Chapter 7
Commercialisation Journey in Business Ecosystem: From Academy to Market

Zhaojing Huang, Clare Farrukh, and Yongjiang Shi

Abstract Scientists are becoming more entrepreneurial in trying to commercialise their findings as new technologies and products. However, academic research focuses very little on the commercialisation process and the management tools needed by entrepreneurial scientists. This paper looks at commercialisation from scientists' viewpoint seeking to develop new products from successful research. It takes a business ecosystem perspective and presents a theoretical framework developed by mapping diverse literature. This framework is then compared to data collected during a longitudinal case study on the development of a fibre optic sensor analyser with application in the construction industry. A key finding is that relationships with partners and other supporting organisations need to be formed earlier than the literature currently suggests and that an awareness of the business ecosystem within which the technology fits is as important to scientists as knowledge of available innovation and technology management tools. Hence an early focus on communication and partnership is highlighted as an important factor for commercialisation success.

Keywords Commercialisation process • Business ecosystems • Innovation and entrepreneur

7.1 Introduction

In an attempt to speed the uptake of research to give benefit to society, as well as potentially reap rewards to feed back into ongoing research, research institutes are assuming a much more important role in bringing new technology to the market. Increasingly researchers and scientists are becoming new entrepreneurs, trying to commercialise their scientific findings as new technologies or products. Although

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J. Leitão et al. (eds.), *Entrepreneurial, Innovative and Sustainable Ecosystems*, Applying Quality of Life Research,
https://doi.org/10.1007/978-3-319-71014-3_7

different parts of the process are supported by innovation and technology management techniques, academic research focuses very little on the whole commercialisation process. There is also a lack of approaches documented in the literature to provide guidance for scientists in their commercialisation journey. Therefore, this work (Huang 2015) aims to investigate the question 'How can a group of scientists commercialise a new product from a successful piece of research?' To do this a wide-ranging literature review has been carried out to piece together the commercialisation process within a business ecosystem view, and this process has been contrasted with activities carried out during a longitudinal case study.

7.2 Literature Review

7.2.1 Overview

The main areas of literature reviewed fall within an overall view of the business ecosystem which is seen as the commercialisation context. The resultant innovation ecosystem, open innovation, technology readiness levels and new product development all contribute to an understanding of the commercialisation path from research to a product. The area of new product development is seen as informed by knowledge of entrepreneurship, business models and supply chain (Fig. 7.1).

7.2.2 Commercialisation Context: The Business Ecosystem

Companies evolve rapidly with the creation of innovative new business. Therefore, they need to attract resources of all sorts, drawing capital, forming partnerships and securing suppliers and customers. The collaborative networks formed become the

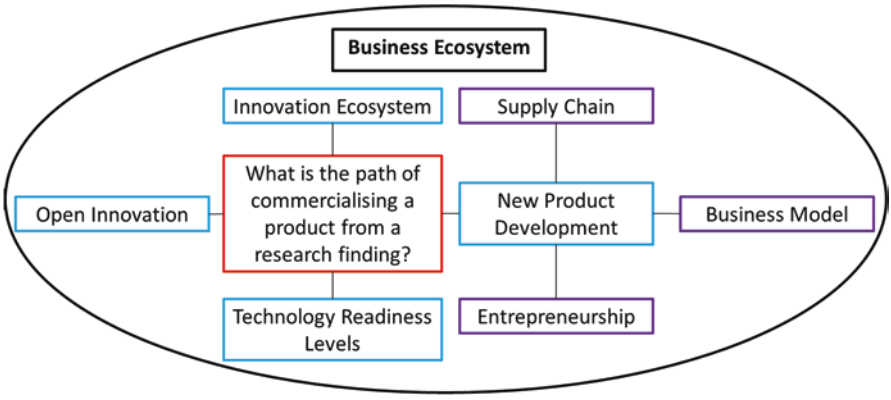

Fig. 7.1 Overview of involved literature in commercialisation process

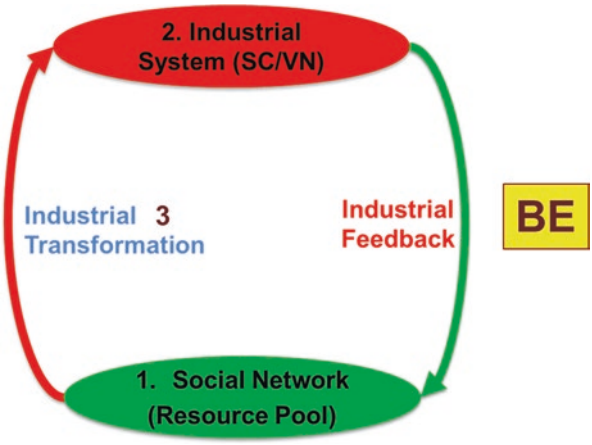

Fig. 7.2 Research focus on the commercialisation process within a business ecosystem (Adapted from Shang and Shi 2013)

business ecosystem (Moore 1993). Taking the business ecosystem concept further, Shang and Shi (2013) argued that the four key building blocks of the business ecosystem are social network (or resource pool), value network, interaction mechanisms and business context. Figure 7.2 adapts their proposed framework and proposes that one form of interactive mechanism (3) is the industrial transformation or commercialisation process between research within the social network (1) and its expression as a product in the industrial system (2, supply chain/value network).

7.2.3 Commercialisation Path: The Related Research Fields

The relevant research fields that have been identified in the literature review need to be integrated to present a larger view of the whole commercialisation path. By arranging and effectively integrating them, it also provides a chance to take a closer look on how these fields of knowledge interact and overlap with each other. Knowing these interactions can also help to enrich the existing knowledge of business ecosystem. Some of the researchers and their key research papers have been identified as their research focuses are related to the commercialisation path. Table 7.1 lists some of the papers identified in each field. It summarises the main findings of each paper and the crucial resources identified as being related to the commercialisation process.

The whole commercialisation path is a complicated and long journey. The research fields stated focus on parts of the journey, solving certain problems that might be faced in the commercialisation process.

Table 7.1 Identified relevant research papers

Field	Author and year	Comments	Resources identified
Innovation ecosystem	Adner and Kapoor (2010)	Focal firms should innovate together with complementary innovators	Industrial knowledge
			Market information
	Wang (2009)	There are interactions between different innovation ecosystems	Industrial recognition
	Adner (2012)	Make sure that the adoption chain is linked and all players along the chain are positive about the new product	Industrial standards and requirements
Open innovation	Traitler et al. (2011)	Firstly, winning respect, establishing trust, building goodwill and finally creating value	Industrial know-how
			Industrial requirement
Technology readiness level	Mankins (2009)	Test the readiness of the technology through prototyping and testing	Funding
			Academic knowledge
	Lin et al. (2007)	It is also important to understand the customer perception of usefulness alongside technology readiness	Customer perception
New product development	Cooper (2006)	5-gate new product development procedure	Academic and industrial knowledge
	Phaal et al. (2011)	It is a transformation process from science to technology to application and then to market	Academic and industrial knowledge
	Fraser et al. (2003)	Fuzzy front-end product development process	Collaboration
Supply chain	Petersen et al. (1999)	Involving suppliers/manufacturers in the new product development process	Suppliers
Business model	Chesbrough and Rosenbloom (2002)	The model requires consideration of both technical and economic domains	Academic knowledge
			Industrial knowledge
		There is a range of possible value capture strategies for resources, control and marketing implications	Market information
			Customer perception
	Morris et al. (2005)	Business model can be dissected into six components	Industrial knowledge
			Customer perception
			Market information

7.2.4 Integration of the Literature

In order to obtain a picture of the whole commercialisation path, the research fields mentioned above need to be integrated.

The research fields identified focus on four main levels, namely, strategy and business model management (strategy), resource and organisation (resource), product and service (product) and technology and science (knowledge) level. The research focusing on the strategy level tends to help companies forming plans and tactics to grow the business further. At the resource level, research focuses on obtaining external resources and allocating internal resources to fit the needs of operation. At the product level, research talks more about the process of developing a successful new product. Knowledge is also crucial in the commercialisation process. At the knowledge level, research focuses on ways to obtain scientific knowledge and convert it into a commercial product.

In the commercialisation process, there are four main stages to a typical new product development (Phaal et al. 2011). The process starts with science and gradually develops into a technology. After reaching maturity, a technology can be tested as part of an application to solve industrial problems. Finally, it can then reach the market as a mature product/service. These four stages are very typical in a research-based new product commercialisation process; therefore it is chosen to be included in the integration as the key stages.

Within these four main stages, there are several key milestones in the whole commercialisation process. The key milestones are research, scope, customisation, prototype, tests and modifications, second prototype, tests and modifications, finalised product, business model formation and launch. These key milestones are being developed from the existing new product development processes and include an element of iteration.

By plotting the individual research fields on a graph with four levels on the vertical axis and the four stages and ten key milestones on the horizontal axis, an integrated view is obtained as shown in Fig. 7.3.

The three boxes below the horizontal axis summarise the key resources identified from the research papers listed in the previous table to transfer the process to the next stage. In order to transfer from science to a technology, funding/capital is important. Academic knowledge is also crucial to further develop the promising science research. In order to move to the application stage, industrial knowledge and requirement is crucial as it tells the developer how to further develop this technology to fit industrial needs and standards. Information regarding customer perception is also vital as the developer wants to design a product that meets the requirements of customers. In order to push the process to the market stage, recognition from the industry, information about the market and suppliers are essential.

Looking at the individual research areas plotted:

Technology Readiness Level: technology readiness level covers the very beginning part of the commercialisation journey. Focusing on testing the maturity of the technology, this framework helps users at both knowledge and product level. The

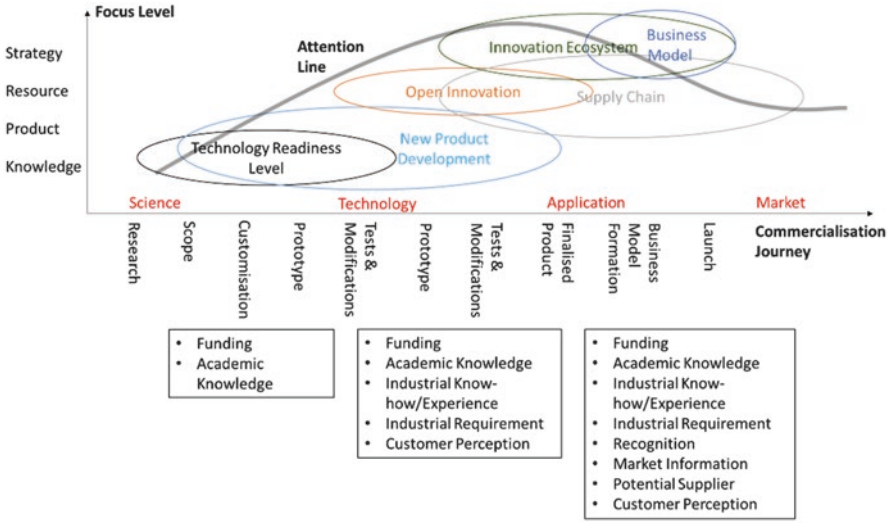

Fig. 7.3 A theoretical framework for commercialisation based on literature mapping

knowledge obtained through testing will feed back to the design with suitable modifications. At the end of the process, a mature technology should have been developed.

New Product Development: the new product development process starts slightly after the technology readiness level framework and lasts much longer. This process typically starts with scoping. The process also covers both product and knowledge level. Through prototyping, testing and modification processes, the knowledge obtained will feed back to the product design to improve the quality and performance. It can also be seen that the new product development plot has an overlapping area with technology readiness level framework plot. This is because both approaches help to test and modify the current technology/product. However, technology readiness level stops at the technology stage, while new product development continues until a product has been finalised and produced.

Open Innovation: open innovation talks about building trust and sharing resources between different players in the business ecosystem focusing on the resource level. According to the research, this process usually starts with a developed mature technology. It is a process where companies are actively looking for new technologies to develop their next-generation products. Therefore, it starts from the technology stage and ends at the application stage. There is also an overlap between new product development and open innovation. As part of the new product development process, developers are looking externally for resources which they are lacking through open innovation to complete the new product development process.

Supply Chain: there are an increasing number of research papers mentioning the importance of involving suppliers in the new product development process. When producing the prototype of the product, there is a need of involving suppliers, so that

once the product is successfully launched, a supply chain can be set up very smoothly. Therefore, the involvement of supply chain should start at the prototyping of the product (typically second prototype) and continues even after the launch of the product. Supply chain overlaps with the new product development process, as it should be considered in the process. There is also an overlap between supply chain and open innovation. This is because suppliers are a resource which can be accessed through open innovation.

Innovation Ecosystem: innovation ecosystem focuses on the strategic level. The developer should co-evolve with suppliers and complementors to ensure the successful launch of the product. When the prototype of the product has been made, the developer should apply the theory of innovation ecosystem by aiming to develop alongside the different players needed to ensure a successful product launch. This theory overlaps with open innovation as it is a process of building trust and obtaining resources to collaborate with different players in the market. It also involves suppliers, as co-evolving with suppliers is an important step to ensure the success of new product development.

Business Model: the business model is the overall strategy a company should formulate to sell its product. This process usually starts after a product/service has been successfully developed. It overlaps with supply chain and innovation ecosystems as it considers and includes suppliers, collaborators and competitors.

After obtaining the relative positioning of the key areas, a thick dark line has been plotted on the graph. This is the 'attention line' which indicates the level where most attention is required at each point of time during the commercialisation. The attention focus starts from the knowledge level and moves through product and resource level to reach the strategic level. Then it falls back to the resource and product level and remains there finally.

By integrating the existing bodies of relevant knowledge, a broader view of the whole commercialisation journey has been obtained. There are several overlaps identified, and the movement of the 'attention line' for the whole process across the different levels has been highlighted. Summarising all the existing knowledge reviewed, it can be seen as a process of obtaining lacking resources from both industry and supporting organisations to complete a new product development. With the appropriate business model generated, the new product can then successfully enter the market and be applied by the customers.

7.3 Methodology

7.3.1 Overview

Based on the current literature, there are several individual research domains which collectively cover the commercialisation journey. These research fields have been identified, arranged and then integrated to provide an overall view of the theoretical

commercialisation path. By means of the case study on the development of fibre optic sensor analyser in Cambridge Centre for Smart Infrastructure and Construction, the practical behaviour in research commercialisation was compared to the theoretically suggested approach. During this research, the whole commercialisation journey has been considered and framed under the business ecosystem scope.

This type of case study is being categorised as single revelatory. It is the preferred choice when an investigator has access to information not commonly accessible (Yin 2002). When building up the single revelatory case study, the common ways to obtain information are reviewing the possibility to access internal information and interview relevant people and building the case based on private information.

7.3.2 Case Study Design

A case study has been built around the development of fibre optic sensor analyser (FOSA), a technology that has been developed from the laboratory by a group of scientists. Although the commercialisation path has not been yet completed, it is now close to the final launch of the product. As the case study ran while the product was still under development, some data has been gathered through observation and participation in the process. At the same time, some data complements have been gathered through individual interviews. The access to Cambridge Centre for Smart Infrastructure and Construction (CSIC) technology development meetings, past project documentation and interviewing key stakeholders in the FOSA project allowed identification of FOSA's key development stages and CSIC's approach to expedite its product development. As part of the case study, an interview with Cambridge Enterprise was also held to confirm the accuracy and representativeness of the data collected from this case study. Cambridge Enterprise is the commercialisation arm of the University of Cambridge, formed to help students and staff commercialise their expertise and ideas.

7.3.3 Phases of the Research

The whole research has been divided into three phases:

Phase 1 focused on understanding the existing theories and background of the research area. Determining and obtaining the relevant existing academic literature was the first step. There are eight academic fields that were identified to be relevant to the whole journey from scientific research to commercialisation. The next task was to integrate the relevant academic research obtained into a theoretical framework of the commercialisation process.

Phase 2 focused on obtaining the academic and industrial data regarding the case study. The past project reports, interviews and participating in project meetings with CSIC regarding the FOSA served as important inputs to understand the case study more thoroughly. Analysing this data helps to understand the whole development process of this new product. The next task was to understand and visualise the whole development process of the FOSA project which is the case study for this work using the theoretical framework as a structure.

Phase 3 followed after the first two phases were completed, where the framework formed from integrating the existing research can then be tested and improved through comparison with the development process of FOSA in CSIC. The aim was to enrich existing academic research of the commercialisation process and enable the drawing of preliminary conclusions.

7.4 Case Study

7.4.1 Background

CSIC is a research institute based in Cambridge aiming to develop and commercialise emerging technologies which will provide radical changes in the construction and management of infrastructure, leading to considerably enhanced efficiencies, economies and adaptability. Civil engineering infrastructure is generally the most capital-intensive national investments of any country and has a long service life expectation. It is costly to maintain and difficult to replace. Therefore, routine manual visual inspection must be performed periodically to ensure the buildings are safe and there are no signs of degradation and corrosion. Fibre optic sensors have been spotted to be an ideal tool to complete the inspection tasks more effectively and accurately. By attaching the fibre to the infrastructure, scans of the whole building are possible as measurements are taken and recorded using an analyser. Although the initial tests have shown the method performs to a high level, there still exist several major disadvantages. One of them is the high expense of the equipment, and another major disadvantage is the bulky size of the equipment. These two major disadvantages are preventing this technology from being adopted in the civil industry. Therefore, CSIC decided to develop a portable, low-cost and high-performance fibre optic sensor analyser (FOSA) product to fit the needs of the civil industry.

7.4.2 Data Gathering

7.4.2.1 Reports

There were nine major construction events that have been conducted since the beginning of the FOSA development programme in 2005. This information was obtained from past industrial reports (Shi 2014) and updated during the research. These events are summarised in Table 7.2.

It can be observed that these major events happened throughout the development programme. With collaborative relationships set-up with the industrial companies, the researchers could test their technology and product in the industrial projects of the companies. The results obtained from the projects are used to modify the design further. Therefore, it can be concluded that the theory of open innovation and innovation ecosystem has been applied from the beginning of the project till today. It can be also observed that through these activities, the technology has been tested and new product has been gradually developed by applying the theory of technology readiness levels and new product development.

7.4.2.2 Interviews

Interviews were carried out with a range of partners and researchers related to the FOSA project from April 2014 to July 2015. These include two industrial partners, one academic partner and four members of CSIC.

In order to understand the whole development process, one of the interviews was an in-depth discussion with the project leader. Secondary data such as past industrial reports was collected and reviewed before and after the interview to obtain more information and data for this case study. The key finding from the interview was that the developer of this new technology/product started to establish good relationships with the industrial players at the very beginning of the development programme. Through these stable and long-term collaborative relationships with the industry, the developer was able to understand the industrial needs and requirements early on in order to put this information into the product design. It was also mentioned in the interview that with the collaborative relationships set-up, the developers could communicate with the industrial companies frequently, throughout the whole development process. This was particularly helpful, as the developers were able to update the companies with the current progress while obtaining feedback and modifying the product design accordingly. Through the communication processes, some valuable information was also obtained, for instance, industrial know-how and market information. With trust built up, the developers could test their technology and products in the construction projects of the partners. From the interview, it is also known that the whole process started with establishing good relationships with the industry and the supporting organisations while going through the process of research and technology testing. Almost at the end of the new product

Table 7.2 List of major project events in 2005–2015

Events	Client type	Problem encountered	Date	Corresponding theory	
1	Thames link tunnel at King's Cross – deformation monitoring during proximity tunnelling	Tunnelling subcontractor	Delicate handling exposed cables prone to damage	Jan 05	Technology readiness levels
2	Singapore Circle Line – monitoring twin tunnel interaction	Asset owner	Change in tunnel elevation and surrounding soil type affects data output. Exposed cables prone to damage	Oct 06	Technology readiness levels
3	Lambeth College – pile loading and thermal response test	Asset owner	–	May 07	Technology readiness levels
4	Francis Crick Institute – preliminary load test	Piling contractor	Clamps introduce large change in strain about a localised spot	Sep 11	Technology readiness levels New product development
5	Abbey Mills Pumping Station – shaft monitoring during excavation	Asset owner	Damage to cable during excavation	Dec 11	New product development
6	259 City Road – preliminary load test	Design subcontractor	FO cable damage – no signal from one side of pile	Jul 12	New product development
7	6 Bevis Marks – monitoring and reuse of piles	Piling subcontractor	–	Oct 12	New product development
8	Newfoundland project – test pile 2	Consultants	Clamps introduce large change in strain about a localised spot	May 14	New product development
9	Final product prototype	Product design consultant	Proceeding	June 15	New product development

development process now, the team is considering involving potential suppliers and looking for suitable business model for the newly developed product.

As part of the case study, an interview was also conducted with two technology consultants in Cambridge Enterprise who are currently collaborating with CSIC on the FOSA project to provide guidance on the commercialisation process. They have noticed through numerous commercialisation projects that they have worked on in the past years that the researchers who have good relationships with the industry were much more likely to succeed. The earlier the relationships with the industry were set up, the higher chances of success. Cases where researchers approached with excellent technology/product but limited connection with the industry have failed severely. The FOSA project is a very good representative case, where researchers started to communicate with the industry early on to build up the mutual understanding.

7.4.2.3 Participation

When the opportunity arose, theoretical approaches and management tools highlighted in the literature review were discussed with members of CSIC. For example, as the FOSA team was approaching the stage where an appropriate business model needed to be generated, the theory of business models was shared in meetings with the team as a discussion framework. The final business model generated was presented to a venture capital team to attract new investment. Although the commercialisation process of FOSA is not yet completed, some of the theories supporting the uncompleted part of the journey have been tested through such activities to verify their accuracy, and the outcome so far is favourable.

7.5 Results

7.5.1 Comparison of Areas of Literature with Practical Concerns in the Case Study

The theoretical behaviours listed on the left side of Table 7.3 are compared to the practical behaviours observed in the case study, listed on the right side of the table. Through comparison, it can be seen that the factors affecting the commercialisation stated in relevant research fields match with the practical behaviours in the industry. In practice, the researchers of FOSA have gone through the processes suggested in the relevant research fields unconsciously to secure the success of the commercialisation. Therefore, the practical behaviours of commercialisation largely match with the integrated research view as they both show the same consideration factors for successful commercialisation process.

Table 7.3 Comparison between literature and case study

Literature	FOSA case study
Innovation ecosystem	
Innovate together with complimentary innovators	Obtain recognition from the industry and work with the service companies
Adoption across the value chain	Working closely with industrial partners and building up good relationship with service companies
Interaction between innovation ecosystems	Started from oil and gas industry and the technology can be potentially applied to various industries
Open innovation	
Win respect, establish trust, build goodwill and finally create value	Long-term partnership with the industrial companies from the beginning of the project
Technology readiness level	
Test the readiness of the technology through prototyping and testing	Test the technology through partners' industrial projects
Customer perceived usefulness	Consistently discuss with the industrial partners to understand their needs and requirements of the product
New product development	
5-gate new product development procedure	Applying this procedure for developing the new product
It is a transformation process from science to technology to application and then to the market	The technology started off from a laboratory research and then developed into a technology that is aiming to be launched in the civil industry
Fuzzy front-end product development process	Collaborating with industrial companies to obtain industrial requirements of the product. Working with design consultancy to clarify doubts and identify wastes in product design
Supply chain	
Involving suppliers/manufacturers in the new product development process	Considering looking for manufacturers to participate in the product development process. However, it is unclear as the business model has not been determined at the moment

7.5.2 Comparison of the Commercialisation Timeline

Although both academic literature and the industrial case study considered the same factors within their commercialisation processes, the order of how things happened during the commercialisation journey of the case study is slightly different and can be seen clearly in the two commercialisation charts generated. The practical chart (top) is based on the case study findings, and the theoretical chart (bottom) is based on the literature. The commercialisation's 'current position' shows the progress of the FOSA development when this work was completed.

The data obtained from the case study illustrates that the collaboration with the industry started right at the beginning of the project in order to build trust and obtain resources which were lacking. Therefore, the theory of innovation ecosystem and open innovation has been applied at the beginning of the project. In addition, it can

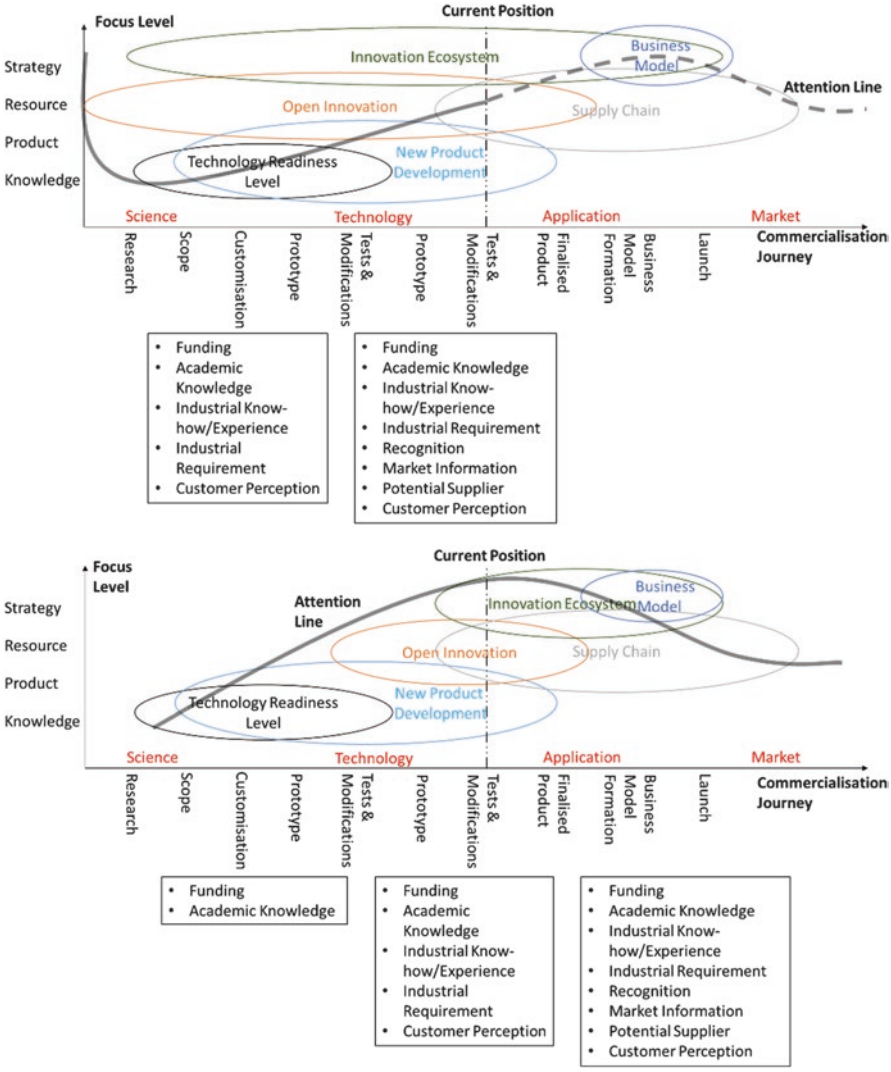

Fig. 7.4 Practical (top) and theoretical (lower) commercialisation charts

be seen from Fig. 7.4 that the thick dark line plotted which is presenting the 'attention line' moves differently. In the case study, it starts from resource and strategy level and moves down quickly to the knowledge and product level. Then it gradually shifts to the highest strategic level and eventually comes down to the resource and product level. As noticed from the interviews, a large amount of resource was required at the early stage to help the researchers to set the correct direction for their research. With larger resources and information provided at an earlier stage, the results of the research have more chance of meeting the industrial needs more

quickly and with fewer and smaller modifications. The vertical dotted line represents the current stage of FOSA project. Finishing the final product prototyping, the researchers are making the final modifications before finalising the product design. This project is close to the application stage.

7.5.3 Future Projections

As the whole commercialisation process has not yet been completed, therefore the 'attention line' after the current stage is plotted in a thick dotted line. This information was obtained through interviewing the project leader of the commercialisation programme regarding their future plan. Based on the theoretical chart, the researchers should be thinking about forming a suitable business model in order to push the product to the market. Based on the interviews, this is exactly what the team is trying to work out now together with the help from Cambridge Enterprise.

7.5.4 Key Stages Observed in the Practical Commercialisation Process

The practical commercialisation chart generated showed an early start of applying the approaches stated in open innovation and innovation ecosystem research. The research focuses on the strategy and resource level of the commercialisation path. Therefore, the attention in the practical process of commercialisation starts from a high level (strategy and resource level) before it comes to a lower level (product and knowledge level). After this early stage, the behaviour observed in the practical commercialisation path becomes more similarly behaved to the theoretical commercialisation path. By paying attention to the flow of the 'attention line', a four-stage process can be observed from the chart which is presented in Fig. 7.5.

By observing the behaviour of the 'attention line', it can be seen from the figure that there are four main stages in the whole commercialisation process. With 'attention line' lying on the strategic and resource level, the first stage is relationship building, where it focuses on building good relationships with the industrial companies and supporting organisations to facilitate the development of technology and product. The second stage is technology and product development stage. Most of the resources are required at this stage, which can be seen from the two boxes in the figure. At this stage, the attention is more focused on the product and knowledge level. The next stage is business strategy formation. At this stage, with the attention on the strategic level, business model is generated in consideration of the characteristics of the product and the management model. After this stage, it enters business growth and maintenance stage where products and technologies enter the market and profit is generated. Currently, the FOSA project is at the end of the second stage

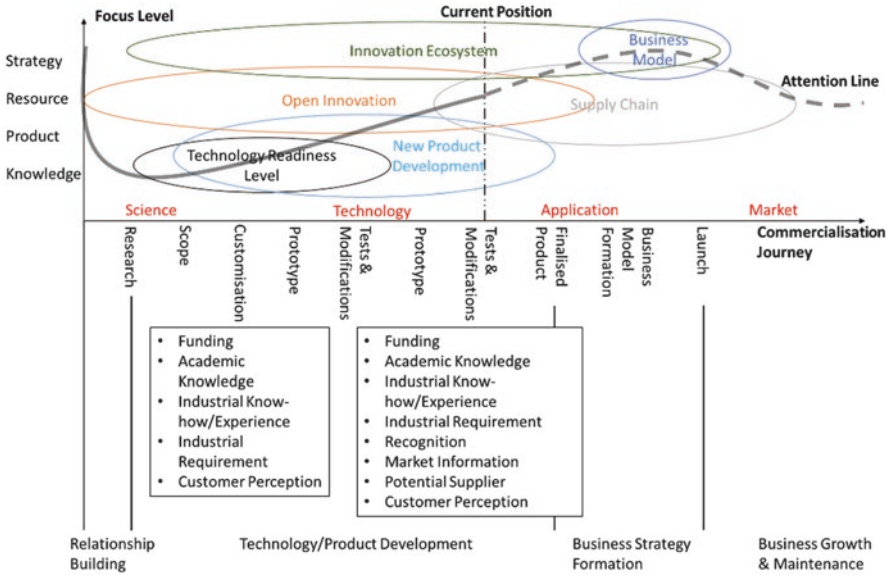

Fig. 7.5 Commercialisation process flow

(technology/product development) and the beginning of the third stage (business strategy formation). These stages help to determine the use of appropriate tools to support the commercialisation process.

7.5.5 Dissecting Commercialisation Process by Derived Four-Stage Process

With the aim of helping users to complete the commercialisation path, the whole journey is broken down into smaller tasks by applying the derived four-stage commercialisation process as shown in Table 7.4.

The table summarises the tasks at each stage of the process. In order to move on to the next stage of the process, the tasks at all attention levels in the previous stage need to be completed. When tasks in all stages are completed, commercialisation is then accomplished.

With the goal to assist users on the selection of the applicable tools to address each one of the tasks, Table 7.5 summarises the available tools in the literature to guide the users towards achieving every stage of the process.

These tools are summarised from the literature reviews and categorised using the four-stage commercialisation process derived from this work. The tools under each stage can be used to help the users accomplishing the tasks of the stage and then move on to the next stage of the four-stage process.

Table 7.4 Tasks in commercialisation

Attention level	Commercialisation stages			
	Relationship establishment	Technology/product development	Business strategy formation	Business growth and adaptation
Strategy and business model management (strategy)	Trust formation	Forming strategic partnership with complimentors	Obtaining overall business strategy	Business model modifications
	Partnership building		Business model formation	
Resources and organisation (resource)	Knowledge sharing	External resources obtaining	Supply chain establishment	Value chain management
	Idea exchanging	Supplier selection		Industry formation
Product and services (product)	Scoping	New product development	Finalising product	Product launch
	Idea refining	Prototyping and testing		
Technology and science (knowledge)	Scientific research	Research and development	Obtaining matured technology	Further research and development
		Technology maturity testing		

Table 7.5 Tools for commercialisation

Attention level	Commercialisation stages			
	Relationship establishment	Technology/ product development	Business strategy formation	Business growth and adaptation
Strategy and business model management (strategy)	Wide-lens view	Adoption chain	Six-question framework	
			Business model canvas	
Resources and organisation (resource)	Share-is-winning framework	Innovation strategy map	Supplier integration frameworks	Business ecosystem nurturing strategy
		Chess vs poker management process	New product ramp-up	
Product and services (product)		Stage-gate new product development process		
		S-T-A-M process		
Technology and science (knowledge)		Technology readiness levels		
		Technology readiness and acceptance model		

7.6 Discussion

The theoretical commercialisation path derived focuses on the view of established companies. Established companies usually hunt for new technologies that can be used in their design of the next-generation product. Through the approach stated in open innovation and innovation ecosystem, the established companies can obtain developed technologies very quickly and apply them in their new products. Therefore, from the academic point of view, the collaboration with external organisations can start slightly later, which is after the scope of the new product development has been determined.

However, the commercialisation journey of a research finding by a group of scientists is different. Coming from an academic background, the scientists have limited knowledge about the industry and the needs of the final customers. Therefore, in order to make sure that their research can be developed into a product that is meeting the industrial requirements and the needs of the customers, the scientists and researchers need to approach industrial companies and customers to obtain the necessary information. These communications enable the industry to become better informed about the scientists' ongoing research. This mutual understanding and working relationships help the scientists in the later part of the commercialisation journey. The industrial companies understand and know the technology/product that has been made in the research institute, and they save time in the due diligence process when they are trying to decide on whether to closely collaborate or purchase these technologies or products. A newly formed relationship is less favourable, as the companies need to spend a significant amount of time understanding the technology/product that has already been developed and there is a higher chance that it will not fit the industrial needs. Therefore, in order to ensure a successful commercialisation and reduce the risk as early as possible, the scientists need to start from a high level (i.e. the strategy and resource level) when they are trying to develop a new technology/product with a view of commercialising it eventually. It is worth noting at this point the iterative and resource-dependent nature of commercialisation, especially within an academic environment. There is a difference between what could be done and what is possible to do at each point of the process, with investment (time/attention as well as capital)-related progress being achieved.

In summary, the research suggests that there is importance in a collaborative path towards commercialisation for research, drawing upon the awareness and resources of the encompassing business ecosystem. Continuous communication with the industry and supporting organisations helps the scientists and researchers to obtain the resources needed. Through the continuous interactions and communications, the product can be developed meeting all the requirements of the industrial needs and ready to be deployed into the market with a suitable business model in place (Fig. 7.6).

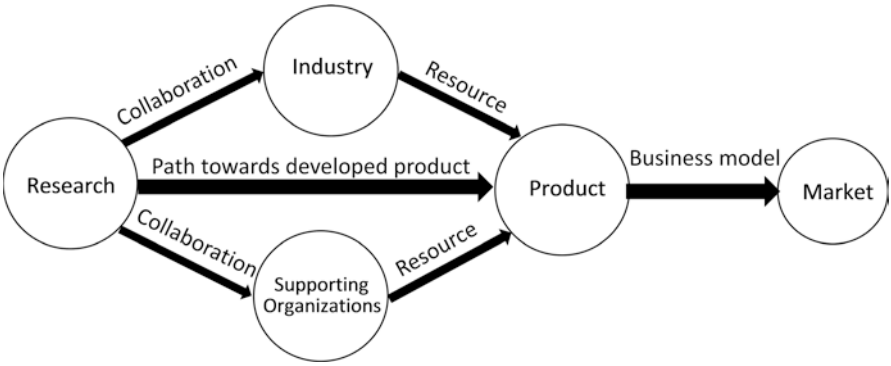

Fig. 7.6 Simplified commercialisation path highlighting collaboration

7.7 Conclusion

This work has identified and discussed the similarities and differences between theoretical and practical behaviours in the commercialisation journey. Although major similarities in behaviour have been identified, there is still a difference in the timing/order of doing things in practice compared to the perceived order derived from the literature. In practice, the scientists and researchers started with their attention on a high level where strategic alliances are formed and resources are obtained. Based on the specific case where a group of scientists and researchers are commercialising their research into a technology or product, a simplified roadmap has been developed to guide similar programmes in the future.

The key findings are as follows:

- Practical guidance on commercialisation of research is not readily accessible to entrepreneurial scientists although they welcome timely interventions from both academics and support agencies.
- The comparison between theoretical approaches to commercialisation based mainly on large companies and the practical behaviour found in one case study of commercialisation of academic research revealed differences in timing and behaviour.
- Continuous communication with industrial partners and supporting organisations from the very beginning is necessary to obtain useful information and resources to ensure the success of commercialisation.
- Awareness of the relevant business ecosystem could help to keep the commercialisation process dynamic and make available support networks more visible.

The research findings contribute to both academia and industry. For academia, this research recognised a wider commercialisation process as a relatively new body of knowledge which requires further attention. In addition, this work identified and integrated the relevant individual research fields of commercialisation process providing an overall view of commercialisation. This integration can also be used to enrich the interaction mechanism in the theory of business ecosystem. For industry,

this research discusses the commercialisation process in a way that could be used as a discussion prompt to guide future commercialisation projects in research institutes and support the application of appropriate tools and techniques. Further research could include further case studies, with perhaps advanced materials, to explore the proposed commercialisation process in more depth and more focus on the role of enterprise support organisations and practical materials that they might find useful.

Acknowledgement The case study used is fibre optic sensor analyser as developed by the Cambridge Centre for Smart Infrastructure and Construction (CSIC) and pioneered by Professor Kenichi Soga and Professor Robert Mair.

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