The Journal of Technology Transfer (2019) 44:1367–1395
https://doi.org/10.1007/s10961-019-09737-w

University technology transfer efficiency in a factor driven economy: the need for a coherent policy in Egypt

David A. Kirby[1] · **Hala H. El Hadidi**[2]

Published online: 29 May 2019

Abstract
The article examines the effectiveness of instruments to promote technology transfer and foster entrepreneurial innovation in Egypt where there are individual measures but no comprehensive, unified policy or strategy to promote the transfer and commercialisation of the intellectual property stemming from university research. The study examines the extent of technology transfer in the country and the effectiveness of the various existing measures through a four-phase investigation involving in-depth interviews with experts, a questionnaire survey of 400 Egyptian Science, Engineering and Technology academics, three case studies of Technology Transfer Offices and a 237 respondent industry survey. The results indicate that despite the measures that have been introduced, there is little university–industry collaboration and that the interventions are of limited effectiveness. The article concludes that there is a need for a broad, national co-ordinating policy that encourages universities and industry to collaborate, particularly on research, and to engage in the transference and commercialisation of technology.

Keywords Technology transfer · Efficiency · Factor-driven economy · Egypt · National policy

JEL Classifications D04 · D02 · E61 · I23 · I25 · I28 · L32 · L53 · L88 · O25 · O38

✉ David A. Kirby
Kirbydavid1@gmail.com

[1] The British University in Egypt, El Sherouk City, Misr-Ismalia Road, Cairo, Egypt

[2] Department of Business Administration, The British University in Egypt, El Sherouk City, Misr-Ismalia Road, Cairo, Egypt

1 Introduction

Universities are playing an increasingly important role in the modern knowledge economy that characterizes the twenty-first century, and access to new technology, derived from the research activities of the academic staff, are seen as having the potential to be the catalyst for local and regional economic and social development (Bercovitz and Feldmann 2006). Since the introduction of the Bayh-Dole Act in the USA in 1980,[1] which allowed universities to own the patents that arise from federal funded research, the country has witnessed a very considerable increase in the level of university–industry Technology Transfer (Jensen and Thursby 2001). With the success of Silicon Valley[2] and Route 128[3] in the USA and their respective links with Stanford University and the Massachusetts Institute of Technology (MIT), universities are being required, increasingly, to help promote economic development through the transfer of technology and its commercialization through the formation of innovation-led entrepreneurial spin-outs/new ventures. As Gonzalez-Pernia et al. (2013, p. 6) have observed "encouraged by the rise of scientific breakthroughs and technological innovations universities around the world have become increasingly involved in the transfer of knowledge to the marketplace, thereby enhancing economic growth and regional development". What frequently is not acknowledged, however, is the time taken for such developments to occur. While authors such as Siegel et al. (2003a) point to the annual number of patents granted in the US increasing from around 300 in 1980 (the year the Bayh-Dole Act was introduced) to 2000 in 1996, it should be recognized, for example, that the origins of Silicon Valley were in the early twentieth century (Sturgeon 2000) while the successful North Carolina Research Triangle park took 50 years to produce tangible economic benefits (Link 2002). In an attempt to expedite the process, reduce public expenditure and meet public budget constraints, many Governments have introduced "measures necessary to encourage and facilitate knowledge transfer from university to industry and other institutions" (Muscio et al. 2014, p. 1048). As a consequence, there has emerged what Etzkowitz has termed the Triple Helix of university–industry–government interactions (Etzkowitz 2003, 2008, 2014; Ranga and Etzkowitz 2013).

In the factor-driven economies, which compete on basic factor conditions such as low-cost labour and unprocessed natural resources, the process of technology transfer[4] is not as developed as it is in either the efficiency—or innovation—driven economies. This does not mean that it does not exist in such economies or is not needed. Indeed, the Egyptian

[1] The Bayh-Dole (Patents and Trademarks Law Amendment) Act was introduced in the USA in 1980. It permits a university to own an invention developed with public funding.

[2] Silicon Valley, located in the San Franciso Bay area, is the leading region in the USA for high technology innovation. It is strongly associated with Stanford University and other Higher Education institutions in the area.

[3] Route 128 is the Boston (Massachusetts) equivalent of Silicon Valley. It is driven by the technological innovations developed by MIT, Harvard and Boston Universities.

[4] Technology transfer might be defined as the movement of new, novel technology from the originator (in this case the university researcher) to the user. Normally it takes two different forms

- Technology commercialization (patenting, licensing, spin-off ventures, incubators, etc.)
- Academic engagement (research collaboration, contract research, consulting, etc.) between the academics and industry.

The intention is that it should lead to innovation, a definition of which might be the change or/and improvement in performance resulting from the application of new, novel products or processes stemming from research and invention. For the purpose of this research the focus is on the transfer of the scientific research conducted in Egypt's universities and its role in the innovation process.

Government has recognized the need for innovation and is attempting to encourage its universities to modernize and become involved in the technology transfer process, often with the aid of external funding sources (Science Technology and Development Fund 2012). As this research will demonstrate, however, the policy measures that have been introduced have not been especially effective and the purpose of this investigation is not just to examine the efficiency and effectiveness of the policies adopted by the Egyptian Government, but to understand the factors that are impeding the university–industry technology transfer process in the country and make recommendations for how more effective policy may be introduced. The article first explores the Egyptian context before reviewing the research literature on the effectiveness of technology transfer. It then introduces a four phase programme of research, based on the literature, designed to identify the issues and limitations of the policy measures that have been introduced in Egypt The results of each research phase are presented and the implications of the findings are considered, particularly for policy.

2 The Egyptian context

Within the Arab World,[5] university–industry links and knowledge transfer activities between research institutions and the production system are only weakly developed. According to the Director General of the Association of Arab Universities (Abu-Orabi 2016) this is because only a minority of the academic staff (22%) are scientists and the scientific research that is undertaken is "weak and modest", with the result that there is "low awareness of the importance and impact of good scientific research". Traditionally Egypt has been the leading nation, within the region, in terms of the number of scientific articles published, but none of its 43 public and private sector universities (with over 2 million students) is ranked highly in the leading global university league tables. Likewise, with the possible exception of the American University in Cairo,[6] none has strongly developed industry links or a tradition of either technology transfer or technology commercialisation. This is despite the various national mechanisms that have been introduced to support, directly, university–industry collaboration and technology transfer. According to the 2012 report of the Science, Technology and Development Fund (STDF), there are six entities concerned with facilitating university technology transfer from/to established firms,[7] while the Egyptian Academy of Scientific Research and Technology, for provides grants to fund TICOs [Technology Innovation Commercialisation Offices] in all Egyptian Universities,[8] and the Science, Technology and STDF supports university–industry research. However,

[5] The Arab World includes 22 countries, 10 in Africa and 12 in Asia. It is sometimes referred to as the Middle East and North Africa (MENA) region.

[6] The American University in Cairo was founded in 1919. It is an international university offering 37 undergraduate degrees, 44 masters degrees and 2 doctoral degrees. It has some 6453 students and 453 full-time staff. In the 2018 QS World University Ranking it was ranked 420th globally and 1st in Egypt.

[7] These include the Academy of Scientific Research and Technology (Invention and Innovation Development Agency), Ministry of Industry and Foreign Trade Technology and Innovation Centres, National Research Centre Business and Investors Service Office, Technology Innovation and Entrepreneurship Centre, Technology Transfer Offices at Alexandria University, American University in Cairo, Assuit University, Cairo University and Helwan University and a virtual Incubator for Science Based Business.

[8] As of 2018, 43 TICOS had been established by ASRT since 2013/14 at a cost of 30.1 million Egyptian pounds. ($1.74 m).

there is no coherent, co-ordinated strategy and despite these initiatives and mechanisms, Industry/Academia Collaboration activity is "missing to a great extent in Egypt" (STDF 2012, p. 13). The report explained this in terms of:

- The lack of collaboration between the different initiatives.
- The shortage of Technology Transfer Offices.
- The lack of support from senior university management.
- The lack of commercial and professional awareness.
- The lack of support for inventions that solve national problems.
- The lack of any formal course on technology transfer and commercialization.

However, the 2010 Global Competitiveness Report ascribed the country's declining economic competitiveness to the decline in its capacity for innovation resulting from the weakness of the education system in general and Higher Education in particular.

The Higher Education system in Egypt is highly centralised, and "regulated" by the Ministry of Higher Education and the Egyptian Supreme Council for Universities. As a consequence, the institutions have little autonomy or independence, little interaction with "the market" and little involvement in the innovation process (El Hadidi and Kirby 2015a, b, 2016, 2017). Accordingly, only one university, the non-state foreign university, might be regarded as being entrepreneurial (Kirby and Ibrahim 2016), while the provision of entrepreneurship education is only weakly developed and the country was ranked last of all Global Entrepreneurship Monitor countries for entrepreneurial education in 2017/18 (Ismail et al. 2018).

In recent years, however, Higher Education has become recognized as a top priority and despite public spending on it having declined (Reda 2012), the Government has acknowledged the need to reform its provision. In November 2015, as part of this process, an intergovernmental MOU on research, innovation and education was signed with the UK, followed, in January 2018, by a UK-Egypt bilateral MOU on the establishment of international branch campuses that would deliver academic "programmes, research and innovation which contribute to Egypt's national priorities". Subsequently, on 2nd August, Law No. 162 of 2018 was passed permitting the establishment and organisation of international university branch campuses in the country. In February 2019, the Egyptian Minister of Higher Education and Scientific Research announced that the intention is to open eight international universities from Canada, France, Hungary, Sweden, UK and US by 2020.

Thus it would appear that although Egypt has policies and mechanisms to promote technology transfer and foster entrepreneurial innovation, to date they have been largely ineffective, as appears to be the case in much of the Arab world. The Egyptian Government appears to have recognised this and to have acknowledged the need to modernise it universities and engage them more directly in the technology transfer process.

3 Aims and methodology

As acknowledged by Perkmann et al. (2013) the involvement of universities in technology transfer has often been at the initiative of policy makers though, as Hewitt-Dundas (2012) discovered in the UK, its effectiveness is often variable, especially when applied uniformly. Apart from the fact that universities often have different technology transfer strategies requiring different support structures and incentive mechanisms (Phan and Siegal 2006;

Perkmann et al. 2013), it is contended here that the Egyptian policies are addressing the symptoms rather than the cause of the problem—the trappings rather than the substance (De Lourdes Machado et al. 2004).

While the research literature on university–industry technology transfer is focused predominantly on the advanced innovation-driven economies of North America and Europe, it is both voluminous and multi-disciplinary (Bozeman 2000) as evidenced by the publications of both Link (2015) and Perkmann et al. (2013) amongst others. As the literature shows it can be classified in various ways but for the purposes of this study two perspectives are significant—those of academia and industry. Though most studies have focused on the university response to knowledge transfer, the response of industry to the process is equally important. "Unfortunately, there are few studies that consider the firm, rather than the university, as the focal actor" as Bercovitz and Feldmann (2006, pp. 180–181) have recognised.

The research on the former demonstrates the broad range of factors involved. For example, Galan-Muros et al. (2017) show that while university structures/offices are important, as the Egyptian policy has recognised, of more significance are funding and incentives, communication of the mission and, in particular, senior management support. Indeed, the earlier research of Friedman and Silberman (2003) specifically concludes that it is not the presence of a technology transfer office that is important but the experience of its staff, the university's location in a region with a concentration of high technology firms, its mission in support of technology and the way it rewards its staff. Moreover, the research of Markmann et al. (2005a, b) and Phan and Siegal (2006) suggests that formal technology transfer mechanisms, such as Technology Transfer Offices, are more related to technology commercialization than the broader concept of university–industry collaboration.

Inter-organisational trust, prior experience of collaborative research and the breadth of the interaction are identified as further important factors by Bruneel et al. (2010), while D'Este and Patel (2007) conclude that previous experience with industrial collaborators affects positively the attitudes and behaviour of academics towards industry. Similarly Perkmann et al. (2013, p. 427) conclude that "the best and most successful scientists are also those who engage most with industrial partners", while the research of Chukumba and Jensen (2005) stresses the importance of research quality. It is not just the quality and volume of research being undertaken that is important, however, but the type, as Vinig and Lips (2015) recognise. Their research demonstrates that in Holland only the more applied technical and medical universities perform well on technology transfer, a conclusion that is similar to the earlier finding of Avanitis et al. (2008) who discovered that the scientific institutes in Switzerland, with a stronger orientation to applied research, are also stronger in terms of technology transfer. Meanwhile, the research of Bercovitz and Feldmann (2006) has stressed the importance of multi-disciplinary research and concludes that a system that adheres to rigid disciplinary boundaries is likely to inhibit university–industry interaction and restrict the opportunities for technology transfer. This is because "knowledge production increasingly is trans-disciplinary and depends on the ability of researchers to work with others across a broad spectrum of disciplines" (op cit. p. 184). For many academics this is a new experience as are the concepts of technology transfer and commercialization and, as Bruneel et al. (2010) demonstrate, it is not something for which they have been trained or with which they are necessarily comfortable (Boehm and Hogan 2014). Accordingly many academics are reluctant to engage in the process and resist so doing. To overcome such resistance universities have introduced policies on technology transfer and the rewarding of staff. This has led Siegel et al. (2004) to argue that reward systems for university technology transfer and staffing competences are critical, though there is no conclusive

evidence that a positive correlation exists between the level of the award and the efficiency of the transfer process. Importantly, however, such measures also signal the significance of the transfer activity and as Debackere and Veugelers (2005) have recognized, universities do need to develop a clear strategy that manages the transfer process and does not impact negatively on teaching and research. Again, though, there is no consensus on the impact of university policies and governance systems. (Muscio et al. 2014).

Research on the industry perspective shows (Herman 2013) that in countries where the commitment to R&D is low, there is little incentive for firms to collaborate with universities and that the firms that do pursue collaboration are often larger (Fontana et al. 2006) and possess innovation strategies. When university–industry collaboration does occur often there are clashes of culture (Siegel et al. 2003a) as the primary motive of firms is financial gain, whereas publication is of more importance for the university scientist. Accordingly "firms typically do not want researchers to publish their results and share information with colleagues and the general public" (Siegel et al. 2003b, p. 127). This creates tensions between the two, compounded further by the bureaucracy and inflexibility that often typifies universities and slows the transfer process. Additionally, the research shows that firms perceive universities to have unrealistic expectations and complain that "university scientists and administrators do not understand or appreciate industry goals/culture/constraints" (Siegel et al. 2003b, p. 120).

Accordingly, it is clear that there are numerous constraints on university–industry involvement in technology transfer and that to overcome them, policy has to be multifaceted. As the law of requisite variety (Ashby 1968) implies, only variety can absorb variety. This suggests that it is not possible to resolve the problem by addressing, as the Egyptian policy appears to have done just one facet. The solution must be equal to or greater than the number of factors involved. Thus policy to promote university–industry technology and encourage universities to participate has to address the broad range of factors involved.

Against this conceptual and contextual background, therefore, the objective of this research is to examine why university–industry technology transfer is only weakly developed in Egypt despite the various measures introduced to promote it. The aim is to recommend policy that will facilitate greater efficiency and effectiveness and may have relevance not just for Egypt but other factor-driven economies and Arab world countries.

To achieve this, the study addresses the proposition that to facilitate entrepreneurial innovation, through the transfer of technology between universities and industry, policy needs to be coherent and to address the fundamental problems that discourage such activity. Accordingly it adopts a four-phase investigative strategy whereby each phase contributes to greater understanding (Kirby 2007).

3.1 Phase 1

Phase 1 is a qualitative analysis of the views of a panel of 18 experts drawn from senior university administration and relevant Government Departments/Ministries. It is based on unstructured in-depth interviews to scope the subject and identify the key issues. A panel of 10 experts evaluated the content of the intended interview questions and agreed (70 to 100%) that it is consistent with the theoretical and operational definitions of the variables of interest. A test–retest procedure was used to estimate the reliability of the interview (with a 7 to 10 days gap), the results indicating reliability of 0.7 to 0.95.

Table 1 Descriptive statistics and reliability coefficients for study variables

Variable	Mean	SD	Cronbach's alpha
Technology commercialization	41.37	7.23	.739
Technology transfer	57.64	7.01	.830
The support needed	65.85	5.93	.853

Table 2 Comparison of average scores between public and private universities

Variable	Public (n = 240)		Private (n = 160)		T-value
	μ	σ	μ	σ	
Technology commercialization	41.76	4.66	40.77	9.91	1.34
Technology transfer	57.89	4.11	57.26	9.89	.878
The support needed	64.59	5.19	67.73	6.46	5.37***

***Difference is significant at $p < .001$

3.2 Phase 2

Phase 2 is a contextual investigation based on a self-administered questionnaire survey of 560 Science, Engineering Technology (SET) academics in 8 private and public Egyptian universities. The questionnaire ("Appendix 1") comprises 99 statements where the respondents were required to indicate the strength of their agreement/disagreement with each statement on a 5-point Likert-type scale where 5 means strongly agree. A score of 4 or 2 would mean that the respondents either agreed or disagreed with the statement, respectively. The statements on technology transfer and commercialization reveal that these sub-components have acceptable reliability. The content validity was estimated through the agreement of a panel of 10 experts on the items representing each component. Considerably large agreement coefficients among the experts were obtained, ranging from between 75 and 95% for all questionnaire items (Table 1).

The questionnaire was distributed in 3/20 state universities and 5/23 private universities. In total, these 8 universities engaged some 2890 Science, Engineering and Technology (SET) academics (2059 in the public sector and 831 in the private sector). The participants were selected randomly and in total 400 responded, representing a 13.8% response rate. However, only 240 responses (11.7% of the population) were from the state sector, compared with 160 (19.2%) from the private sector. The reasons for this are unclear but it means that the state universities are somewhat under-represented in the study, as they appear to be in the technology transfer and entrepreneurial innovation process, nationally. This might be a reflection of the importance that the state academics place on both the topic and the study, but it means that, statistically, the results for the state sector are not representative of it. The data were processed and analysed using SPSS and the differences in the responses between the public and private universities analysed using a *T* Test (Table 2).

3.3 Phase 3

Phase 3 is based on a set of semi-structured in-depth interviews ("Appendix 2") that form the basis for three different Technology Transfer Office case studies selected purposively from the Phase II survey to illustrate the issues involved. The intention is to provide concrete examples of the problems that have been encountered when efforts have been made to promote technology transfer and facilitate university–industry collaboration to foster innovation.

3.4 Phase 4

Phase 4 examines the issue from the perspective of industry. To do this a questionnaire survey of 300 Egyptian businesses located in different industrial zones in Greater Cairo was undertaken. A structured questionnaire ("Appendix 3") was used. It consisted of open and closed questions developed from the relevant theoretical and empirical literature. The validity of the instrument was reviewed by a panel of 5 economic experts and tested using a pilot (n = 30). The test–retest reliability method was used to assess the stability and reliability of the instrument over time and proved to be high (0.78–0.95). The questionnaire was written initially in English before being translated into Arabic. To ensure accuracy of the translation, it was independently back-translated into English.

Of the 300 firms contacted, 26 declined to participate and 37 failed to complete the questionnaire. Thus 237 usable responses were received yielding a 79% response rate. The results show that 5% could be classified as small or medium sized firms (fewer than 50 employees) and 95% as large (50 + employees). This compares with the results of the official 2012/13 Economic Census that shows that 99.7% of the 2.4 million establishments in the formal sector could be classified as SMEs and only 0.4% as large. Thus the sample is biased heavily towards the larger firm, though some 86.5% of the sample are Egyptian businesses with only 13.5% being multinational organisations. Ten industrial sectors are represented including Manufacturing and Production (30%), Retail and Distribution (16%) and Healthcare and Pharmaceuticals (12%) but there is only weak representation of the knowledge/technology-based sectors (Information Technology—4%; Telecommunication—6%), reflecting the structure of a factor-driven economy. However, some 35% of the sample claimed to be engaged in R&D.

4 Findings

4.1 Phase 1: the experts' survey

This phase of the research produced some important confirmatory findings. Not only did it confirm that the involvement of Egypt's universities in technology transfer and commercialisation was limited, but it lent support to the findings of researchers such as Chukumba and Jensen (2005) and Vinig and Lips. While the experts recognized that some universities are involved through joint programmes with international universities and with guest lecturers, they believed that the majority of Egypt's universities were not involved because their research was not sufficiently influential. The academic staff were regarded as undertaking research only for promotion purposes as the promotion laws require publication rather than application. Additionally, it was recognized that

> …The current universities law does not allow commercialization. State university staff are not allowed to become part or full partners in enterprises (spin-offs).

This would suggest that the STDF policy to create Technology Transfer Offices (TICOs) in the country's universities might not be the optimum strategy as such formal technology transfer mechanisms have been found to more related to technology commercialisation than the broader concept of university–industry collaboration (Markmann et al. 2005a, b; Phan and Siegal 2006).

In common with Bruneel et al. (2010) the experts also recognized the importance of inter-organisational trust and noted this was lacking between Egyptian academics and industry. As one respondent pointed out,

> The business word is considered to be a shameful word by most of the universities' staff members.

The various initiatives to promote technology transfer were acknowledged but the experts recognized the need for more coherence and formal management. In particular, they advocated both greater co-ordination between the concerned Government ministries and entities and a mechanism to link industry with the research community.

4.2 Phase 2: attitudes of science, engineering and technology academics

This phase of the study was designed to examine the awareness of Egyptian academics of the technology transfer process and their attitudes towards it. Tables 3 and 4 address the concepts of technology commercialisation and technology transfer. They show that the absence of university involvement in technology transfer or commercialization is not because of opposition amongst Egyptian academics, but rather an apparent lack of understanding or commitment. They reveal that in both the private and the public sectors the respondents neither agree nor disagree with any of the statements referring to either technology transfer or technology commercialization, suggesting that perhaps they are insufficiently well informed to hold an opinion. Certainly the modern concept of transferring the results of academic research to the market is relatively new to Egypt and is not a widely acknowledged university mission priority.

In Table 4 there was some acknowledgement of the conflict between the objectives of academia and industry recognised by Siegal et al. (2003a) but it was not strong, though according to one respondent

> The main goal of industry is profit, and I believe industry does not prefer to invest in a university research project that will take years to yield results.

From Table 5, it would that the respondents acknowledged that support and Government intervention is needed if Egypt's universities are to play a more central role in the technology transfer/commercialization process. 10 out of 14 of the proposals were supported, and according to one respondent

> The main reason universities are not engaged strongly in R&D is the lack of regulations that organise such relationships…

Thus the findings appear to endorse the point made by Rasmussen and Rice (2012, p. 3) that universities all over the world are engaging increasingly in technology transfer "promoted by

Table 3 Technology commercialisation

Statement	Public	Private	All
There are too few university start-up and spin-out companies based on innovative ideas coming from university research and laboratories	3.62	3.14	3.43
The mechanisms that allow universities to create links with companies are missing	3.63	3.60	3.62
Universities have to avoid moving towards a profit company	3.41	3.30	3.37
Universities do not understand the needs of the economy	3.20	3.49	3.32
Business is considered to be a shameful word by most academics	3.11	3.01	3.07
Universities have an important role to play in technology commercialization	3.42	3.79	3.57
The involvement of Egyptian universities in technology commercialization is limited	3.37	3.90	3.58
University research is not sufficiently innovative to commercialise	3.43	3.68	3.53
Universities have very few patents due to ignorance of the patents law and weak information about IP which leads to no encouragement for inventive ideas and no governmental regulations to govern technology commercialization	3.41	3.68	3.52
The current universities' law does not allow commercialization	3.31	3.18	3.26
State university staff are not allowed to become part or full partners in enterprises (spin-offs)	3.25	3.48	3.34
Egypt's universities are not involved in technology commercialization. It is the role of start-up firms and entrepreneurs. That's why collaboration with industry is important	3.35	3.58	3.44
Universities are not involved in technology commercialization because there is no expert database	3.36	3.40	3.38
No risk taking is allowed in universities	3.57	3.50	3.54
Industry benefits from university research	3.53	3.30	3.44

Table 4 Technology transfer

Statement	Public	Private	All
Universities have a role to play in technology transfer	3.78	3.49	3.67
Scientific publication is a way to transfer technological knowledge to industry	3.81	3.55	3.71
Seminars are a way to transfer technological knowledge to industry	3.88	3.65	3.79
Workshops are a way to transfer technological knowledge to industry	3.76	3.66	3.72
Technology spillovers from universities benefit industry	3.74	3.26	3.55
The transfer of technology from university to industry is affected by geographical distance	3.33	3.16	3.26
Revenue generation is the main goal of universities in technology transfer	3.6	3.26	3.47
The cost of technology transfer affects the innovation process	3.64	3.44	3.56
Some universities are involved in technology transfer through joint programmes with international universities and guest lecturers	3.59	3.56	3.58
There is a lack of trust between university and industry	3.39	3.31	3.36
Universities lack the organizing mechanisms for the proper management of formal relationships with industry	3.53	3.55	3.54
University and industry are on a different wave length	3.35	3.58	3.44
Currently, universities are not working effectively with industry	3.48	3.66	3.55
There is a mutual link between industry and university	3.45	3.51	3.48
Universities offer consultancy to industry to solve problems	3.44	3.33	3.40
Industry does not value the impact of scientific research from universities	3.43	3.24	3.35
Universities often work with industry because according to the law of scientific research, taxes are decreased for scientific research and there is the training of personnel	3.31	3.19	3.26
Sometimes there are centres inside universities dealing with industry but the link is weak	3.59	3.34	3.49
Universities are not oriented to the needs of industry	3.53	3.40	3.48

Table 5 The support needed in Egypt

Statement	Public	Private	All
More needs to be done if universities are to fulfil their potential in the innovation process	4.14	4.15	4.15
It needs to be clear why universities should be involved	4.03	4.28	4.13
The promotions laws need to recognize applied research and patent application	3.92	4.16	4.02
There is a need for training	4.06	4.36	4.18
Universities need to be permitted to be more autonomous	3.74	4.11	3.89
Egypt has weak policies to increase the capacity to innovate from the part of the university and research institutes	3.93	3.79	3.88
The funding for research and innovatory projects needs to be increased	4.06	4.43	4.21
Universities must be encouraged to solve problems relevant to the needs of the market through their research	3.95	4.51	4.18
The government needs to have a coherent policy towards increasing the capacity for innovation and university–industry research	4.07	3.85	3.98
Innovators must be supported and rewarded	4.30	4.50	4.38
Part or complete tax exemptions need to be introduced for innovatory projects in order to motivate industry to activate their R&D departments or/and link with universities	3.94	4.20	4.05
The bureaucratic rules that discourage the registration of IPR need to be reduced	3.90	4.01	3.95
Bureaucracy needs to be kept to a minimum	4.02	4.15	4.07
Universities need to be encouraged to work with business	4.00	4.44	4.18
Universities should be required to conduct leading edge research	4.03	4.50	4.22
Academics should be encouraged and supported to bring main findings to market	4.04	4.44	4.20
A “can do” culture needs to be fostered in universities to encourage staff to try new things	4.13	4.49	4.27
There needs to be a programme for capacity building	4.25	4.55	4.37

Government policies and initiatives". However, the state university respondents did not agree (3.74) that universities should be more autonomous. This not only contrasts with the views of those from the private sector (4.11) but it contradicts Naghizadeh et al. (2015) and others who contend that to optimise their entrepreneurial capability, universities need to move away from close government regulation and sector standardisation. In both sectors, though, the need to capacity build (4.37) and to reward those academics who innovate and collaborate with industry (4.38) was recognised. Indeed, it was suggested by one respondent that the "staff with industrial research achievements should be recognised and appointed to leadership positions".

4.3 Phase 3: case studies

4.3.1 Case 1: Cairo University[9] Innovation Support Office

Founded in 2009 by a Computer Science Professor with a Ph.D from Brunel University in the UK, the Cairo University Innovation Support and Patent Registration Facilitation Office (CUISO) is the outcome of two European Tempus projects[7]. It was intended as the first "port of call" for academic innovators in Cairo University who wish to commercialize their innovative ideas and for members of Egyptian industry who wish to collaborate with the University research staff and students. In 2010, a Technology Transfer Office was opened in the University, also with funding from the European Union Tempus programme[10] and with similar objectives (See case 3 below).

Since its foundation, the Centre has been responsible for 5 disclosures and 2 patents while it has also brought 3 projects to market and the Director believes that there is now, in the University, a better understanding of the value of problem-oriented research. From an industry perspective, there has developed greater awareness of the value of open innovation and the benefits of in-depth analysis of both the problem and the market. However, the Centre has faced challenges, mainly in the form of funding and space. Accordingly, the Director suggests that there needs to be more long-term strategic co-ordination and planning at the institution level in higher education. This should be coupled with a change in the mindset of senior managers, enabling them to recognize the importance of the role of universities in the innovation process. He also suggests, there needs to be a change in the Egyptian University law so that universities and academics can take ownership of university spinout companies based on the intellectual property stemming from their research.

4.3.2 Case 2: Technology Innovation and Commercialization Office (TICO) at Zagazig University[11]

Zagazig University opened its Technology Innovation and Commercialization Office (TICO) in July 2013, in response to a call for bids from the Academy of Scientific Research

[9] Cairo University is a state university founded in 1908. It has some 280,000 students and 12,158 staff in 17 Faculties plus Schools of Law and Medicine. QS ranked it 481–490 in the world in 2017 and second in Egypt, 11th in the Arab world.

[10] Tempus was, from 2007 to 2013, the European Union's programme supporting the modernization of higher education in the EU's surrounding area including the Mediterranean region.

[11] Zagazig University was established in 1974 as a state university. It has over 170,000 students and some 7000 academic staff in 17 Faculties and 2 Institutes. It is ranked by QS as 8th in Egypt and 43rd in the Arab World.

and Technology (ASRT). In total, 30 such offices were created around the country at that time and Zagazig University received a grant of 600,000 EGP to establish the office over a period of 2 years. Apart from paying for the facilities, which are housed on the University's main campus, the grant is used to employ a Director and 6 part-time staff, plus three administrators. A further 300,00 EGP was made available from the University.

Since its formation, the Office has created 26 innovative student ventures (13 innovations for school pupils' aged 13–18 years and 13 for university students) and 12 staff projects. The office has also raised campus awareness of the importance of innovation, so that academic colleagues, students and graduates now come to the TICO for help and promotion. Despite this, the TICO has faced numerous challenges, not least with respect to funding.

The TICO staff members suggest that if universities are to play a significant role in the economic development process, Government Policy is required to encourage the country's universities and industry to engage and cooperate more. Among their various suggestions are that the law on staff spinout companies needs to change, the Supreme Council should require entrepreneurship and innovation modules to be introduced into all degree programmes, the criteria for staff promotion needs to be changed to include research application not just publication and firms should be required to work with the country's universities.

4.3.3 Case 3: American University in Cairo (AUC) Technology Transfer Office

The Office is one of four TTOs established in Egypt in 2010 as part of an Enterprise—University Partnership (EUPART) project funded under the European Union Tempus programme. AUC was the lead partner in the project, which included Cairo, Assiut and Helwan universities in Egypt and four European universities plus the European Patent Office, the Egyptian Patent Office, the Science and Technology Development Fund and 6th of October City Investors Association.

The TTO concluded its first deal in 2013 with an MIT- educated Egyptian entrepreneur based on the research of an AUC Chemistry professor. The resultant new venture (D-Kimia), which develops novel and affordable diagnostic solutions to detect a broad range of diseases, was Egypt's first university spinout company. Since then, the TTO, which employs 4 staff including a Director, an administrator and two licensing officers, has filed 78 patents in 32 patent families. Its activities, now that the Tempus funding has ceased, have been funded by the University, though, in 2013, it was one of the 30 universities and research centres that successfully bid for TICO funding. Apart from funding, the lack of industry interest/support is seen as a challenge, as is the relatively low level of funded, cutting-edge research, together with the university, labour, commercial and intellectual property regulatory framework in Egypt.

Accordingly, its Director suggests that for Egyptian universities to participate more effectively in the innovation process several changes are required. First, there needs to be greater understanding on the part of industry of the need to collaborate with universities, second there needs to be a change in the law to better manage IP prosecution and permit universities to take equity in ventures resulting from their research, and third the relationship/contract between the university and the academic at public universities needs to be revised.

Table 6 Types of university–industry collaboration

Type[a]	%
Partnership on teaching and learning	60
Offering internship for university students	45
Partnership on graduate recruitment	27
Partnership on research	68
Partnership on knowledge/technology transfer	73
Partnership on knowledge/technology commercialisation (the commercial exploitation of intellectual property generated by academic research)	48

[a]Sums to more than 100% as more than one type of partnership may be chosen

Table 7 Perceived challenges of University–industry collaboration

Challenge	%
Mismatches in terms of relevance, time horizons and expectations	37
Lack of information about what universities can actually offer	23
Lack of quality of information provided by universities	14
Low level of engagement with universities as partners	11
Determining the upper hand on collaboration	8
Conflicting focus: research versus money	7

4.4 Phase 4: industry survey

The survey was intended to complement the academics' survey by establishing the attitudes and behavior of the Egyptian business community. The findings reveal that while only 6% of the sample (n = 14) had some sort of partnership with an Egyptian university one-third (n = 79) claimed to have knowledge of the concept of the Triple Helix University (Etzkowitz 2003). Of these 79, however, only 36% (n = 28) identified correctly that it was a university that works in partnership with industry and government, indicating a clear lack of real understanding of the concept among the business community.

Of the 14 businesses that have links with a university, just under half claimed to partner with universities on technology transfer—to bring to market the intellectual property generated from university research. In contrast almost three quarters of the partnerships involved consultancy and training while some 68% partnered on research and 60% on teaching and learning (Table 6). Just over one-quarter collaborated with a university in order to recruit graduate students and some 45% offered student internships.

Such partnerships were perceived to create benefits for the industrial partners of which the most important were a reduction in costs (35%) and access to new research and knowledge (25%). Other benefits were seen to be a reduction in risk (17%) and access to graduates (12%) with access to new research skills being cited by only 9% of the sample. However, the partnerships were not without their challenges (Table 7). Chief among them were the mismatch between the universities and industry in terms of relevance, time horizons and expectations which was cited by 37% of the respondents. When coupled with focus

Table 8 Suggestions for facilitating more university–industry collaboration

Suggestions	%
Industry–university partnerships should become a strategic priority	19
Create a joint steering group including senior academics and company executives	18
Make industry–university partnerships a priority for the entire academic community	17
Make the goals and benefits of partnering clear for both parties	13
Incentivise university faculty to develop such partnerships	11
Assess the core academic strengths of the university and the core research competence of the company to identify promising opportunities for collaboration	9
University programmes need to be strongly orientated toward helping solve the scientific and technological challenges that companies encounter	8
Resolve the problems of intellectual properties	5

conflicts (7%), these accounted for almost half of the sample (44%), supporting the findings of Siegal et al. (2003a) with respect to the impact of culture clashes. The second most frequently cited challenge related to the industrial partner's knowledge of the university and what it can offer. Some 23% of the respondents complained about a lack of information of what the contribution that universities could make while a further 14% expressed concerns about the quality of the information provided. Other problems were perceived to arise from

- The low level of engagement with university partners (11%), resulting, presumably, from partnership with industry not being perceived as an institutional priority and
- How the agenda was decided and by whom—who was the "dominant" partner in the relationship (8%).

When asked why they did not partner with universities in Egypt, over one-third (35%) of the 213 respondents claimed it was because they were too theoretical, confirming the importance of the type of research being conducted (Avanitis et al. 2008; Vinig and Lips 2015). The conflict that occurs between academia and industry resulting from universities wishing to publish their findings while industry wants to keep them confidential (Siegal et al. 2003b) was recognised by some 22% and a further 13% pointed to the different objectives of academia and industry—to the fact that universities wish to create knowledge whereas industry wishes to create competitive advantage. When taken together, this would suggest that over one-third of the sample (35%) do not collaborate with higher education because of the conflicting interests and objectives. However some 15% percent also claim that universities are too expensive, a point also raised in the USA by industrialists (Silverman 2007) in the USA. The issue of research quality and type was raised again by 7% of the sample who suggested that the research undertaken in Egypt's universities is not leading edge or "disruptive".

In order to encourage university–industry partnerships, the industrialists put forward a range of suggestions (Table 8). These included university—industry collaboration becoming a national strategic priority (19%) and a core/priority activity for universities (17%). To facilitate collaboration joint steering groups were proposed by 18% of the sample and a further 13% suggested that the goals and benefits of partnering need to be made clear for both parties. At the same time it was recognized by 11% of the sample that the current reward

system in universities does not encourage partnerships with industry and it was proposed that if the academic staff of the universities are to develop and engage in such partnerships, they will need to be incentivized and rewarded as recognised in the research of Friedman and Silberman (2003). Linked to this is the issue relating to intellectual property ownership and the concern of the academic to publish the results of his/her research. This was recognized by a further 5% of the sample as an issue that needs to be resolved, presumably as part of the academic staff incentivization and reward process. Finally the industrialists recognized that the role of universities needs to change so that they become more strongly oriented to helping solve the scientific and technological challenges companies encounter (8%) and match their strengths with the core research competence of the company in order to identify promising opportunities for collaboration (9%).

5 Discussion

The results from the four phases of the research demonstrate the level of involvement of Egypt's universities in the technology transfer or commercialization process and provide insight into the effectiveness of the measures being taken to foster entrepreneurial innovations. They confirm the limited effectiveness of the measures and support the proposition that to promote technology transfer between universities and industry in order to facilitate entrepreneurial innovation, policy needs to be both comprehensive and coherent and to address the fundamental problems that discourage such activity

They show that although university TICOs have been established, the resultant programme of activity remains somewhat piecemeal and un-coordinated, frequently being the result of individuals and institutions taking advantage of external funding programmes that are in some cases external to the country. While such programmes are intended to bring about change, and modernisation, their effectiveness is often relatively limited. First they are usually short- or fixed- term and tend not to be sustainable, lasting only for the duration of the project. Second, they tend to be "bolt on" and not regarded as a core activity of the institution. Accordingly, there is often no sense of corporate ownership and they are not, therefore, something in which all of the academics engage. Third, on occasions, they actually conflict or compete with, rather than reinforce or complement, other, similar initiatives within the institution. This is not unique to Egypt and in part results from the initiatives not being integrated into the institution's core strategic planning framework. As a consequence, there is often little coherence and institutional change is thereby limited. Accordingly, the institutions continue to focus on the two traditional activities of teaching and learning and research.

The findings also suggest that these initiatives have had some success in raising internal awareness, amongst both university staff and students, but also reinforce the further need to raise awareness and understanding both within universities and the external business community. Neither community fully acknowledges the role the modern university can play in innovation, appearing unaware of, in particular, the benefits that can be derived from research collaboration. Hence, there remains only limited collaboration between the two.

Finally, all four phases of the study demonstrate the constraints imposed by the laws and regulations governing Egypt's universities, in particular the criteria for the promotion of university academics and the constraints on entrepreneurial spin-out activity resulting from academics and their employer universities not being permitted to secure equity in

the ventures created to exploit, commercially, the outcomes of their research. As a consequence, the modern third mission of universities, embracing both technology transfer and entrepreneurial innovations, remains underdeveloped.

6 Implications

The study findings have considerable implications for the promotion of technology transfer in Egypt as well as the factor-driven economies in general and the Arab World in particular. They suggest that in Egypt a comprehensive, coherent national strategy is required that promotes university–industry technology transfer and coordinates the various support measures. Clearly, it is important not to over-estimate the role of Government and their expectations of what is achievable (Henry 2013) but as might be expected from the Triple Helix model, and has been witnessed elsewhere (Kirby 2006; Mock 2005), the role of Government is important. The need is for a strategy where all of the stakeholders (universities–industry–government) have a clear role and mandate to achieve a common goal, and the universities will need a clear set of policies to help them achieve this goal. Long-term, however, they will need to be freed from both external and internal bureaucracy, allowing them to be more innovative and flexible than appears to be the case at present. At the same time, their funding base will need to be diversified and they should be encouraged to interact with their external environments through both the transfer and commercialization of technology. Importantly, they need to move away from close government regulation and sector standardisation and search for their own special organisational identities, by risking being different and taking chances "in the market". Indeed, they will need to be encouraged to believe "that the risks of experimental change…should be chosen over the risks of simply maintaining traditional forms and practices" (Clark 1998, p. xiv).

While permitting its universities to be more autonomous and responsive to their markets, the Egyptian Government needs, however, to require them to incorporate the "third mission" into their core activities, making it a strategic objective. At the same time the senior management needs to be committed to the concept (Galan-Muros et al. 2017) and to building capacity, in part to raise awareness of the need for the university to engage in this core activity. Simultaneously, the promotion criteria for the country's academics need to be addressed and the value of research exploitation, not just publication, needs to be recognized. Equally, the law regulating the ownership of university spinout ventures, based on the intellectual property stemming from university research, needs to be amended to permit both the individual researchers and their employers to take equity in the resultant new ventures.

Industry also needs to be encouraged/incentivised to enter into collaboration with the country's universities. As in Norway (Rasmussen and Rice 2012) for example, this might include fiscal incentives though this implies there is no benefit to industry from collaboration. At the same time, the Government might consider creating a permanent national academic-industry-government forum in which members can explore areas of mutual interest and benefit, together with opportunities for collaboration.[12] Finally, the Government may wish to continue to avail itself, and its universities, of the support being made available

[12] The US Business-Higher Education Forum (http://bhef.com) is an example of such an initiative as is AURIL (Association for University Research and Industry Links) in the UK (auril.org.uk).

from external sources such as the European Union[13] and the UK Newton—Mosharafa fund.[14] However, when so doing, it needs to ensure that these projects fit into coherent institutional frameworks intended to bring about the changes that promote and enable sustainable university–industry collaboration and participation, leading to increased technology transfer and commercialization, innovation and economic and social competitiveness.

7 Conclusion

Recent years have witnessed the increasing importance of technology transfer and commercialization and the role of universities in economic development through the entrepreneurial exploitation of their research. With this development there has emerged a significant and growing body of literature on the impact of these activities and the various measures introduced to support and sustain them. Most of this research has been conducted in the developed, innovation—led economies but relatively little remains known about the effectiveness of these processes, not least as the research evidence is at times contradictory.

The aim of this article, therefore, has been to examine university–industry technology transfer in a factor-driven economy, Egypt, in an attempt to identify the factors affecting its development in order to formulate effective policy to promote its development. What is known from the extant body of understanding is "that those HEIs successfully engaged with industry put in place a series of mechanisms simultaneously at strategic and operational levels" (Galan-Muros et al. 2017) and change or adapt their organizational structure and culture and mission in order for their institutions to become more entrepreneurial. At the same time they have developed facilities, such as Technology Transfer offices, Incubators and Science Parks to facilitate the transfer and commercialization of the technology stemming from their research. These are all required in Egypt[15] though it must be recognized that it is not the structures/buildings that are important but the people employed in them, and their experience and skills, coupled with the integration of the facilities into the core activities of the institution. What is known, also, is that university–industry collaboration and the transfer and commercialization of technology from universities is more prevalent in the innovation-driven economies where firms engage in and value the significance of R&D. In the factor driven economies, such as Egypt, there appears to be a lack of awareness on the part of industry of the benefits to be derived from collaboration. Numerous factors contribute to this situation, including the nature, quality and amount of research

[13] The EU is working to develop closer scientific ties between Egypt and the European Research Area particularly through increased Egyptian participation in Horizon 2020, the on-going EU Framework Programme for Research and Technological Development. Horizon 2020 is the biggest EU Research and Innovation Programme ever with nearly 80 billion Euro of funding available between 2014 and 2020 intended for collaboration with third world partners such as Egypt. The programme is intended to ensure Europe produces world class science, remove the barriers to innovation and make it easier for the public and private sectors to work together to deliver results.

[14] The UK's Newton-Mosharafa Fund is a 20 million pound sterling fund over five years intended to bring together the British and Egyptian scientific research and innovation sectors to find solutions to the challenges facing Egypt in economic development and social welfare. It is part of the UK's 375 million pound sterling Newton Fund to support science and innovation partnerships between the UK and emerging powers.

[15] In December 2018, the first Egyptian university-linked science park was opened at The British University in Egypt. It is a 14,000 m^2 Science and Innovation Park operated in co-operation with China's Tus-Holdings Co Ltd, the arm of Tsinghua University with responsibility for the University's Science Park (Tus-Park).

being conducted in the country's universities, the mistrust between industry and academia and the lack of resources, both human and physical. Accordingly, though support is already available, there is a need for Government intervention. This is needed to emphasise the importance of the technology transfer/commercialization process to both academia and industry in order to facilitate its efficient development, as has occurred in Saudi Arabia (Alshumaimri et al. 2010)

While there are clearly limitations to this study, relating not just to the size and composition of the samples, but the fact that it has been conducted in one factor-driven economy, the research does corroborate the findings of previous investigations. Also, it demonstrates some very specific differences compared with the technologically more advanced innovation-driven economies, where technological research and development are more highly developed. Further research is needed, in particular to monitor developments in Egypt, The Egyptian Government's efforts to modernise the country's system of Higher Education by permitting universities from the innovation-led economies to open branch campuses is particularly interesting. It provides an opportunity to monitor the impact of these universities on the technology transfer process in the country and the way universities and industry interact and collaborate. However, it is not just in Egypt that further research is required but in other Arab World countries and similar factor-driven economies where the role of Higher Education in the transition process is not recognized so clearly. In particular, there is a need for research similar to this to better understand the impediments to university–industry collaboration and university involvement in technology transfer and entrepreneurial innovation, with the objective of using the results of such research both to aid policy formulation and monitor and help facilitate its implementation. Especially, though not exclusively in Egypt and the factor-driven economies, there is a need for further research into the efficient transfer of technology between universities and the small- and medium-sized indigenous enterprises that contribute so significantly to economic and social development, but which have been relatively neglected in the research literature.

Funding The research was part-funded under the 2013 Emerald/EFMD MENA Management Research Fund Award.

Appendix 1: Survey of SET academics

The British University in Egypt.
Research on university–industry collaboration and knowledge transfer

In the modern knowledge economy that characterises the twenty-first century, university–industry collaboration is of increasing importance. Accordingly, we are undertaking research into such collaboration in Egypt and would be extremely grateful if you could complete this short questionnaire. It should take you no more than 20 min. Naturally your answers will be treated in strictest confidence and analysed anonymously on an aggregate basis.

The quality and accuracy of all such research depends on your contribution so I urge you to participate fully, as we want the research to be of benefit both to you and Egypt.

Thank you for your co-operation.

On a scale of 1–5, where 1 means you strongly disagree and 5 means you strongly agree, please rate each of these below statements in the blank column provided. A score of 3 would mean

Statement	Ratings (1–5)
Innovation	
More needs to be done if universities are to fulfill their potential in the innovation process	
It needs to be clear why universities should be involved	
The promotions laws need to recognize applied research and patent application	
There is a need for training	
Universities need to be permitted to be more autonomous	
Egypt has weak policies to increase the capacity to innovate from the part of the university and research institutes	
The funding for research and innovatory projects needs to be increased	
Universities must be encouraged to solve problems relevant to the needs of the market through their research	
The government needs to have a coherent policy towards increasing the capacity for innovation and university–industry research	
Innovators must be supported and rewarded	
Part or complete tax exemptions need to be introduced for innovatory projects in order to motivate industry to activate their R&D departments or/and link with universities	
The bureaucratic rules that discourage the registration of IPR need to be reduced	
Bureaucracy needs to be kept to a minimum	
Universities need to be encouraged to work with business	
Universities should be required to conduct leading edge research	
Academics should be encouraged and supported to bring main findings to market	
A “can do” culture needs to be fostered in universities to encourage staff to try new things	
There needs to be a programme for capacity building	
Teaching	
Universities teach innovation and entrepreneurship as part of the curriculum	
Universities equip students with: knowledge to innovate/skill to innovate	
Universities are not producing creative graduates who can innovate	
The curriculum depends: on rote memorization/dated teaching methods	
Universities have too many students	
There is the ability to increase the pool of innovative students	
Teaching in universities needs to be geared more towards industry needs in terms of problems faced and new developments	
Universities can and do produce creative graduates who can innovate but not in all specialties and on a very small scale as this is only a recent development	
Universities produce graduates that are not fit for the labour market	
R&D	
Universities have R&D activities	
University R&D impacts strongly on innovation	
There is collaboration in research between universities and industry	
There are cost pressures in universities that impede R&D	
Universities constitute an important input to industry R&D	
University budgets allow for R&D	

Statement
Ratings (1–5)
Research in the university needs to be geared more towards industry needs in terms of problems faced and new developments
Universities have strong research environments
Technology commercialisation
There are too few university start-up and spin-out companies based on innovative ideas coming from university research and laboratories
The mechanisms that allow universities to create links with companies are missing
Universities have to avoid moving towards a profit company
Universities do not understand the needs of the economy
Business is considered to be a shameful word by most academics
Universities have an important role to play in technology commercialisation
The involvement of Egyptian universities in technology commercialisation is limited
University research is not sufficiently innovative to commercialise
Universities have very few patents due to ignorance of the patents law and weak information about IP which leads to no encouragement for inventive ideas and no governmental regulations to govern technology commercialisation
The current universities' law does not allow commercialisation
State university staff are not allowed to become part or full partners in enterprises (spin-offs)
Egypt's universities are not involved in technology commercialisation. It is the role of start-up firms and entrepreneurs. That's why collaboration with industry is important
Universities are not involved in technology commercialisation because there is no expert database
No risk taking is allowed in universities
Industry benefits from university research
Technology transfer
Universities have a role to play in technology transfer
Scientific publication is a way to transfer technological knowledge to industry
Seminars are a way to transfer technological knowledge to industry
Workshops are a way to transfer technological knowledge to industry
Technology spillovers from universities benefit industry
The transfer of technology from university to industry is affected by geographical distance
Revenue generation is the main goal of universities in technology transfer
The cost of technology transfer affects the innovation process
Some universities are involved in technology transfer through joint programmes with international universities and guest lecturers
There is a lack of trust between university and industry
Universities lack the organizing mechanisms for the proper management of formal relationships with industry
University and industry are on a different wave length
Currently, universities are not working effectively with industry
There is a mutual link between industry and university
Universities offer consultancy to industry to solve problems
Industry does not value the impact of scientific research from universities
Universities often work with industry because according to the law of scientific research, taxes are decreased for scientific research and there is the training of personnel
Sometimes there are centres inside universities dealing with industry but the link is weak
Universities are not oriented to the needs of industry

Statement
Ratings (1–5)
The ecosystem
The infrastructure of universities encourages innovation
There are too few incentives to universities to encourage innovation
There are people in universities who can help raise funding for innovation
Universities compete in terms of innovation
Universities are part of an ecosystem that encourages innovation
Universities should concentrate on "market pull" not "technology-push"
Co-operation between universities and industry promotes innovation
Size affects the capacity of universities to innovate
The location of a university helps promote innovation
The government has a policy towards increasing the capacity for innovation and university–industry research
There are mechanisms that have been in place for several years which support university–industry collaboration
There needs to be a national policy that encourages universities to get involved with the "third" mission
Support needed
More needs to be done if universities are to fulfil their potential in the innovation process
It needs to be clear why universities should be involved
The promotions laws need to recognize applied research and patent application
There is a need for training
Universities need to be permitted to be more autonomous
Egypt has weak policies to increase the capacity to innovate from the part of the university and research institutes
The funding for research and innovatory projects needs to be increased
Universities must be encouraged to solve problems relevant to the needs of the market through their research
The government needs to have a coherent policy towards increasing the capacity for innovation and university–industry research
Innovators must be supported and rewarded
Part or complete tax exemptions need to be introduced for innovatory projects in order to motivate industry to activate their R&D departments or/and link with universities
The bureaucratic rules that discourage the registration of IPR need to be reduced
Bureaucracy needs to be kept to a minimum
Universities need to be encouraged to work with business
Universities should be required to conduct leading edge research
Academics should be encouraged and supported to bring main findings to market
A "can do" culture needs to be fostered in universities to encourage staff to try new things
There needs to be a programme for capacity building

Appendix 2: Case study interview schedule

In the modern knowledge economy that characterises the twenty-first century, knowledge transfer and university–industry collaboration is of increasing importance. Accordingly, we are undertaking research into such collaboration in Egypt and I am extremely grateful to you for agreeing to this interview. I want to use it as the basis for a case study of the xyz TICO. Clearly, I will not publish anything without first consulting you on the accuracy of the case and without your prior approval.

We want the research to be of benefit to both you and Egypt so thank you once again for your co-operation.

When was the office created?
Why was the office created?
Whose idea was it?
How was/is it funded?
Initially?
Now?
How many staff does the office have?
What does it do exactly?
What has it achieved?
What challenges does it face?
What support does it receive and from where?
What support is needed?
What are the plans for the future?
How can we collaborate?

Appendix 3: Industry Questionnaire

The British University in Egypt.
Research on university–industry collaboration

In the modern knowledge economy that characterises the twenty-first century, university–industry collaboration and knowledge transfer are of increasing importance. Accordingly, we are undertaking research into such collaboration in Egypt and would be extremely grateful if you could complete this short questionnaire. It should take you no more than 10 min. Naturally your answers will be treated in strictest confidence and analysed anonymously on an aggregate basis.

The quality and accuracy of all such research depends on your contribution so I urge you to participate fully, as we want the research to be of benefit to you and Egypt.

Thank you for your co-operation.

Q1. What type of company are you?

- ☐ Egyptian
- ☐ British
- ☐ Part of a multinational organization
- ☐ Other(specify)……
  ……
  ……

Q2. How many people do you employ?

- ☐ 1-4
- ☐ 5-49
- ☐ 50-99
- ☐ 100+

Q3. In which sector do you operate?

- ☐ Construction
- ☐ Distribution and Retailing
- ☐ Energy
- ☐ Financial Services
- ☐ Healthcare and Pharmaceuticals
- ☐ Hospitality and Tourism
- ☐ Information Technology
- ☐ Manufacturing and Production
- ☐ Telecommunications
- ☐ Utilities
- ☐ Other
  (specify)……
  ……
  ……
  ……..

Q.4 Does your organization engage in Research and Development (R& D)

- ☐ Yes, here in Egypt
- ☐ Yes, elsewhere
- ☐ No, not at all

Q5. Do you partner with any Egyptian universities?

- ☐ Yes (Go to Q. 10)
- ☐ No (Go to Q.6)

If no,

Q 6. Why not?

- ☐ Universities are too theoretical
- ☐ University research is not leading edge
- ☐ there is a conflict of interest between academia and industry (universities wish to publish their findings industry wants to keep it confidential)
- ☐ universities and industry have different objectives (universities want to create knowledge, industry to create competitive advantage)
- ☐ universities and industry have different time horizons
- ☐ universities are too expensive

- other(specify)……
  ……
  ……
  ……
  ……

Q.7. What would be needed for you to partner with an Egyptian university?
(specify)……
……
……
……
……

Q.8. Have you ever partnered with an Egyptian university?

- Yes (Go to Q.9)
- No (go to Q21)

Q.9. Why did you stop? (specify)……
……
……
……
……

Q.10. Do you partner with any universities outside of Egypt?

- Yes (Go to Q. 11)
- No (Go to Q.21)

If yes to 10, Q.11. What are the benefits of partnering with a university?

- Risk reduction (reduced risk of failure)
- Cost reduction
- Access to new knowledge
- Access to research skills
- Access to graduate recruits
- Other
  (specify)……
  ……
  ……
  ……

Q.12. Do you partner on teaching and learning?

- Yes
- No

Q.13. Do you offer student internships?

- Yes
- No

Q.14. Do you partner on graduate recruitment?

- Yes
- No

Q.15 Do you partner on research?

- Yes
- No

Q.16. Do you partner on knowledge/technology transfer (consultancy and training)?

- ☐ Yes
- ☐ No

Q.17. Do you partner on knowledge/technology commercialisation (the commercial exploitation of intellectual property generated by academic research)?

- ☐ Yes
- ☐ No

Q.18.Do you partner on other activities
(specify)……
……
……
……
……

Q.19 Are there any difficulties in collaboration?

- ☐ Yes (Go to Q.20)
- ☐ No (Go to Q.21)

Q.20. If yes, what are
they?……
……
……
……

Q. 21. If you are part of a multinational organization, does your parent company collaborate with universities?

- ☐ Yes
- ☐ No

Q.22. Have you heard of the concept of the Triple Helix University?

- ☐ Yes (Go to Q.23)
- ☐ No (Go to Q.24)

Q.23. If yes, is it a university that

- ☐ Undertakes teaching, research and community service
- ☐ Works in partnership with industry and government
- ☐ Is part of an international consortium of universities.

Q.24. Are there any other comments you would like to make
(specify)……
……
……
……
Thank you for your assistance. Please return this to me by **Thursday 14th April,2016**

Please provide a contact address if you would

- ☐ like a copy of the findings
- ☐ like to participate in a university-industry workshop
- ☐ Be prepared to be interviewed in a little more detail

May I assure you we will treat your responses in strictest confidence. *Thank you once again*.

References

Abu-Orabi, S.T. (2016). Higher education and scientific research in the Arab World. Paper presented at the 15th IAU general conference, November 13–16. Bangkok: Chulalongkorn University.

Alshumaimri, A., Aldridge, T., & Audretsch, D. B. (2010). The university technology transfer revolution in Saudi Arabia. *The Journal of Technology Transfer, 35,* 585–596.

Ashby, W. R. (1968). Variety, constraunt, and the law of requisite variety. In W. Buckley (Ed.), *Modern systems research for the behavioral scientist*. Chicago IL: Aldine Publishing Co.

Avanitis, S., Kubli, U., & Woerter, M. (2008). University–industry knowledge and technology transfer in Switzerland: What university scientists think about co-operation with private enterprises. *Research Policy, 37*(10), 1865–1883.

Bercovitz, J., & Feldmann, M. (2006). Entrepreneurial universities and technology transfer: A conceptual framework for understanding knowledge-based economic development. *Journal of Technology Transfer, 31,* 175–188.

Boehm, S. N., & Hogan, T. (2014). 'A jack of all trades': The role of PIs in the establishment and management of collaborative networks in scientific knowledge commercialization. *The Journal of Technology Transfer, 39*(1), 134–149.

Bozeman, B. (2000). Technology Transfer and public policy: A review of research and theory. *Research Policy, 29,* 627–655.

Bruneel, J., D'Este, P., & Salter, A. (2010). Investigating the factors that diminish the barriers to university–industry collaboration. *Research Policy, 39*(7), 858–868.

Chukumba, C., & Jensen, R. (2005). University invention, entrepreneurship and startups. NBER working paper series 11475, Cambridge, MA.

Clark, B. R. (1998). *Creating entrepreneurial universities: Organisational pathways of transformation*. Oxford: Elsevier.

D'Este, P. D., & Patel, P. (2007). University–industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy, 36*(9), 1295–1313.

De Lourdes Machado, M., Farhangmehr, M., & Stover Taylor, J. (2004). The status of strategic planning in Portuguese higher education institutions: Trappings or substance. *Higher Education Policy, 17*(4), 383–404.

Debackere, K., & Veugelers, R. (2005). The role of academic technology transfer organizations in improving industry science links. *Research Policy, 34*(3), 321–342.

El Hadidi, H., & Kirby, D. A. (2015a). Universities and innovation in a factor-driven economy: The Egyptian case. *Industry and Higher Education, 29*(2), 151–160.

El Hadidi, H., & Kirby, D. A. (2015b). The attitude of Egyptian SET academics towards innovation: Universities and innovation in a factor-driven economy. *Industry and Higher Education, 29*(4), 1–11.

El Hadidi, H., & Kirby, D. A. (2016). Universities and innovation in a factor-driven economy: The performance of universities in Egypt. *Industry and Higher Education, 30*(2), 140–148.

El Hadidi, H., & Kirby, D. A. (2017). University–industry collaboration in a factor-driven economy: The perspective of Egyptian industry. *Industry and Higher Education, 31*(3), 195–203.

Etzkowitz, H. (2003). Innovation in innovation: The triple helix of university–industry–government relations. *Social Science Information, 42*(2), 151–160.

Etzkowitz, H. (2008). *The triple helix: University–industry–government innovation in action*. Abingdon: Routledge.

Etzkowitz, H. (2014). The entrepreneurial university wave: From ivory tower to global economic engine. *Industry and Higher Education, 28*(4), 223–232.

Fontana, R., Guena, A., & Matt, M. (2006). Factors affecting university–industry R&D projects: The importance of searching, screening and signalling. *Research Policy, 35*(2), 309–323.

Friedman, J., & Silberman, J. (2003). University, technology transfer: Do incentives, management and location matter? *The Journal of Technology Transfer, 28*(1), 17–30.

Galan-Muros, V., Van der Sijde, P., Groenewegen, P., & Baaken, T. (2017). Nurture over nature: How do European universities support their collaboration with business? *The Journal of Technology Transfer, 42*(1), 184–205.

Gonzalez-Pernia, J. L., Kuechie, G., & Pena-Legazkue, I. (2013). An assessment of the determinants of university technology transfer. *Economic Development Quarterly, 27*(1), 6–17.

Henry, C. (2013). Entrepreneurship Education in HE: Are policy makers expecting too much? *Education + Training, 55*(8/9), 836–848.

Herman, C. (2013). Industry perceptions of industry–university partnerships related to doctoral education in South Africa. *Industry and Higher Education, 27*(3), 214–222.

Hewitt-Dundas, N. (2012). Research intensity and knowledge transfer activity in UK universities. *Research Policy, 41*(2), 262–275.

Ismail, A., Tolba, A., Barakat, S., & Meshreki, H. (2018). *Global entrepreneurship monitor: Egypt National Report, 2017-2018*. Cairo: American University in Cairo.

Jensen, R., & Thursby, M. C. (2001). Proofs and prototypes for sale: The licensing of university inventions. *American Economic Review, 91,* 240–259.

Kirby, D. A. (2006). Creating Entrepreneurial universities in the UK: Applying entrepreneurial theory to practice. *The Journal of Technology Transfer, 31,* 599–603.

Kirby, D. A. (2007). The contextual stepwise approach to enterprise research and the use of undisguised stories and focus groups. In D. Hine & D. Carson (Eds.), *Innovative methodologies in enterprise research*. Cheltenham: Edward Elgar.

Kirby, D. A., & Ibrahim, N. (2016). Entrepeneurial universities in Egypt: Opportunities and challenges. In N. Rizk & H. Azzazy (Eds.), *Entrepreneurship + Innovation in Egypt*. Cairo: The American University in Cairo Press.

Link, A. N. (2002). From seed to harvest: The growth of the research Triangle Park. Research Triangle Foundation of North Carolina.

Link, A. N. (2015). Capturing knowledge: Private gains and public gains from university research partnerships. *Foundations and Trends in Entrepreneurship, 11*(3), 139–206.

Markman, G. D., Glaniodis, P. T., Phan, P. H., & Balkin, D. B. (2005a). Innovation speed: Transferring university technology to market. *Research Policy, 34*(7), 1058–1075.

Markman, G. D., Phan, P. H., Balkin, D. B., & Glaniodis, P. T. (2005b). Entrepreneurship and university-based technology transfer. *Journal of Business Venturing, 20*(2), 241–263.

Mock, K. H. (2005). Fostering entrepreneurship: Changing role of government and higher education governance in Hong Kong. *Research Policy, 34*(4), 537–554.

Muscio, A., Quaglione, D., & Vallanti, G. (2014). University regulation and university–industry interaction: A performance analysis of Italian academic departments. *Industrial and Corporate Change, 24*(5), 1047–1079.

Naghizadeh, R., Elahi, S., Manteghi, M., Ghazinoory, S., & Ranga, M. (2015). Through the magnifying glass: An analysis of regional innovation models based on co-word and meta-synthesis methods. *Quality & Quantity, 49*(6), 2481–2505.

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Brostrom, A., D'Este, P., et al. (2013). Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research Policy, 42*(2), 423–442.

Phan, P. H., & Siegal, D. S. (2006). The effectiveness of university technology transfer. *Foundations and Trends in Entrepreneurship, 2*(2), 77–144.

Ranga, M., & Etzkowitz, H. (2013). Triple helix systems: An analytical framework for innovation policy and practice in the Knowledge Society. *Industry and Higher Education, 27*(4), 237–262.

Rasmussen, E., & Rice, M. P. (2012). A framework for government support mechanisms aimed at enhancing university technology transfer: The Norwegian case. *International Journal of Technology Transfer and Commercialisation, 11*(1/2), 1–25.

Reda, M. (2012). *Enhancing Egypt's competitiveness: Education, innovation and labor*. Cairo: Egyptian Centre for Economic Studies.

Science and Technology Development Fund. (2012). *Egypt's innovation ecosystem*. Cairo: Innovation Support Department, Science and Technology Development Fund.

Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. (2003a). Commercial knowledge transfers from universities to firms: Improving the effectiveness of university–industry collaboration. *Journal of High Technology Management Research, 14*(1), 11–133.

Siegel, D. S., Waldman, D. A., Atwater, L. E., & Link, A. (2004). Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: Qualitative evidence from the commercialization of university technologies. *Journal of Engineering and Technology Management, 21*(1–2), 115–142.

Siegel, D. S., Waldman, D., & Link, A. (2003b). Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: An exploratory study. *Research Policy, 32,* 27–48.

Silverman, E. (2007, January 1). The trouble with tech transfer. *The Scientist*.

Sturgeon, T. J. (2000). How Silicon Valley came to be. In M. Kenney (Ed.), *Understanding silicon valley: The anatomy of an entrepreneurial region* (pp. 15–47). Stanford, CA: Stanford University Press.

Vinig, T., & Lips, D. (2015). Measuring the performance of university technology transfer using meta data approach: The case of Dutch universities. *The Journal of Technology Transfer, 40*(6), 1034–1049.