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COMMERCIALIZATION JOURNEY IN BUSINESS ECOSYSTEM

FROM ACADEMY TO MARKET

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Commercialization Journey in Business Ecosystem: from academy to market

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Abstract: In today's world, research institutes are playing an increasingly important role in bringing new technology to market. Researchers and scientists are becoming more entrepreneurial in trying to commercialize their findings as new technologies and products. However, academic research focuses very little on the whole commercialization process and the management tools needed by entrepreneurial scientists. This paper looks at commercialization from the viewpoint of a group of scientists seeking to develop a new product from successful research. It takes a business eco-system perspective and presents a theoretical framework developed by mapping a wide range of 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 organizations 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 commercialization success.

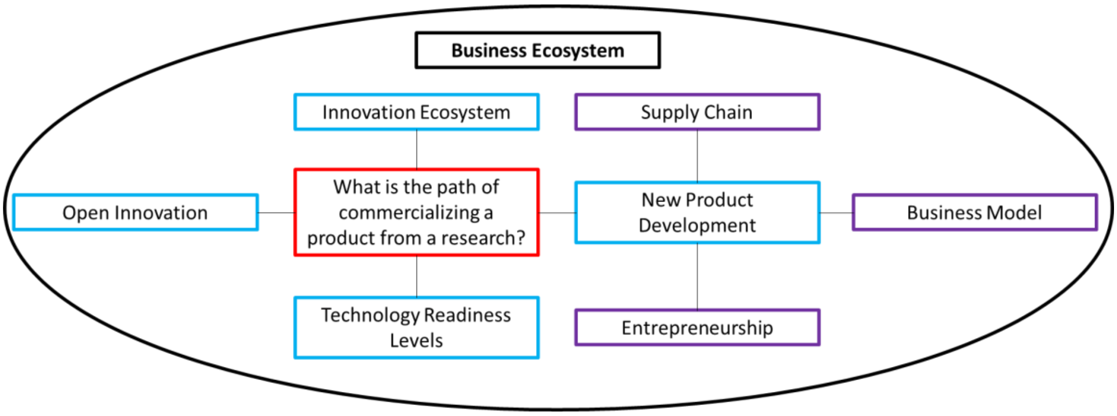
1. Introduction

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 market. Increasingly researchers and scientists are becoming new entrepreneurs, trying to commercialize their scientific findings as new technologies or products. Although different parts of the process are supported by innovation and technology management techniques, academic research focuses very little on the whole commercialization process. There is also a lack of approaches documented in the literature to provide guidance for scientists in their commercialization journey. Therefore, this paper aims to investigate the question "How can a group of scientists commercialize 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 commercialization process within a business ecosystem view and this process has been contrasted with activities carried out during a longitudinal case study.

2. Literature Review

2.1 Overview

The main areas of literature reviewed fall within an overall view of the Business Ecosystem which is seen as the commercialization context. The resultant Innovation Ecosystem, Open Innovation, Technology Readiness Levels and New Product Development all contribute to an understanding of the commercialization 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.



2.2 Commercialization 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, securing suppliers and customers. The collaborative networks formed become the business ecosystem (Moore 1993). Taking the business ecosystem concept further, Shang & 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 1 below 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).

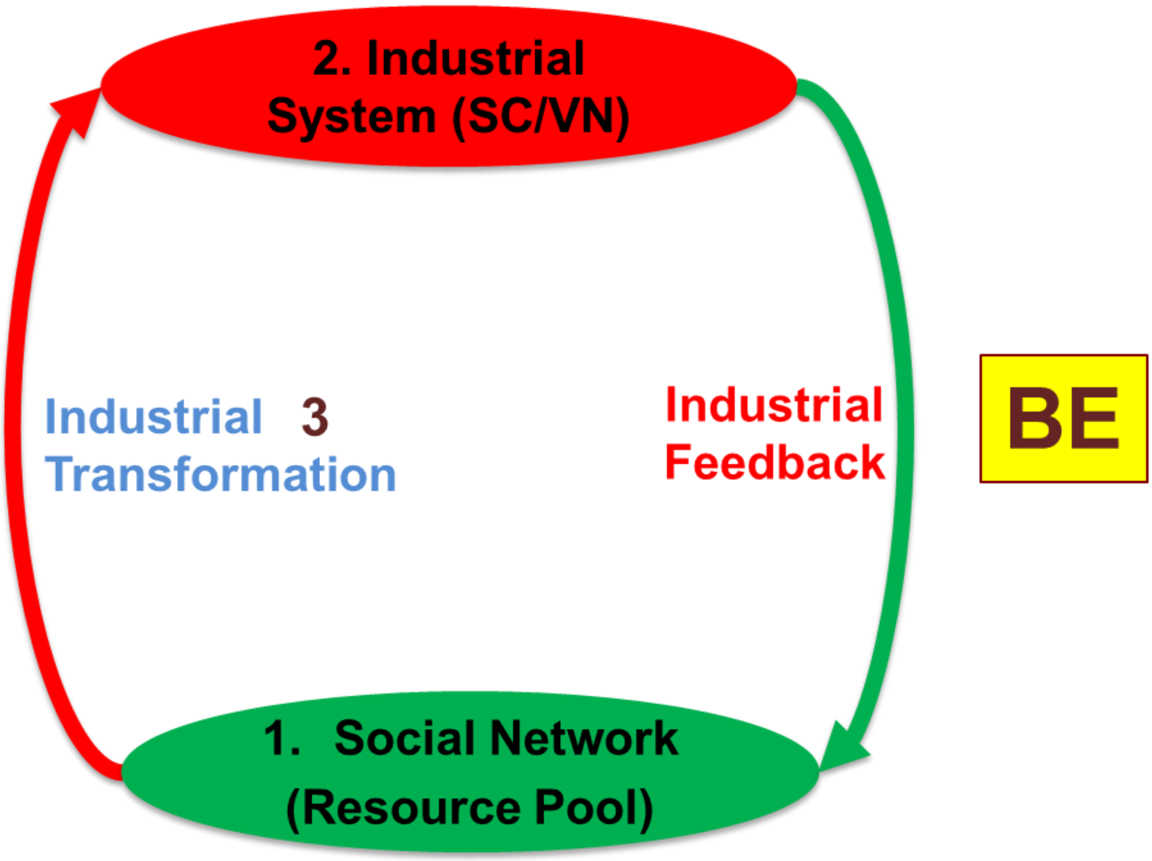


Figure 1: Research focus on the commercialisation process within a business ecosystem (adapted from Shang & Shi 2013).

2.3 Commercialization path

The relevant research fields that have been identified in the literature review need to be integrated to provide 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 relationships can also help enriching the existing knowledge of business ecosystem. From the detailed literature review, some of the researchers and their research papers are being identified as their research focuses are very much based on the commercialisation path. Table 2.1 below lists some of the papers identified in each fields. It summarizes the main findings of each paper and the resources that are identified to be crucial to the commercialisation process.

Field	***Author & Year***	***Comment***	***Resources Identified***
Innovation Ecosystem	Adner & Kapoor 2010	Focal firm 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 connected and all players are positive about the new product	Industrial Standards & 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. 2008	It is also important to understand the customer perceived usefulness alongside with 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 the market	Academic and Industrial Knowledge
	Fraser et al. 2003	Fuzzy front end product development process	Collaboration
Supply Chain	Petersen et al. 1999	Involving Suppliers/manufacturer in the new product development process	Suppliers
Business Model	Amit & Zott 2001 Chesbrough & Rosenbloom 2002 Morris 2005 Teece 2010	Requires consideration of both technical and economic domains. There is range of possible value capture strategies with resource, control and marketing implications	Academic Knowledge Market Information Customer Perception

Table 2.1: Identified Relevant Research Papers

The whole commercialisation path is a complicated and long journey, the research fields stated above focus on parts of the journey, solving certain problems that might face during the commercialisation.

2.4 Integration of the literature

As discussed in this section, there are many fields of research that are tackling parts of the commercialisation journey. In order to obtain the view of the whole commercialisation path, the research fields mentioned in this section need to be integrated.

The research fields identified, focus on four main levels, namely strategy, resource, product and knowledge level. The researches focusing on strategy level tend to help companies forming plans and tactics to push the business further. At the resource level, researches focus on obtaining external resources and allocate internal resources to fit the need of operation. At the product level, researches talk more about the process of developing a successful new product. Knowledge is crucial in the commercialisation process. At the knowledge level, researches focus on ways to obtain the scientific knowledge and convert it into a commercial product.

In the commercialisation process, there are 4 main stages where a typical new product development need to go through (Phaal et al. 2011). The process starts with science and gradually developing it into a technology. After obtaining a matured technology, it can be tested as an application to solve some industrial problems. Finally, it can then reach the market as a matured product/service. These 4 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, Customization, Prototype, Tests & Modifications, Prototype, Tests & Modifications, Finalized 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 integration view is obtained as show in the chart 2.1.

The three boxes below the horizontal axis summarize 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 important as it tells the developer on how to further develop this technology to fit the industrial need and standard. Information regarding customer perception is also important as the developer wants to develop the product which meet the requirement of customers. In order to push the process to the market stage, recognition from the industry, information about the market and suppliers are important.

Looking at the individual research areas plotted:

Technology Readiness Level: technology readiness level covers the very beginning of the commercialisation journey. Focusing on testing the maturity of the technology, this framework helps users at both knowledge and product level. The knowledge obtained through testing will feedback 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 technology readiness level framework and lasts much longer. This process typically starts with scoping. The process also covers both product and knowledge levels. Through a few prototyping, testing and modification processes, the knowledge obtained will feedback to the product design to improve the quality and performance. It can also be seen that the new product development has an overlapping area with technology readiness level framework. 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 resources level. This process usually starts after a mature technology has been developed. Companies are looking for new technologies to develop their next generation products. Therefore, it starts from the technology stage and end at the application stage. There is also an overlapping 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 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 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 to co-evolve with different players to ensure the successful launch of the product. 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: business model is the overall strategy which the company should generate in order to sell its product. This process usually starts after a product/services has been successfully developed, then the company will start looking for a suitable business model for its product. It overlaps with supply chain and innovation ecosystems. This is because as an overall strategy of the company, it considers and includes suppliers and different players that you are collaborating or competing with.

After obtaining this graph, a thick dark line has been plotted on the graph. This is the attention line which plots the level where attention is required at each point of time. The attention focus started from the knowledge level and moved through product and resource level to reach the strategic level and then it falls back to the resource and product level and remained there eventually.

By integrating the existing bodies of relevant knowledge, a broader view of the whole commercialisation journey has been obtained. There are several overlaps that have been identified. The attention of the whole process started from the knowledge level to strategy level and then back to resource and product level. Summarizing all the existing knowledge and expressing it in short, it is a process of obtaining lacking resources from both industry and supporting organisations to complete the new product development. With the appropriate business model generated, the new product can then successfully enter the market and be tested by the customers.

The following diagram has been developed based on the literature review and demonstrates existing theoretical models and tools contributing to the commercialisation process. The commercialization's 'current position' is shown for illustrative purposes within the process.

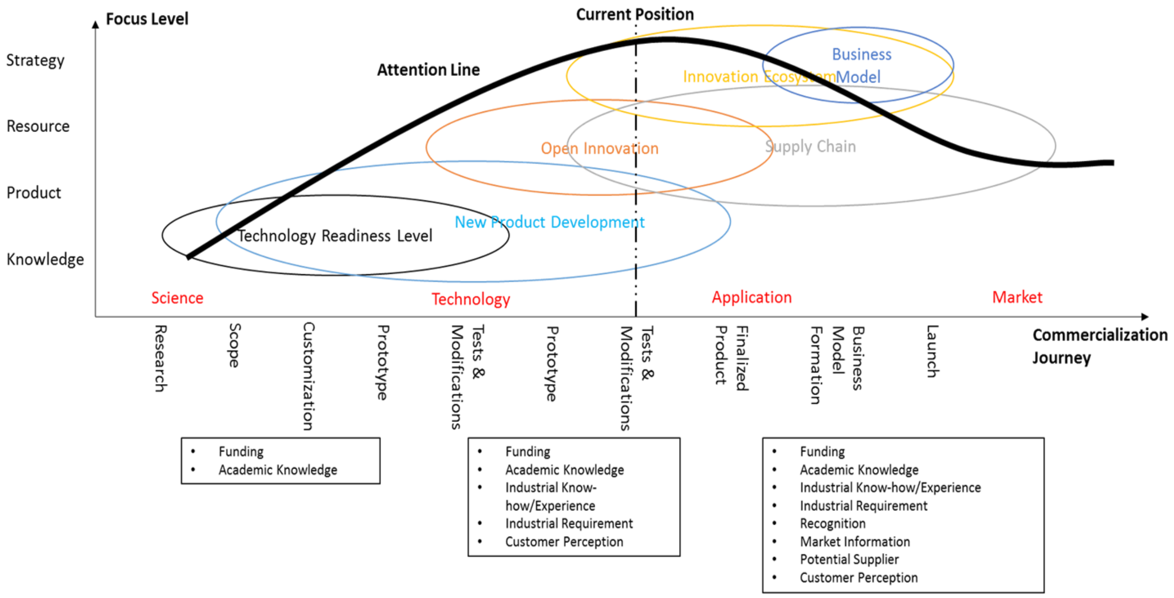


Figure: 2.1 A Theoretical Framework for Commercialization based on Literature Mapping

3. Methodology

3.1 Overview

Based on the current literature, there are several individual research domains which collectively cover the commercialization journey. These research fields have been identified, arranged and then integrated to provide an overall view of the theoretical commercialization 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 commercialization was compared to the theoretically suggested approach. During this research, the whole commercialisation journey is being considered and framed under the business ecosystem scope.

This type of case study is being categorized 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; building the case based on private information.

3.2 Case Study Design

In order to answer the research question, the 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. This data complements that which has 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 FOSA's key development stages and CSIC's approach to expedite its product development to be identified. 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.

3.3 Phases of the research

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 8 academic fields that were identified to be relevant to the whole journey from scientific research to commercialization. The next task was to integrate the relevant academic research obtained into a theoretical framework of the commercialization 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 helped to understand the whole development process of this new product. The next task was to understand and visualize 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, when 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.

4. Case Study

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 sensor has been spotted to be an ideal tool to complete the inspection tasks more effectively and accurately. By attaching the fibre to the infrastructure, it scans the whole building and measurements are taken and recorded using an analyser. Although the initial tests have shown significant performance, there still exist several major disadvantages. One of them is the high expenses 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 FOSA product to fit the needs of the civil industry.

4.2 Data Gathering

4.2.1 Reports

There were 9 major construction events that have been conducted from the beginning of the FOSA development program in 2005. This information is obtained from past industrial reports (Shi 2014) and updated to the current progress. These events are summarized in the table 4.1 below.

	EVENTS	**CLIENT TYPE**	**PROBLEM ENCOUNTERED**	**DATE**	**THEORIES APPLIED**
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 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 localized 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 Re-use of Piles	Piling Subcontractor	-	Oct-12	New Product Development
8	Newfoundland Project - Test Pile 2	Consultants	Clamps introduce large change in strain about a localized spot	May-14	New Product Development
9	Final Product Prototype	Product Design Consultant	Proceeding	June-15	New Product Development

Table 4.1: List of Major Project Events 2005-2015

It can be observed that these major events happened throughout the development program. With collaborative relationships set-up with the industrial companies, the researchers were able to 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 are been applied from the beginning of the project till today. It can be also observed that through these activities, the technology is been tested and new product is been gradually developed by applying the theory of Technology Readiness Levels and New Product Development.

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 included 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 interview 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 program. Through these stable and long-term collaborative relationships with the industry, the developer was able to understand the industrial need and their requirement early on 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 is particularly helpful, as the developers can update the companies with the current progress while obtaining feedbacks 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 were able to 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 researching and technology testing. Almost at the end of the new product 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, the researchers who have good relationships with industry were much more likely to succeed. The earlier the relationships with industry were set up, the higher chances of succeeding. Cases where researchers approached with excellent technology/product but no 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.

4.2.3 Participation

When the opportunity arose, theoretical approaches and management tools highlighted by 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. So 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.

5. Results

5.1 Comparison of areas of literature with practical concerns in the case study
The theoretical behaviours listed on the left side of Table 5.1 are compared to the practical behaviour observed in the case study, listed on the right side of the table. Through comparison, it can be seen that the factors affecting the commercialization stated in relevant research fields matches the practical behaviour in the industry. In practice, the researchers of FOSA have been through the processes suggested in the relevant research fields unconsciously to secure the success of the commercialization. Therefore, the practical behaviour of commercialization path largely matches with the integrated research view as they both shows the same consideration factors for successful commercialization process.

Literature	FOSA Case study
Innovation Ecosystem	
Innovate together with complimentary innovators	Obtain recognition from the industry and work with the services companies
Adoption across the value chain	Working closely with industrial partners and building up good relationship with services companies
Interaction between innovation ecosystems	Started from oil & gas industry and the technology can be potentially applied to various industries
Open Innovation	
Winning 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 partner's industrial projects
Customer perceived usefulness	Consistently discusses with the industrial partners to understand their needs and requirement of the product
New Product Development	
5-gate new product development procedure	Following this procedure of 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 requirement of the product. Working with design consultancy to clarify doubts and wastes in product design
Supply Chain	
Involving Suppliers/manufacturer 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

Table 5.1: Comparison between Literature and Case Study

5.2 Comparison of the commercialisation timeline

Although both academic literature and the industrial case study considered the same factors within their commercialization processes, however the order of how things happened during the commercialization journey of the case study is slightly different and can be seen clearly in the two commercialization charts generated. The practical chart (top) is based on the case study findings and the theoretical chart (bottom) is based on the literature.

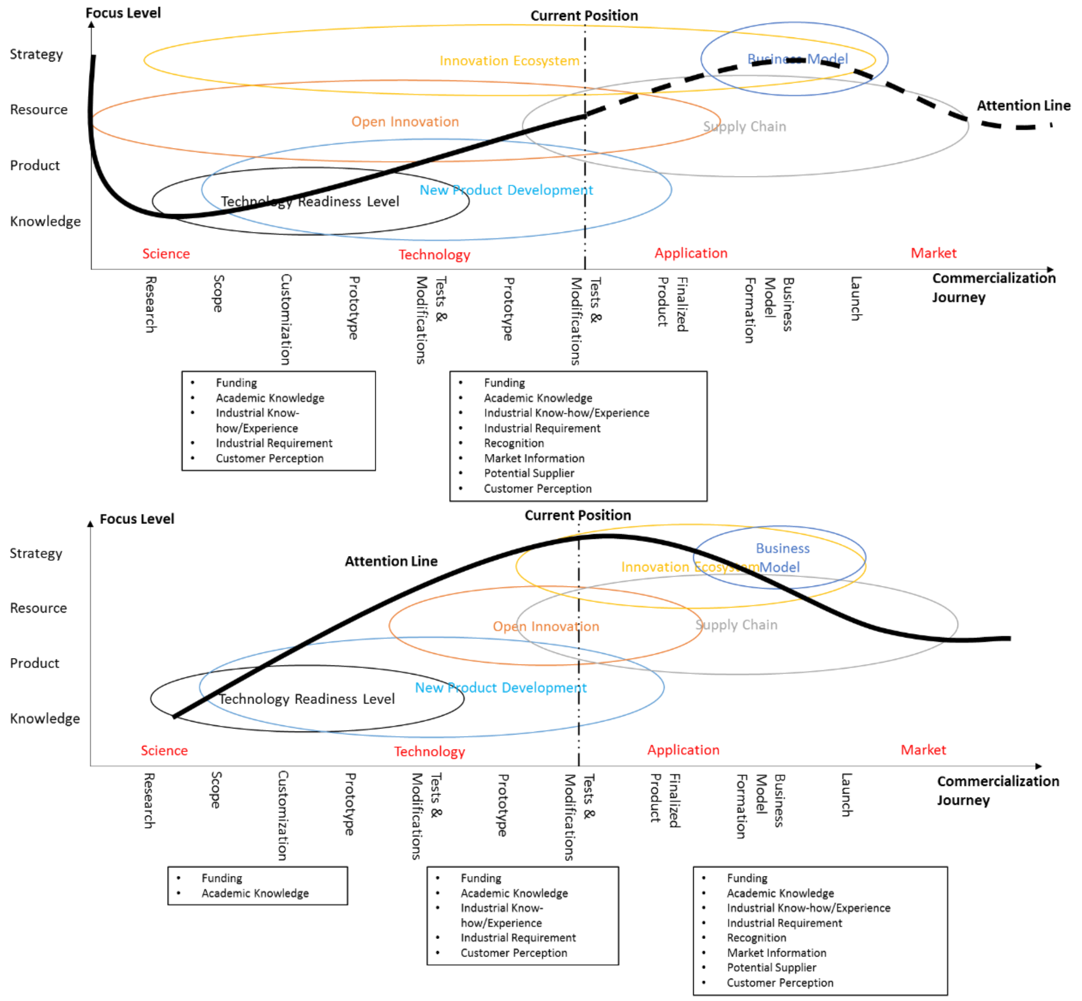


Figure 5.1: Practical (top) and Theoretical (lower) Commercialization Charts

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 are lacking. Therefore, the theory of innovation ecosystem and open innovation has been applied at the beginning of the project. In addition it can be seen from the top figure above that the thick dark line plotted which presenting the attention line moves between different levels. It started from resource and strategy level and move down quickly to the knowledge and product level, and then gradually shifted to the highest strategic level and eventually comes down to the resource and product level. As noticed from the interviews, large amount of resources was required at an early stage to help the researcher to set up 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 need much quicker with fewer and minor modifications. The vertical dotted line represents the current stage of FOSA project. Finishing up the final product prototyping, the researchers are making the final modifications and tests before finalising the product design. This project is close to the Application Stage.

5.3 Future projections

As the whole commercialisation process has not been completed, therefore, the attention line after the current stage is plotted in thick dotted line. This information was obtained through interviewing the project leader of the commercialisation programme regarding their future plan. Based on the 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.

5.4 Key stages observed in the practical commercialisation process

The practical commercialization chart generated showed an early start of applying the approaches stated in Open Innovation and Innovation Ecosystem research. The research focused on the strategy and resource level of the commercialization path. Therefore, the attention of the practical process of commercialization started from a high level (strategy and resource level) and then come to a lower level (product and knowledge level). After this early stage, the behaviour observed in the practical commercialization path becomes more similar to the theoretical commercialization path. By paying attention to the flow of the attention line, a 4-stage process can be observed from the chart which is presented in the figure below.

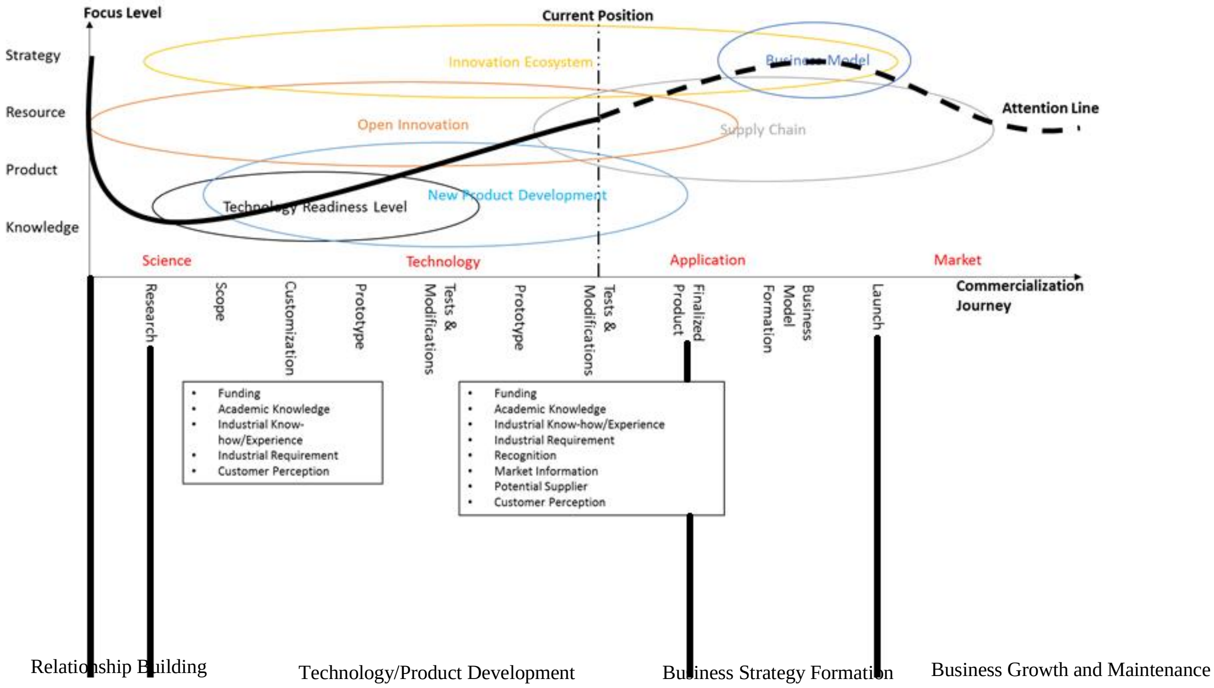


Figure 5.1: Commercialization Process Flow

By observing the behaviour of the attention line, it can be seen from the figure above that there are 4 main stages in the whole commercialization process. With attention line lying on the strategic and resource level, the first stage is Relationship Building, where focuses are on building good relationships with the industrial companies and supporting organizations to facilitate the development of technology and product. The second stage is Technology and Product Development stage. Most of the resources are obtained at this stage which can be seen from the two boxes in the figure above. 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 base on 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 earned. Currently, the FOSA project is at the end of the second stage (Technology/Product Development) and the beginning of the third stage (Business Strategy Formation). These stages help with choice/supply of appropriate tools to support the commercialization process.

6. Discussion

The theoretical commercialisation path derived focuses on the view of established companies. Established companies usually start hunting for new technologies that can be used in their design of the next generation of product. Through the approach stated in Open Innovation and Innovation Ecosystem, the established companies can obtain developed technologies very quickly and apply them in the new products. Therefore, from the academic point of view, the collaboration with external organizations can start slightly later, after the scope of the new product development is being determined.

However, the commercialisation journey of a research by a group of scientists is different. Coming from an academic background, the scientists have limited knowledge about the industry and the need of the final customers. Therefore, in order to make sure that their research can be developed into a product that is meeting the industrial requirement 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 industry to become better informed about the scientists' ongoing research. This mutual understanding and working relationships help the scientist 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 make a decision on closely collaborating or purchasing these technologies or products. A newly formed relationship is less favourable, as the company 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 need. 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 to final commercialization. It is worth noting at this point the iterative and resource dependent nature of commercialization, 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 commercialization for research, drawing upon the awareness and resources of the encompassing business ecosystem. Continuous communication with 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.

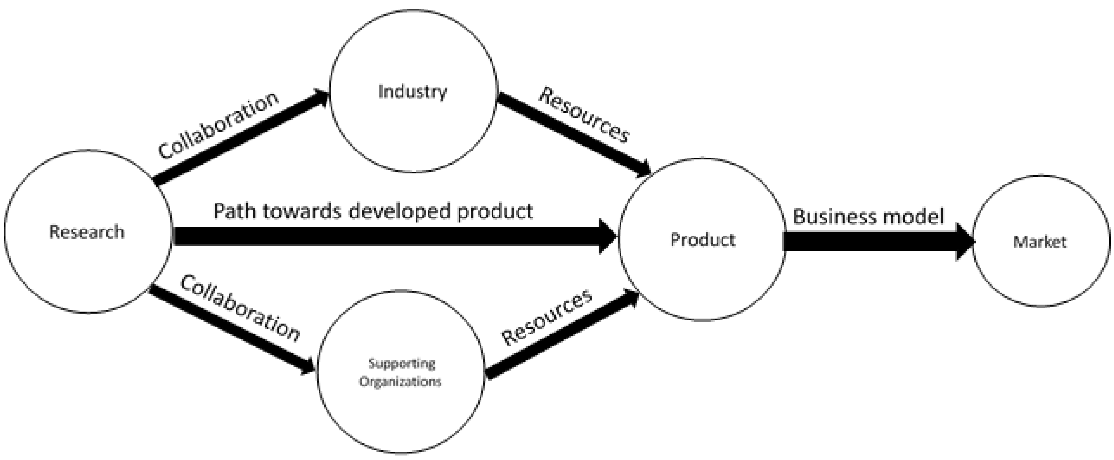


Figure 6.1 Simplified commercialization path highlighting collaboration

7. Conclusion

This work has identified and discussed the similarities and differences between theoretical and practical behaviours in the commercialization 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 commercializing their research into a technology or product, a simplified roadmap has been developed to guide similar programs in the future.

The key findings are as follow:

- Practical guidance on commercialization 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 commercialization based mainly on large companies and the practical behaviour found in one case study of commercialization of academic research revealed differences in timing and behaviour
- Continuous communication with industrial partners and supporting organizations from the very beginning is necessary to obtain useful information and resources to ensure the success of commercialization
- 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 recognized wider commercialisation process as a relatively new body of knowledge which requires further attention. This paper also identified and integrated the relevant individual research fields of commercialization process providing an overall view of commercialization. This integration can also be used to enrich the interaction mechanism in the theory of business ecosystem. For industry, this research discusses the commercialization process in a way that could be used as a discussion prompt to guide future commercialization 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 commercialization process in more depth, and more focus on the role of enterprise support organisations and practical materials that they might find useful.

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http://www-smartinfrastructure.eng.cam.ac.uk/what-we-do-and-why/focus-areas/sensors-data-collection/projects-and-deployments-case-studies/fibre-optic-strain-sensors

References

Adner, R., 2006. Innovation Ecosystem. *Harvard Business Review*, 84(4), pp.98–107.
Adner, R., 2012. *The Wide Leans - A New Strategy for Innovation*,
Adner, R. & Kapoor, R., 2010. Value Creation in Innovation Ecosystems : How The Structure of Technological Interdependence Affects Firm Performance in New Technology Generations. , 333(May 2008), pp.306–333.
Amit, R. & Zott, C., 2001. Value creation in e-business. *Strategic Management Journal*, 22(6-7), pp.493–520.
Chesbrough, H., 2004. Managing open innovation. *IEEE Engineering Management Review*, 32(2), pp.52–56.
Chesbrough, H. & Crowther, A.K., 2006. Beyond high technology: early adopters of open innovation in other industries. *R&D Management*, 36(3), pp.229–236.
Chesbrough, H. & Rosenbloom, R.S., 2002. The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. *Industrial and Corporate Change*, 11(3), pp.529–555.
Cooper, R.., 2006. Winning at New Products : Pathways to Profi table Innovation What Are the Keys to Success in Product Innovation ? *Proceedings of 2006 project management*, pp.1–19.
Easterby-Smith, M., 2002. *Management research.*,
Emden, Z., Calantone, R.J. & Droge, C., 2006. Collaborating for new product development: Selecting the partner with maximum potential to create value. *Journal of Product Innovation Management*, 23(4), pp.330–341. 90
Farrukh, C., Fraser, P. & Gregory, M., 2003. Development of a structured approach to assessing practice in product development collaborations. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, 217(8), pp.1131–1144.
Fraser, P., Farrukh, C. & Gregory, M., 2003. Managing product development collaborations ---- a process maturity approach. *Proc Instn Mech Engrs Part B: J Engineering Manufacture*, 217(11), pp.1499–1519.
Gambardella, A. & McGahan, A.M., 2010. Business-model innovation: General purpose technologies and their implications for industry structure. *Long Range Planning*, 43(2-3), pp.262–271.
Gassmann, O. & Enkel, E., 2004. Towards a theory of open innovation: three core process archetypes. *R&D management conference*, pp.1–18.
Hedman, J. & Kalling, T., 2003. The business model concept: theoretical underpinnings and empirical illustrations. *European Journal of Information Systems*, 12(1), pp.49–59.
Heikkilä, M. & Kuivaniemi, L., 2012. Ecosystem Under Construction: An Action Research Study on Entrepreneurship in a Business Ecosystem. *Technology Innovation Management …*, (June), pp.18–24.
Hoyer, W.D. et al., 2010. Consumer Cocreation in New Product Development. *Journal of Service Research*, 13(3), pp.283–296.
Huang, Z., 2015, Business Ecosystem: From Academy to Market, ISMM MPhil, Sept 2015.
Iansiti, M. & Levien, R., 2004. Strategy as Ecology. *Harvard Business Review*, 82(3).
Jarillo, J.C., 1989. Entrepreneurship and growth: the strategic use of external resources. *Journal of Business Venturing*, 4(2), pp.133–147.
Johnson, M.W., Christensen, C.M. & Kagermann, H., 2008. HBR ' s Must-Reads on Strategy What Is Strategy ? *Strategy*, 86(12), p.143. 91
Kothari, C.R., 1990. *Research Methodology: Methods & Techniques*,
V. Krishnan; Karl T. Ulrich, 2001. Product development decisions.pdf. , pp.1–21.
Li, H.-H.J.K.. et al., 2014. Rapid production ramp-up capability: A collaborative supply network perspective. *International Journal of Production Research*, 52(10), pp.2999–3013.
Lin, C.-H., Shih, H.-Y. & Sher, P.J., 2008. Integrating Technology Readiness into Technology Acceptance: The TRAM Model. , 24(July 2007), pp.641–657.
Lounsbury, M. & Glynn, M.A., 2001. Cultural entrepreneurship: Stories, legitimacy, and the acquisition of resources. *Strategic Management Journal*, 22(6-7), pp.545–564.
Mankins, J.C., 2009. Technology readiness assessments: A retrospective. *Acta Astronautica*, 65(9-10), pp.1216–1223.
Mankins, J.C., 1995. Technology Readiness Levels. *White Paper April*, 6(2), p.5.
Mishra, A. a. & Shah, R., 2009. In union lies strength: Collaborative competence in new product development and its performance effects. *Journal of Operations Management*, 27(4), pp.324–338.
Moore, J.F., 1993. A New Ecology of Competition Harvard Business Review. *Harvard Business Review*, pp.75–86.
Moore, J.F., 1996. *The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems*,
Morris, M., Schindehutte, M. & Allen, J., 2005. The entrepreneur's business model: Toward a unified perspective. *Journal of Business Research*, 58(6), pp.726–735.
Nicolaou, N. et al., 2008. the Influence of Sensation Seeking in the Heritability of Entrepreneurship. , 94, pp.73–94. 92
Parasuraman, A., 2000. Technology Readiness Index (Tri): A Multiple-Item Scale to Measure Readiness to Embrace New Technologies. *Journal of Service Research*, 2(4), pp.307–320.

Perks, H., 2000. Marketing Information Exchange Mechanisms in Collaborative New Product Development: The Influence of Resource Balance and Competitiveness. *Industrial Marketing Management*, 29(2), pp.179–189.
Petersen, K.J. et al., 1999. Involving suppliers in new product development? *California …*, 42(1), pp.59–82.
Petersen, K.J., Handfield, R.B. & Ragatz, G.L., 2005. Supplier integration into new product development: Coordinating product, process and supply chain design. *Journal of Operations Management*, 23(3-4), pp.371–388.
Phaal, R. et al., 2011. A framework for mapping industrial emergence. *Technological Forecasting and Social Change*, 78(2), pp.217–230.
Reid, S.E. & De Brentani, U., 2004. The fuzzy front end of new product development for discontinuous innovations: A theoretical model. *Journal of Product Innovation Management*, 21(3), pp.170–184.
Remenyi, D., 1995. So you want to be an academic researcher in business and management studies ! So you want to be an academic researcher in business and management studies ! *University of Witwatersrand,Johannesburg*, Management(Working Paper), p.28.
Rong, K. & Shi, Y., 2009. Constructing Business Ecosystem from Firm Perspective: Cases in High-tech Industry. *Proceedings of the International Conference on management of emergent digital ecosystems, 10/2009, MEDES '09*, pp.417–421.
Rong, K., Shi, Y. & Yu, J., 2013. Nurturing business ecosystems to deal with industry uncertainties. *Industrial Management & Data Systems*, 113(3), pp.385–402. 93
Shang, T. & Shi, Y., 2013. *Nurturing Emerging Industries through Business Ecosystems: The Evolutionary Processes and Key Building Blocks*,
Shi, B., 2014. Development of Fibre Optic Sensor Analyser in Civil and Construction Industry. , (September).
Teece, D.J., 2010. Business models, business strategy and innovation. *Long Range Planning*, 43(2-3), pp.172–194.
Traitler, H., Watzke, H.J. & Saguy, I.S., 2011. Reinventing R&D in an Open Innovation Ecosystem. *Journal of Food Science*, 76(2).
Vecchio, R.P., 2003. Entrepreneurship and leadership: Common trends and common threads. *Human Resource Management Review*, 13(2), pp.303–327.
Van de Vrande, V. et al., 2009. Open innovation in SMEs: Trends, motives and management challenges. *Technovation*, 29(6-7), pp.423–437.
Wang, P., 2009. Advancing the Study of Innovation and Globalization in Organizations. *Advancing the Study of Innovation and Globalization in Organizations*, pp.301–314.
Yin, R.K., 2002. *Case Study Research: Design and Methods*. Sage.