national strategy to guarantee development through technology not through a single sector.[16]

Thus, the PqTec fosters economic complexity and technological capacity additions to retains it in the city:

> The PqTec influences this gateway city effect only because we facilitate and promote the flow of many technological knowledge but not in only one sector. It happens because we are opened to any area that using our aerospace expertise, add other technical capabilities to different sector. [17]

Embraer states it always incentivized diversification so as to the PqTec follow its own destiny and not to be under this sector control.

> We were aware we had to assume a role not as the protagonist of the PqTec so we always incentivize diversification. The main example was the creation of our first lab, LEL. It can attend any sector with complex structures requiring light materials, like the automotive and oil and gas sectors.[18]

The PqTec representatives insist they are not to be specialized in one segment. They prioritize the knowledge development, how to retain it and how to apply it. This knowledge can be created, developed in one specific sector, but its application can vary and it is the PqTec responsibility to apply them in any sector transversally. This can generate development to many sectors including the aerospace one itself.

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[15] Report from a representative of medium-size enterprise of the aero APL located outside the PqTec.

[16] A PqTec counselor gave shared this insight.

[17] Information given by the PqTec directory.

[18] This was the report of interview that operates inside Embraer.

4.5 PqTec Opens the Gate to Other Actors and Regions

All companies from the APLs with headquarters outside São José dos Campos have to pass by the PqTec to be certified, better trained and to make connections locally and globally. Other APLs are being created in other regions, also encouraged by the PqTec. They are being called sub APLs. But they will always depend on the PqTec in some degree because the R&D centers and labs are there, as well as, programs, workshops and preparation to fulfill the high level of global safety standards in this sector.

Besides that the PqTec operates in many other regions providing STPs implantation services counseling. They are being contracted by many Brazilian regions because they are seen as a development policy model.

> The PqTec is extending its influence in the region. We are participating in many bids to run different STPs. As Financial Times recognizes SJC is the center irradiator of opportunities and we have a great deal to do with this result. [19]

Finally, the PqTec is signing an agreement with European Union to serve as a soft land of any European company willing to operate in Brazil. They occupy an office there with low cost and learn everything they need to decide to really open their operation in Brazil. By doing this the PqTec will also encourage partnerships with its residents and provide a way for them to internationalize their operation in Europe.

5 Discussion

The developing countries catching up process seems to rely on several institutional tools and specific public policies so as to cope with the international economic challenges which changes overtime. In Brazil, and in São José dos Campos city in particular, different strategies applied over time demonstrate this rationale. Since it was chosen by the Federal Government to develop a national strategic sector, São José dos Campos has been adapting its policies and entities in order to survive in the global reality presented.

Its most important company, Embraer, was a state-owned company by the time the country put great emphasis in import substitution policies, in a process known as the "Big Push" of the industrialization process. This was also the time when government control institutions such as CTA and INPE were created. Internationally it was an era of a nationalist world, with few global interactions where a mass production process, known as Fordism, reigned. In fact, even though the global intrinsic characteristic of the aerospace sector, Coe and Yeung [1] remmber this was a time of the TNCs tendency to self-contained their multi-domestic structures merely replicating abroad their home operations [1].

[19] Information given by the PqTec directory.

Later on, in the 1980s, Brazil experienced a long period of stagnation and inflationary crisis followed by criticism of intense state intervention in Latin America and had to redesign a new economic and structural policy based on the so-called Washington Consensus. The result was economic reforms aimed at privatization programs and Embraer in 1992 was part of it. It was included in the privatization program and sold to a consortium of banks and pension funds. The world, much more competitive, forced the company to change its focus from political to more administrative and financial private efficiency, even though most part of Embraer success would still be dependent on the many government technological order for military purposes, which resulted in the creation of sophisticated aircrafts, such as "Tucano" and "Super Tucano".

This company, perhaps because of its global operation, was also able to foreseen a new global organization much more dispersed and fragmented, where global leading companies would controlled several complex production networks fostered by various strategic policies [1]. This new scenario demanded from the emerging economies a new developmental model with more coordination induced by the state in partnership with the private sector. Now a more inductive role was required and public policies directed to strategic development were supposed to be designed.

Those were the reasons why Embraer actively participated in the PqTec project, but it did not assume a protagonist role. It induced the government to diversify sectors, its first effort was to construct a complex lab to come up with innovative solutions regarding light structures, not only to be used in the aerospace sector, but to be also applied in any other fields that requires complex light structures.

PqTec as a hybrid organization had not served only Embraer interests. It attracted its biggest competitors and induced them to implant there R&D centers and to transfer to talents graduated there the technology created. It also gives the support it can to internationalize its stakeholders, training them to better fulfill with the highest international standards, organizing various events which enables partnerships of various level, fostering an environment where people co-locate and collective learn locally and globally in a super cluster. Because of the international initiatives it also fosters global pipelines and are managing to enable actors and regions from other parts of Brazil to access the complex global economy.

These features, anchored in a territorial embedded sectorial history and based on the power not only of Embraer, but also of national, regional and local governments and of many talents the city has formed over the years in ITA, are determining the way PqTec activate the gateway city function in São José dos Campos. It is preparing the city to operate in the current global world, capturing values created and enhanced and fostering productive knowledge.

Companies willing to come to Brazil to operate in the aerospace and correlated sectors are naturally attracted by its many features: institutionalization that minimize the Brazilian institutional deficiencies, talents, synergies among many players, training and certification programs, besides the APLs administration. All these together with its ability to replicate this model over Brazil and to open the gate to the global economy for other players confirm studies on GPN, regional development and gateway cities, highlighting new strategies for policies and development.

6 Final Remarks

Although the São José dos Campos history of decades of investment in the aerospace sector, a successful global leading company, the third largest in the sector, the MIT intelligence capacity absorption, the many institutions it counts such as CTA, ITA and INPE, only recently the city managed to find a way to captured values and to occupy a prominent position in GPNs, which resulted being nominated as the Aerospace City of the Future by fDI Intelligence. A new institutional model was required, a hybrid one, able to make government, academia and private sector to dialogue and to come up with technology solutions to face the current global economy: the PqTec.

If the city's investment trajectory in one sector taught the city the ways to become part of the global economy, the PqTec taught that in today's complex world it is necessary to add technological capacity to strategic sectors in which the cities have the greatest vocation to promote better positioning and sustainability in global articulations.

These are the main conclusions the longitudinal case study developed in this paper revealed. It sought to understand patterns, which identify the PqTec influence on the transformation of São José dos Campos into a gateway city. We have done it from three theoretical approaches' perspectives that understand the importance of innovative environments in shaping cities where they are located: GPN, regional studies and gateway city studies.

The theoretical contribution of this investigation regards thus the association of these three fields of studies with the rationale of STPs as policy for local and global development. Our effort was to allow an interchange between these theoretical approaches by presenting a specific case study.

We accomplished that although it is too early to measure all impacts, it is reasonable to conclude that PqTec is playing a strategic role transforming São José dos Campos into a gateway city. This result depended on previous necessary conditions the city developed over the years, but without the PqTec performance the city would have not been able to capture values in many different GPNs.

It happens not only because of the territorial embeddedness and the power the PqTec has to attract international companies with their R&D centers and to export its own stakeholders, retaining in its region the values created and enhanced, but also because it is being able to open the city gateway to other actors and regions to access the global economy.

Future studies would be important to isolate the PqTec economic performance and perhaps to compare these results with other STP's experience in developing countries, which demands particular policies, cities configuration and institutions to be internationally competitive.

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What Do We Know About University-Industry Linkages in Africa?

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Abstract Interactions among academia and industry as a research theme is getting more and more attention of scholars from different fields and policy makers, due to the synergy of these relationships and what they can generate as benefits in terms of innovation, technology, development and economic growth. Literature in this field provides evidences, practices and several aspects of university-industry linkages worldwide. However, little is known about Africa and knowledge about this phenomenon is still limited. This paper is aiming to give a state of the art of different incarnations of university-industry linkages in Africa through analysing literature and secondary data. We identified 31 African countries in The Global Innovation Index reports (from 2011 to 2018), which has an index on university-industry research collaboration. Then, we gathered literature of those countries by searching related keywords to university-industry linkages. Based on what we obtained as information, we build a general idea about this phenomenon in African context, exposing realities and challenges, leading the way to new research streams for future studies.

Keywords University-Industry linkages · Triple helix · Africa · The global innovation index

1 Introduction

Universities play a fundamental role within societies through educating the population and creating knowledge. Thus, those are not the only mission which universities are involved since they have taken action in building relationships with knowledge users for the sake of the transfer [12–14]. The growing role of knowledge in economic development implies that universities and industry have no choice to interact in order to create and exploit knowledge. In the national innovation system framework, higher education system and industries are expected to interact and be involved in mutually

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beneficial knowledge exchanges that generate innovation. University-industry linkages help universities to improve the quality and relevance of academic agenda by getting access to relevant sources for research activities, additional funds, equipment and support for students, as well as learning opportunities in field-testing [22], while firms get help to obtain a competitive advantage to face globalisation. Everyone is winning through various forms and practices of linkages such as academic knowledge commercialisation, joint research projects, joint curriculums and employees' training and outcomes such as innovation and economic growth. The outcomes of such linkages are broader than the predefined goals of each partner, and manifest on a greater level impacting knowledge environment and innovation system as well as the economic development.

Literature is rich and still expanding, getting more and more interest by researchers in related disciplines as well as policy communities [32, 33, 35]. However, little is known about Africa, knowing that those relationships might be influenced by factors related to context since economic and social realities vary from a continent to another, especially if less-developed countries are the dominant like Africa's case.

We address these gaps by presenting an exploratory study on university-industry linkages in Africa asking the question about context as follows: what do we currently know about university-industry relationships in Africa?. By reviewing what we found in the literature concerning African countries, and analysing secondary data extracted from The Global Innovation Index reports from 2011 to 2018 about university-industry research collaboration, we could identify several specificities to this phenomenon, leading the way to research perspectives that we suggest for a better understanding.

This paper is organised as follows, after introduction, a second section that exposes specific aspects about African countries that can influence the nature of university-industry linkages in the continent. Methodology is explained in the third section, findings follow in the fourth section. We discuss our results in the fifth section, then ending by the conclusion.

2 What Can Make University-Industry Linkages Different in Africa?

First, context matter in studying such phenomena. In Africa, several gates might play a role in delaying knowledge improvement, depriving stakeholders from basic conditions to establish relationships. The shakiness in national development programs, have tended to shift with donor ideals [8] and poor management [9, 18], university funding decline, increasing brain drain, deterioration of the service conditions and quality of education, all are facts that cause drops in efficiency and productivity of the university in such contexts.

Technological developments and their institutional environments grow mutually and bring progressive changes in knowledge structure. University policies and practices in a country are largely shaped by the historical development [4], and institutional behaviour and cooperation patterns between universities, firms and other actors are shaped by social factors [4]. Consequently, drivers of interaction between organisations such as universities, firms and others, can be radically different from one context to another.

Since the economy is increasingly becoming knowledge-based, the ability to produce and exploit knowledge for industrial purposes is a major issue. However, the synergy generated through relationships between different stakeholders namely government, industry and universities, is a key driver to face different challenges in the area of knowledge-based economy. Such synergy seems not to exist in African economies and the reasons behind this lack might vary depending on each actor involved in the knowledge environment, starting by the university and the perception of its mission, to the industry actual need and its relation with academia, ending by policy makers who are supposed to build platforms to bring the two parts together.

Looking at the circumstances of universities in Africa, as well as the nature of economy which is a resource-based for most of the countries in the continent, the expectations of university-industry linkages might be idealistic. The dimensions of linkages might not be as elaborate as in developed economies for several reasons. For the most part, universities in developing countries function independently of industry, and the industry as effect relies on foreign knowledge sources to sustain production and meet competitive challenges [1]. The university in Africa is under pressure by government and industry to answer the need in terms of human capital, while global standards of knowledge-based society put further pressures on the university to produce research and leaders who can be responsive to global trends [28]. However, in the middle of this dilemma, it is difficult for universities in Africa to be proactive to succeed in their missions, since they still dependent on the Ministry of Higher Education for their programmes, resources and learning goals, in a very bureaucratic way and hostile. Further, most legislation establishing public universities provide for teaching, research, and community engagement. Technically, teaching and research are not confusing missions even if they also need to be clarified in terms of alignment with knowledge-based economy strategy, but the room of subjectivity is greater when it comes to community engagement, and academic institutions interpret it differently depending on their leadership and policy.

On the industry's side, before we ask firms if they are willing to collaborate with universities for any determined purpose, we have to look at their circumstances too, by asking the question about African economy in general and what it relies on. Africa's GDP is dominated by services, then come mining and agriculture, and if the share of industrial output is significant, it is due to the importance of extractive industries in many African countries [37]. In such economies, certainly there are many areas of collaboration, but knowledge, innovation and technology are not considered crucial for those activities and firms might not be concerned about what universities can offer.

When it comes to policy making, and by observing the economic situation of Africa, it seems that industrial policy is addressing innovation, technology, finance, strategy and growth outside the system which includes higher education, research and their relationship with everything.

Developing countries, especially in Africa, have concentrated their efforts on promoting pure academic research and higher education, ignoring the need of economic knowledge. According to Ogbu [31], African institutions have not been successful in enhancing innovation and economic growth because of the limited collaboration with industry. The reason why the research field needs more studies concerning such context, to elaborate on managerial and policy implications for African economies.

3 Methodology

In order to draw an image about university-industry linkages in Africa, we used literature and secondary data. First, we reviewed what we could find in university-industry linkages' literature concerning Africa. Since scholars use different appellations to refer to this concept, we used every possible keyword that it can refer to the concept, such as (University-industry linkages, university-industry collaboration, university-industry partnership, university-industry relationships, Triple Helix … etc.). Triple Helix is a term referring to university, industry and government relationships, using this keyword in the research process was helpful even if government is not included in the concept, but we are investigating this field in its larger picture where government is definitely involved in the linkage sphere. Intervention of the government might be necessary in many African countries where universities and firms' initiatives toward each other are exceptional. We structured our review in (Table 1), shedding the light on authors, countries, and some interesting findings that helped us to build an understanding about this theme in Africa. Then, we looked at university-industry research collaboration of 31 African countries that we identified in The Global Innovation Index reports of 8 years (Table 2), starting from 2011 to 2018, in order to have an idea about collaborative research, its level and progress in Africa.

4 Findings

4.1 What African Literature Revealed

Africa has in total 54 countries, but only few are concerned with literature in this research field. Nigeria has the largest number of papers covering different aspects of university-industry linkages (see Table 1), only two countries from north Africa that we have read about (Algeria and Egypt), and Mozambique is quite represented by many studies, as well as South Africa.

Table 1 African literature

Authors	Country	Interesting findings
Adeoti [1]	Nigeria	Since Nigeria's education and industrial policies are isolated from each other, creating developmental universities in Nigeria needs the integration of education and industrial policy University-industry linkages are strategic in strengthening the national system of innovation and they are crucial catalysts for making the role of universities more developmental in the countries of the South
Adeoti [1]	Nigeria	The study showed that until 2007, Nigeria's development planning process failed to appreciate the crucial role of science, technology and innovation in economic and social improvement. Science and technology focus on supplying irrelevant knowledge for expected users, due to the lack of interactions between different stakeholders
Attia [2]	Egypt	The Egyptian environment suffers from orientation-related barriers because university is extremely oriented to pure science as well as there is a lack of understanding of work practices, and transaction-related barriers since most of public universities do not have a liaison office and the system is too rigid

(continued)

Table 1 (continued)

Authors	Country	Interesting findings
Elnasr Sobaih and Jones [10]	Egypt	The research gap between Egyptian universities and the hospitality and tourism industry is wider than what university–industry collaboration literature suggests There is an absence of a research culture in faculties of tourism and hotels where social science research is perceived to have little/no value for knowledge creation or to inform industry practices There is no evidence of government intervention to drive university–industry research collaboration for the tourism and hospitality industry, despite its importance to the Egyptian economy
Etzkowitz and Dzisah [11]	Africa	Africa is lacking knowledge-based industries and university government interactions are needed to jump-start the creation of an economic model that support knowledge One of the important statements made by the authors is the need to redefine the mission of universities in Africa. A mission that must include economic development

(continued)

Table 1 (continued)

Authors	Country	Interesting findings
Juvane [16]	Mozambique	For both government institutions, the main IT challenges are related to infrastructure, business processes, software, human resources, budget and education. In terms of obstacles that prevent industry to collaborate with university, authors found financial constraints, excessive bureaucracy, lack of leadership will and support and lack of IT skills and qualified staff at universities
Konde [19]	Zambia	Triple helix might be a key driver in transferring, adapting and mastering knowledge-based technologies in Africa
Kruss and Visser [21]	South Africa	The analysis shows the patterns of interaction in an emerging economy with immature system of innovation, distinguished by a hierarchical, segmented higher education system that restricts knowledge flows and mobility The incentives that drive South African academics and block university-industry interaction are strongly related to their differentiated nature as organisations controlled by reputation

(continued)

Table 1 (continued)

Authors	Country	Interesting findings
Kruss et al. [20]	Nigeria, Uganda and South Africa	The nature of university–firm interaction in South Africa is more direct, formal and knowledge intensive compared to Uganda and Nigeria Nigerian or Ugandan or South African universities adopt models of firm interaction, of technology transfer, incubators or science parks without analysing sectors and firms in their contexts. As effect, they might not succeed in achieving their aims
Lotayif [23]	Egypt	Communication has positive effects on easing tensions and conflicts between universities and firms, which increases the possibilities of building constructive collaboration between the two Firm trust toward universities is a crucial driver, and it is built by satisfaction, solving conflicts effectively, commitment, collaboration, willingness to invest, and expectation of continuity
Mêgnigbêto [27]		University is so far, the biggest information producer, while the government contributes less to the west African scientific production, leaving the last rank to industry which its contribution is little. The weakness of the scientific output of the industrial sector makes the collaboration between the three spheres negligible
Mihyo [25]	Eastern and Southern Africa	Inter-organisation relationships between universities and industry in Africa are weak, rather loose, and predominantly informal

(continued)

Table 1 (continued)

Authors	Country	Interesting findings
Mpehongwa [26]	Tanzania	Linkages between academia, industry and government are weak, however, policy reform in the private sector and global trends are offering great opportunities to establish such relationships
Nwagwu [28]	Nigeria	The local response of Nigeria to the global dynamics in technology development affected the university made it not ready to fit the triple helix model, as well as the social, economic and political circumstances of the university in Nigeria that doesn't play in its favour
Nyerere and Friso [29]	Kenya	The University tend more towards basic research for knowledge and publication purposes There is a lack of platforms where universities can communicate with the labour market
Obanor and Kwasi-Effah [30]	Nigeria	University-industry collaboration is episodic and differentiated by types of technological and managerial knowledge possessed by firms, as well as by firm size, industry sector and university discipline Potential channels of interaction that could provide positive impact to innovation are constrained in Nigeria, since the industry involvement is low and universities do not collaborate sufficiently with knowledge users

(continued)

Table 1 (continued)

Authors	Country	Interesting findings
Saad el al. [36]	Algeria	The centralised approach forms a strong feature of the new system of innovation which positions the Algerian triple helix in the statist model. In addition, even if the new policy framework allows institutions from the government, industry and university spheres to be involved in development of the national innovation system, it is not clear how coordination between their activities can take place
Zavale and Macamo [38]	Mozambique	Findings suggest that university-industry linkages in Mozambique are weak and informal, and that academics engage with firms and exchange embodied knowledge and ideas in informal meetings, internship/employment and consultancies
Zavale [39]	Mozambique	Firms generally face barriers such as: differences in values/missions, level of company, and universities' capabilities and government policies Due to the lack of structures, policies, and mechanisms for linking firms to universities, their possibility to collaborate constrained by organisational gaps

Table 2 University-industry research collaboration score (0–100)

Country	2011	2012	2013	2014	2015	2016	2017	2018
Algeria	31.3	22.2	14.2	18.5	21.1	21.1	28.5	27.0
Angola	n/a	17.8	17.8	19.7	16.9	n/a	n/a	n/a
Benin	34.8	38.5	34.1	28.0	n/a	27.9	35.6	30.6
Botswana	41.4	43.2	44.6	37.2	35.7	35.7	40.2	38.0
Burkina Faso	38.9	36.9	36.1	37.3	36.1	n/a	n/a	n/a
Burundi	n/a	21.8	n/a	25.3	29.7	29.7	30.2	n/a
Cameroon	33.3	39.1	37.1	34.0	39.6	39.9	37.2	37.6
Côte d'Ivoire	27.0	22.8	22.8	30.2	39.0	39.0	38.2	n/a
Egypt	30.8	26.6	28.1	27.5	23.8	23.8	23.8	29.2
Ethiopia	35.1	35.5	36.8	41.5	41.0	41.0	47.2	n/a
Gambia	n/a	42.4	46.0	44.2	38.9	n/a	n/a	n/a
Ghana	38.5	37.2	35.9	40.5	41.0	41.0	n/a	41.2
Guinea	n/a	n/a	23.7	19.8	19.7	19.7	19.7	67.2
Kenya	46.4	47.9	52.8	54.7	53.6	53.6	57.6	54.9
Lesotho	n/a	30.0	25.7	28.7	36.7	n/a	n/a	n/a
Madagascar	35.2	36.7	36.8	37.8	37.6	37.6	40.0	38.9
Malawi	39.9	43.9	41.6	35.0	30.7	30.7	28.5	28.4
Mali	37.4	38.0	35.1	31.5	36.7	36.7	35.8	38.7
Mauritius	36.5	36.8	38.3	38.0	36.5	36.5	36.5	36.6
Morocco	34.9	36.5	33.5	34.0	37.2	37.2	35.4	33.4
Mozambique	n/a	46.5	41.3	37.8	38.0	38.0	37.8	37.2
Namibia	39.8	41.4	41.7	42.0	41.0	41.0	37.7	38.0
Nigeria	34.9	35.7	41.8	38.2	29.2	29.2	27.8	25.3
Rwanda	43.2	17.7	46.7	45.2	44.2	44.2	38.9	42.1
Senegal	47.6	45.2	39.8	37.2	44.0	44.0	44.0	42.7
South Africa	60.1	60.3	58.5	59.0	58.1	58.1	57.4	56.3
Tanzania	40.5	45.1	46.1	41.8	39.5	39.5	42.3	41.7
Tunisia	51.3	45.8	45.8	34.2	32.0	32.0	32.8	32.8
Uganda	40.0	41.7	43.0	45.5	44.7	44.7	46.5	43.2
Zambia	42.5	45.8	46.3	42.5	41.4	41.4	41.4	37.8
Zimbabwe	34.9	36.6	35.0	34.7	30.4	n/a	25.0	25.6

Papers generally study challenges to establish of university-industry linkages in African countries, or potential in terms of drivers. Words such as (Barriers, fail, weak, lack, absence … etc.) are frequently repeated in most of the papers, which is unfortunate since it shows how much late is the continent.

Reviewing literature, one of the interesting aspects we observed is that most of the case studies follow a pattern, we assume that it is a non-conventional scheme and we explain its existence by the reality of empirical fields in Africa. Since relationships between universities and firms are barely exist in Africa, and governments rarely take the initiative to strengthen them, the empirical field lacks of cases to study. Consequently, researchers based on their perception, they try to label anything close to the phenomenon as university-industry type of fact.

4.2 University-Industry Research Collaboration in Africa

University-industry research collaboration is one of the indicators concerning innovation linkages in The Global Innovation Index report. It is calculated through average answer to the survey question: In your country, to what extent do businesses and universities collaborate on research and development (R&D)? [1 = do not collaborate at all; 7 = collaborate extensively].[1]

In total of 54 countries, only 31 of them have their place in the reports (listed in the Table 2), knowing that some countries have their sections in the reports, but their data about the indicator we need are temporarily not available, was the reason why we only kept the countries that their data is at least 4-year-old.

By looking at the numbers, we can see that most of the listed countries' data is expressing a weakness. Generally, data is alarming, especially for the countries with a level close to the minimum score (2.14). Even for countries that evolve around the mean score (25.37), their position is significant but not enough to recapture with the world advancement in terms of research collaboration between universities and industrials. However, some countries are maintaining an interesting level around the maximum score 67.25 such as South Africa and Kenya.

5 Discussion

Recognising the value of linkages from both sides might be a reason behind the rarity of collaboration cases. However, even if the two parties do recognise the benefits of collaborations, the lack of communication and opportunity is causing this non-existing collaboration [16]. Recognising the advantages of collaboration is not enough, without the will and support of the leadership [16]. This cut between the two

[1] *Source* World Economic Forum, Executive Opinion Survey 2016–2017 (https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1).

parties is not without impact. Disconnection of scholars with the industry can cost time and funds, for no fruitful results. It is prevalent in such contexts that researchers define problems and projects without knowing the market needs. Additionally, it is difficult for a disconnected professorial corps to elaborate updated curricula to accomplish the education mission, and as effect, students need to do significant amounts of self-study to bridge the gap between theoretical knowledge acquired at university and the practical knowledge in demand at the workplace [16]. Universities might have other priorities such as citizens health care, water purification, or promoting basic scientific research to achieve a global reputation [21], which might explain the distance between them and firms. However, there is a belief that if universities get engaged too much in industrial research projects, there is a risk of becoming knowledge businesses and teaching might become a part-time activity [6], showing that the will of leadership is actually a serious matter.

On the same line of beliefs, perception of university-industry linkages might be another reason for lack of initiatives. Whenever the concept is being raised, there is a temptation to think big [25] because of the idea of technology that makes it revolve around machines, patents and licences. Even technology is overrated, since its extended definition of Autio and Laamanen [3] "… the ability to recognise technical problems, the ability to develop new concepts and tangible solutions to technical problems, the concepts and tangible developed to solve technical problems, and the ability to exploit the concepts and tangible in an effective way" shows that it is not what usually people imagine. From this perspective, collaborating could be misunderstood while there are several modalities through which university and industry can collaborate for knowledge creation and utilisation. Hughes [15] identified four ordinary areas where university-industry linkages can be established knowing: training qualified human capital, basic research, problem-solving and public space functions of universities, where African universities and firms can collaborate together easier.

Even where universities took the initiative to establish networks, institutes of production innovation, technology centres or even incubators, these do not have any strong organic linkages with industrials [25]. However, when it comes to the public space functions mentioned by Hughes [15], African universities are quite active. In effect, the question about what drives universities to interact with firms should be a higher interest for scholars in Africa. Some studies shed the light on the organisational level of university, its role and its different units as drivers from university sides [17, 24, 34], while others concluded that the individual level is what influence more the forms and interaction frequency [5, 7].

When it comes to scientific and technical research. There are several barriers that can explain the weak level of collaboration we reflect on what we identified in literature as key issues that contribute to research gaps between university and industry.

– *Lack of interest and commitment*—to collaboration between non-profit institutions aiming to create knowledge and educate and profit organisations that produce products and service for commercial purposes.

- *Confidentiality* versus *publishing*—the university tend more towards basic research for knowledge and publication purposes, while the industry is not interested to share publicly operational details of their projects.
- *Intellectual property rights*—and the question about ownership get intense when the join project is successful, universities need it for educational and research aims, and industrial demanding it for commercialisation.
- *Lack of mutual trust*—industrial believe that scholars lack professional experience and skip understanding industry's needs, and universities are aware of this perception.
- *Acquisition* versus *exploitation*—universities develop new knowledge in an absolute the act of acquiring it by itself a benefit, but for the industrial knowledge has no value if it is not exploited and commercialised.
- *Lack of communication platforms*—lack of platforms where universities can communicate with firms and discuss potential partnerships.

Several papers from what we reviewed, discuss university-industry linkages in the model of national innovation system. As the linear model of innovation states, research in public institutions generates basic knowledge that leads to inventions, and when they are commercialised they become innovation. A very simplistic view that isolates universities from industry [1]. Actually, this is what is happening in the African context, while enterprises are struggling with their basic financial and managerial needs, the discussion about innovation and knowledge is exclusively academic. Innovation is an advanced outcome that requires strong foundations and a dynamic knowledge environment, which is not the case in Africa. Countries in the continent need to start building relationships on a basic way, and move gradually to more established forms of collaboration.

6 Conclusion

In the present paper, we explored literature and secondary data in order to build an understanding about university-industry linkages in Africa. Our list of literature about Africa is not exhaustive since we might have missed some of the papers which is a limitation of our study. Results showed how much the distance between the two parties is great and data confirms what literature shows concerning the lack in the continent. However, the lack might have other explanations under the informal relationship view. Inter-organisation relationships between universities and industry in Africa are weak, predominantly informal that take form in interpersonal relationships [38, 25]. Informal forms of linkages should be more investigated in the continent, collaboration between universities and firms might exist more than we actually aware of, but it is informally established.

Knowledge and academic research have grown in importance due to economic evolution into a knowledge-based paradigm and innovation is too important to be left for initiatives, and all stakeholders should be responsible for the development of knowledge environment. While the world benefits from globalisation opportunities, Africa is incurring its negative effects. Countries in the continent cannot keep relying on sectors of services and mining, strengthening economy can only be achieved by investing in knowledge and dynamic system of innovation of its production. University-industry linkages are to be strengthened to promote national development in African context, reorient the higher education system, and sensitise all stakeholders about the importance of collaboration to face knowledge environment issues and create innovation system.

University research streams should be identified in collaboration with industry, and government should be an active participant to provide platforms for linking the two sides. In effect, the triple helix model seems to be the greatest solution even if it may not be applicable in poor countries where universities are too 'academic', industries too 'weak' and government too 'rigid' to play their respective roles in the model [19]. African countries have no choice but to change their paradigm in terms of institutional leadership and economic vision, in order not to only remove barriers to accelerate university–industry collaboration, but to foster drivers too.

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