Instituto Tecnológico y de Estudios Superiores de Monterrey

EGADE Business School

From research to market: An examination of support mechanisms for science-based new firms

A dissertation presented by

Elda Barrón Pérez

Submitted to the
EGADE Business School
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
in
Business Administration

Major in Entrepreneurship

Monterrey Nuevo León, May 22th, 2019

Instituto Tecnológico y de Estudios Superiores de Monterrey

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The committee members, hereby, certify that have read the dissertation presented by Elda Barrón Pérez and that it is fully adequate in scope and quality as a partial requirement for the degree of Doctor of Philosophy in Business Administration, with a major in Entrepreneurship.

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Declaration of Authorship

I, Elda Barrón Pérez declare that this dissertation titled, from research to market: An examination of support mechanisms for science-based new firms and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this dissertation has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this dissertation is entirely my own work.
- I have acknowledged all main sources of help.
- Where the dissertation is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Elda Barrón Pérez
Monterrey Nuevo León, May 22, 2019

Acknowledgments

First of all, I would like to thank my committee chair, José Ernesto Amorós, for his expertise and guidance throughout the process to develop this dissertation. I thank him for offering me the opportunity and freedom to participate in the research of an entrepreneurial program. Also, I would like to thank my committee, Marcía Villasana and Fernando Moya. Thanks to help and feedback, this project was possible. I was fortunate to have a committee that is passionate about entrepreneurship and science. I thank EGADE Business School to providing a supportive environment during my doctoral project.

To my family, I would like to thank you for all your support, cheers, and patience. Dad, thanks for being my number one fan and read every single work. Mom, thank you for all your love and messages. To my doctoral team, thanks for every moment during this journey. OB team, thanks for every research discussion, every trip, and friendship. To all my friends thank you for supporting and understanding my doctoral project

Besides, I would like to thank NoBI staff. Thanks, NoBI Norte, Bajío, Innovación en Salud, MAP, Sureste, Universitario, Noroeste and Energía for the support and facilities for this research took place. I want to thank each NoBI coordination for the attention and support during this research. For the teams, thanks for your time, each interview was a fantastic experience. For the teaching team, thanks for making me feel part of a big team in each node.

Finally, I acknowledge the support of CONACYT (Mexico) for this research under 2018 project number: 0296891 “Evaluación de Impacto y Seguimiento de los

Nodos Binacionales de Innovación (NoBIs).” Also, I thank CONACYT and EGADE, Tecnologico de Moterrey, for the grant to make my doctoral project possible.

From research to market: An examination of support mechanisms for science-based new firms

By

Elda Barrón Pérez

Abstract

Science-based entrepreneurship, like other types of new venture creation, is thoroughly exposed to "valley of death" phenomena. The "valley of death" is a time-period where scientists move from research to product development and subsequent commercialization phase. Despite several efforts, the majority of these new ventures fail to reach the following growth period. This dissertation examines entrepreneurial mechanisms as bridges to cross the valley. Through four studies, I analyze entrepreneurship mentoring, the lean startup method, and entrepreneurial education as bridges to move scientist from research to market. This research examines an entrepreneurial program as a context to study the scientific community. I combined a systematic review, qualitative, and qualitative methodological approaches. This research highlights the fact that it is possible to move scientists from research to market. Results suggest a positive impact of an entrepreneurial program on their participants in terms of business knowledge, entrepreneurial behavior, and customer validation. Also, this research contributes to understanding the context and public policies related to science commercialization in developing economies.

Contents

From research to market: An examination of support mechanisms for science-based new firms

Chapter 1

Introduction

Entrepreneurship research covers different perspectives, from individual perspectives to the more holistic perspective of the entrepreneurial ecosystem. Among these perspectives, this thesis uses science-based entrepreneurship as a study subject. This type of entrepreneurship is related to the opportunities that scientific researchers need to take to produce and transform knowledge into practical application. In particular, I study the context of science commercialization.

Science-based entrepreneurship is used to exploit commercially scientific knowledge, particularly from academic research (Colombo et al., 2010). The concepts of science commercialization and entrepreneurship are closely connected. Entrepreneurs introduce new products into the market. The scientific community, through discovery and research, creates solutions and commercialization, allowing these solutions to be brought to the market.

The increasing interest in science-based entrepreneurship is not a novelty in itself. What is new, however, is the number of programs and public policies focused on it. Many countries allocate efforts to increase their rates of entrepreneurship, and in particular science- and technology-based entrepreneurship. This interest is due to the positive economic and social effects of innovation and new ventures of this kind.

Moreover, there is a gap between science research and marketable science. Although not all science has or should have a commercial purpose, many of the discoveries from the laboratory with commercials goals fail to have practical applications or bring about tangible benefits. The purpose of this dissertation is to address the phenomenon of commercializing science and how entrepreneurial mechanisms support the translation from research to market. This phenomenon has received relevant interest in recent years due to investment in science and technology, as well as the trend of developed economies towards knowledge and technology.

The exploitation of basic scientific discoveries and research to produce commercially viable technological and science-based innovations is critical for innovation. Governments allocate resources for research and development in order to boost innovation and science. For example, according to the Bloomberg Innovation Index 2019, South Korea, Germany, and Finland are the world's most innovative countries (Wei Lu, 2019). These countries present higher indices of R&D expenditures, reflecting how government initiatives can boost innovation and science.

R&D spending covers basic research, applied, and experimental research. These expenditures support different initiatives that include funding for research centers, universities, support for investigators, and government programs, among others. Likewise, more innovative countries also have higher indices of patent filings, research personnel, and high-tech density. According to these results, innovative countries build integrated systems to support research and science production.

In contrast, countries with lower indices of innovation present less R&D expenditures and patent filings. Some developing countries such as China and Brazil bet heavily on science, assigning 2.11% and 1.28% of their GDP, respectively, to R&D. In contrast, Mexico has only increased the resources assigned to R&D by 0.07% in the last ten years, allocating 0.5% of GDP to R&D investments, and many of these resources come from public sources. While there is a positive relationship between investment and innovation and science production, not only the investment in science but also how these funds are used is important to consider.

Even when a country invests in science, if it does not have a favorable context for its development, it will not produce results that motivate it to continue investing. Beyond developing a system to support science economically, there are other factors involved to translate public efforts into results that produce economic and social benefits. In particular, the science community faces “the valley of death” for commercializing science, in both developed and developing economies, regardless of whether or not they are innovative.

The valley of death is a metaphor about the difficulty of moving from research to the market (Auerswald & Branscomb, 2003; Frank, 1996; Markham et al., 2010). The valley of death outlook identifies the elements that continue the tensions between invention and commercial innovation within both research centers and organizations. Previous research identifies different barriers and factors that prevent crossing the valley, such as lack of marketable skills, funding, and intellectual property. Moreover, for many researchers, the problem of commercializing science is related to an entrepreneurial culture, personal goals, and incentives (Upadhyayul, 2018; Wessner, 2005).

The lack of commercially feasible technological and science-based innovations reduces the possibilities of starting science-based new ventures. Previous research has addressed how to bridge “the valley.” Some resources serve as bridges between research and the market. Gamo et al. (2017) proposed to build a translational bridge based on the training of young trainees (scientists) in the process of translating research from academia to industry. There are different actors involved in educational systems (mainly higher education), such as business incubators and accelerators, educational programs, and academic discovery centers. In this way, education, particularly entrepreneurship education, emerges as a bridge to cross the valley of death.

I aim to study entrepreneurial mechanisms as bridges to cross the valley. Specifically, this research focuses on the entrepreneurship education, entrepreneurship mentoring, the lean startup method, and public policy as bridges to help scientist to cross the valley. Moreover, according to prior works, one barrier is related to the product fit to the market. Scientists thus must develop commercial skills to fit their ideas with market requirements.

One of the most of critical issues related to the market is validation. One method to provide a fast way to validate a business model in the market is the lean startup methodology. This methodology is based on the principle that the business model hypotheses must be validated iteratively through customer feedback, matching products to customer problems as much as possible (Heitmann, 2014). The lean startup methodology favors experimentation, iteration, and customer learning (Blank & Dorf, 2012). It is precisely this characteristic of interaction with the market that makes this method attractive for the validation of technologies and scientific inventions.

Thus, there are several questions to address around the topic, such as: Is it possible to transform scientists into entrepreneurs? What are the barriers and facilitators that aid in science commercialization? Can an entrepreneurship education program move scientist from research to the market? Based on these questions, I designed a set of studies to understand the problem of the commercialization of science and the implementation of a program as part of the commercializing process.

This research analyzes main elements of the commercializing process in a specific context: scientific mindset, mentoring and education, and public policy. For empirical purposes, I study a government program, its implementation, actors, and performance. This program, named Nodos Binacionales de Inovacion (NoBi) (translated as Binational Innovation Nodes), has particularities that provide a framework to explore how education can serve as a bridge to cross the valley of death.

This program seeks to train researchers (scientists) and entrepreneurs in the exploration of the market for technology and inventions from higher education institutions or public research centers. This program follows a customer discovery methodology to achieve four objectives: 1) Technological maturation, 2) Transfer and commercialization, 3) Science-based entrepreneurship, and 4) Linkage.

I aim to examine how training and real experience with customers affect the entrepreneurial behavior of scientists. During this program, participants go out of their comfort zone, leaving the laboratory to explore the market. For many scientists, this is their first experience with real customers and with the industry. Moreover, during the program, participants receive training in new business skills and concepts, such as the business model canvas, customer discovery, and buyer profile.

Moreover, another particularity of this program is in the composition of participants. Participants are grouped in teams, each with a principal investigator, entrepreneurial leader, and business mentor. In contrast to other entrepreneurial programs, in this case, the mentor is a member of the team. This characteristic provides an opportunity to analyze the dynamic of the mentor and mentees in a context that mixes science and entrepreneurship.

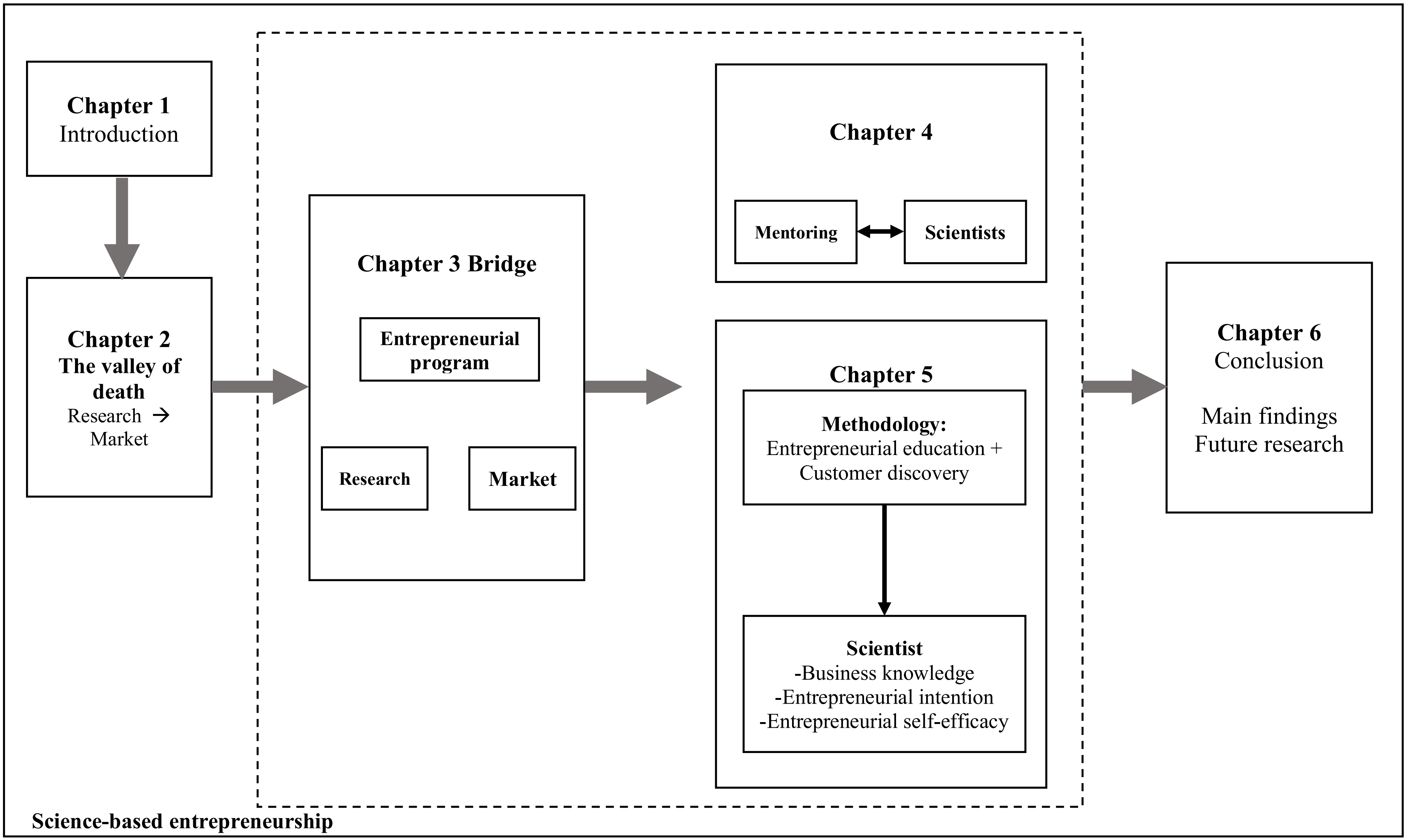
I aim to analyze how to move scientists from research to the market in terms of business knowledge, entrepreneurial behavior, and customer validation, as well as to identify the mechanisms that support scientists during this process. This research seeks to provide a framework to help the starting of new science-based firms.

This dissertation includes four studies, ranging from the analysis of the theoretical perspective of the valley of death to the examination of entrepreneurial mechanisms as bridges to cross the valley. I study mentoring, the lean startup method, and the aforementioned entrepreneurial program as bridges. I combined qualitative and qualitative methodological approaches to gain a better understanding of the phenomenon. Figure 1 shows a schema of the dissertation content.

Following this introductory chapter, Chapter 2 shows an analysis of the problem of science commercialization through the valley of death perspective. I follow a systematic review of the phenomenon of the valley of death to examine the state of the art of this problem. As mentioned earlier, the valley of death refers to the difficulty of moving from research to the market. This study aims to provide an integrated framework that includes barriers, facilitators, and bridges from different disciplines. I take this study as a reference to realize the importance of this problem and how previous studies have addressed it.

Chapter 3 focuses on describing the empirical setting. I describe the NoBI program, including its methods, actors, and performance. This study is an example of public policy focused on boosting science entrepreneurship. I analyze the implementation of the NoBI program through several sources. As a result of case analysis, I present lessons from the experience of different actors immersed in the program.

Figure 1. Dissertation schema



The third study, in Chapter 4, is focused on a specific actor: the mentor. Entrepreneurship mentoring implies a support relationship between an experienced professional or entrepreneur (the mentor), and a novice entrepreneur (the mentee) (St-Jean & Audet, 2012). Existing studies suggest that mentors have a positive impact on the mentees' entrepreneurial activity, increasing their managerial knowledge and improving their entrepreneurial identity.

I followed a qualitative approach to define and examine the impact of mentors under an entrepreneurial program and scientific context. I analyzed eleven mentors from one node of NoBI program. I study the mentor-mentee dynamics during a customer validation process. This study presents a description of the mentors' role under the lean startup methodology and intensive program. I also examine mentors' impact on their teams.

In Chapter 5, I present a study that focuses on a lean startup method and its impact. As is well known, the lean startup method is one of the most popular methodologies for entrepreneurship education worldwide. This study aims to analyze the effect of a lean startup program for science-based projects. The study follows a quantitative two-stage longitudinal approach to measure the impact of the NoBI program on participants.

The goal of this chapter is to show the contrast before and after the program and to measure the change of scientists into entrepreneurs. I performed evaluations of self-efficacy, entrepreneurial intention, and business model learning on a group of 317 scientists. The study examines variables commonly measured in the entrepreneurship literature in a scientific context.

In sum, this integrated thesis aims to contribute to understanding science commercialization through the examination of actors and mechanisms that serve as bridges to transfer research to the market. Science-based entrepreneurship and entrepreneurial programs are important topics with applications beyond academia. These topics have very important practical relevance. Practical implications include the design of public policy, implementation of programs, and technology transfer mechanisms.

Chapter 2

From research to commercialization: A systematic review on the valley of death

1. Introduction

The growing attention and research proliferation in the field of entrepreneurship has brought with it the specialization and diversification of topics, for example, science-based entrepreneurship. This proliferation has repercussions beyond the academic ones presents important challenges that as academics we must attend to. In particular, we must consider science-based entrepreneurship's positive economic and social consequences. It is increasingly common to hear about public policies and private programs focused on launching and supporting science-based ventures (Abbot, 1999; Butler, 1998). Thus, science-based or scientific entrepreneurship requires research focused on understanding its dynamics and peculiarities that provide a framework for the topic.

One of the most critical challenges associated with science-based entrepreneurship is science commercialization. This process deals with the characteristics of this kind of venture. On the one hand, there are difficulties related to the nature of the venture, such as the extended time required to launch a product or the cost to test new technology (Miozzo & DiVito, 2016). On the other hand, there are problems associated with individual factors such as motivation and incentives. Many researchers face the challenge of aligning personal goals and institutional objectives.   These examples illustrate problems related to commercialization of research in the science and technology areas.

The valley of death is a metaphor used to describe the difficulty of commercializing science research. According to this concept, there are a greater number of resources on one side of the valley (research) than on the other side (commercialization/market) (Markham, Ward, Aiman-Smith, & Kingon, 2010). This representation helps visualize a problem through a schema that is easily replicable and adaptable to different sectors. Nowadays, there are many areas that adopt this metaphor to explain problems related to commercialization and their different roots. For example, in medicine this schema is used to exemplify the process used to design a device, from research to the clinical application (Fernandez-Moure, 2016).

The valley of death is a common problem for science-based new firms and academic research. Previous work attributes this situation to the lack of skills of scientists, lack of funding or lack of fit to the market (Auerswald & Branscomb, 2003; Frank et al.,1996). To support academia and research to cross the valley, some mechanisms emerge as a bridge between research and the market, such as consortia, business incubators, and accelerators, to name a few (Gamo et al., 2017). This study focuses on reviewing the literature of the valley of death to identify barriers and facilitators to crossing the valley.

We aim to investigate the "valley of death" phenomenon through a two-stage process that combines a bibliometric analysis and a systematic literature review (Diez-Vial & Montoro-Sanchez, 2017). We identified, evaluated and synthesized relevant studies from different disciplines. In the first stage, we obtained a general perspective of the valley of death from previous research. In the second stage, we analyzed selected studies to identify characteristics, conditions, and actors associated with the valley of death.

We first obtained an overview of the state of the art in the valley of death. Later, we developed a conceptual framework of the success factors and barriers associated with bridging the valley of death. Our results provide a roadmap for critical problems related to many science-based entrepreneurship projects. Also, we offer a level classification of factors, actors, and conditions immersed in the phenomenon. Additionally, this study contributes to describing and identifying bridges and crossing mechanisms.

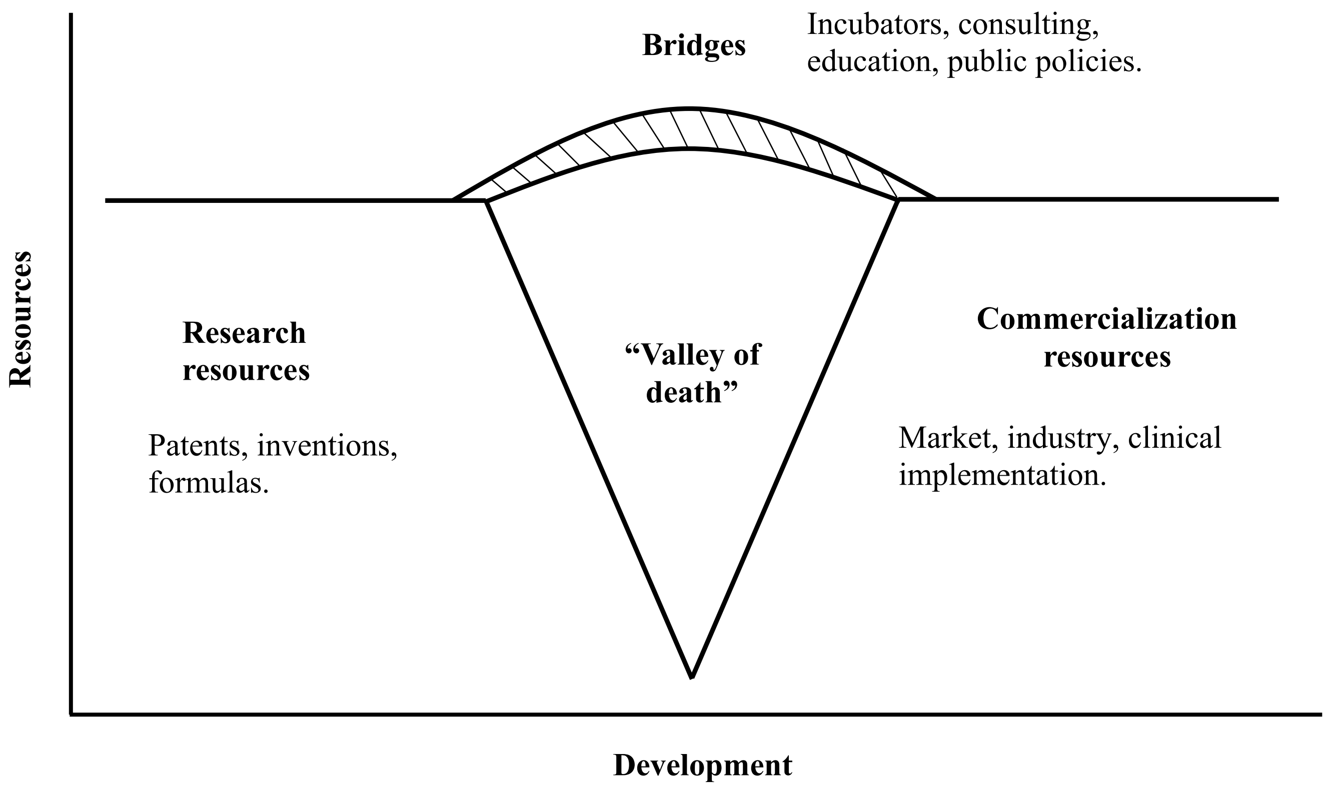
In this article, we contribute to the literature by linking different areas like science and entrepreneurship to build an integrated framework about science commercialization that highlights the issues, challenges, and recommendations to cross the valley of death. We also identify lines for future research under this framework.

2. The Valley of Death

The concept of the valley of death refers to the difficulty to move from research to the product development and commercialization phase (Aragón et al., 2017; Markham, 2002; Markham et al., 2010). There are different concepts associated with this phenomenon to consider. For example, technology transfer refers to the process from invention to commercialization (Van Norman & Eisenkot, 2017). Also, a common term in medicine is translational research, which refers the process to transfer research into practice; in this area, this process has two break points: human testing and medical use (Butler, 2008; Fernandez-Moure, 2016).

The metaphor of the valley of death conceptualizes how the lack of resources and expertise in product development ends in product failure (i.e., researchers end up not crossing but rather falling into the valley). Under this premise, the lack of mechanisms or skills to transition across the valley causes the fall inside the valley, which can be temporary or permanent. This means that many projects never see the light, thus causing financial losses and research without market validation. Also, this failure can cause the close of a research line and funding for research centers. Figure 1 represents the metaphor of the valley death.

Figure 1. The valley of death



Problems associated with science commercialization and the valley of death phenomenon have different origins; for example, some research centers produce scientific and technological research, but they do not have skills to commercialize them. For others it is a matter of funding, and for still other areas commercialization is a necessary and complex process of testing that requires a long-term time investment (i.e., pharmacology, medicine). Previous research suggests that support mechanisms can help bridge the valley (Gamo et al., 2017). These include external institutions like incubators and accelerators that help scientists to align their research to a specific market. Also, there are internal supports, which include the office of technology transfers and mentoring.

Science-based entrepreneurship is created to exploit commercially scientific knowledge, particularly from academic research (Colombo et al., 2010). For this field, the valley of death implies a crucial phase for starting a new business. From an entrepreneurial perspective, the valley of death has been studied with regard to the entrepreneur's skills and the success or failure of science-based firms (Barr et al., 2009). For example, how to provide the scientist with the business and technical skills to start a firm has been considered.

Today, there is research that addresses the valley of death from different perspectives, such as entrepreneurial, commercial and economic perspectives (Meslin et al., 2013; Osawa & Miyazaki, 2016). Research about this phenomenon is in a transition phase, from conceptualization work to empirical investigation. This study provides a framework for understanding previous literature about the valley of death and science commercialization. Our goal is to integrate the different perspectives, concepts, and results on the same phenomenon.

3. Methods

We followed a two-stage methodological design to obtain a deep understanding of the phenomenon, including its concepts, challenges, results, and future steps. On the one hand, bibliometric analysis allows for a panoramic vision of the field;

this perspective shows aggregate results through a quantitative approach. On the other hand, the systematic literature review provides a particular view of the state of literature.

3.1 Bibliometric Analysis

We conducted a bibliometric analysis to recompile and visualize the evolution of the conceptualization and empirical research of the valley of death. We follow similar methodological designs (e.g., Diez-Vial & Montoro-Sanchez, 2017; Vallaster et al., 2019) to compile and analyze previous research. To identify relevant publications related to the phenomenon, we followed a series of steps in the research process. Firstly, we defined the search criteria for the valley of death and commercialization phase. We selected the keyword phrase "valley of death." Secondly, we limited the document type to articles and reviews, thus excluding books, books chapters, conference papers, reports, and notes. Third, we determined the scope as including publications up to 2018. We did not limit this research to management or entrepreneurial journals; instead, this research also covers science and technology publications. Journal criteria follow the top journal's index from Scimago Journal and Country Rank. After determining the selection criteria, we used the Scopus database to obtain the articles for this phase of the searching. We obtained a total of 364 items that met our criterion. After a second filter based on research areas, we selected 99 papers for the bibliometric analysis.

We used VOS Viewer software to analyze our database. This tool allows for identifying connections and frequencies of publications through a quantitative approach. We analyzed the keywords to identify patterns and tendencies.

3.2 Literature review

After the bibliometric analysis, we aggregated the keywords "commercialization," "translational research," "technology transfer" and "science-based entrepreneurship." Also, we included the EBSCO and Science Direct databases to increase the precision. We reviewed the abstracts and keywords manually to clean and discard publications not related to the phenomenon and not focused-on commercialization. After that, we finally obtained a total of 44 articles for the systematic review. For the analysis of this phase, we adapted the systematic review proposed by Jones (2011).

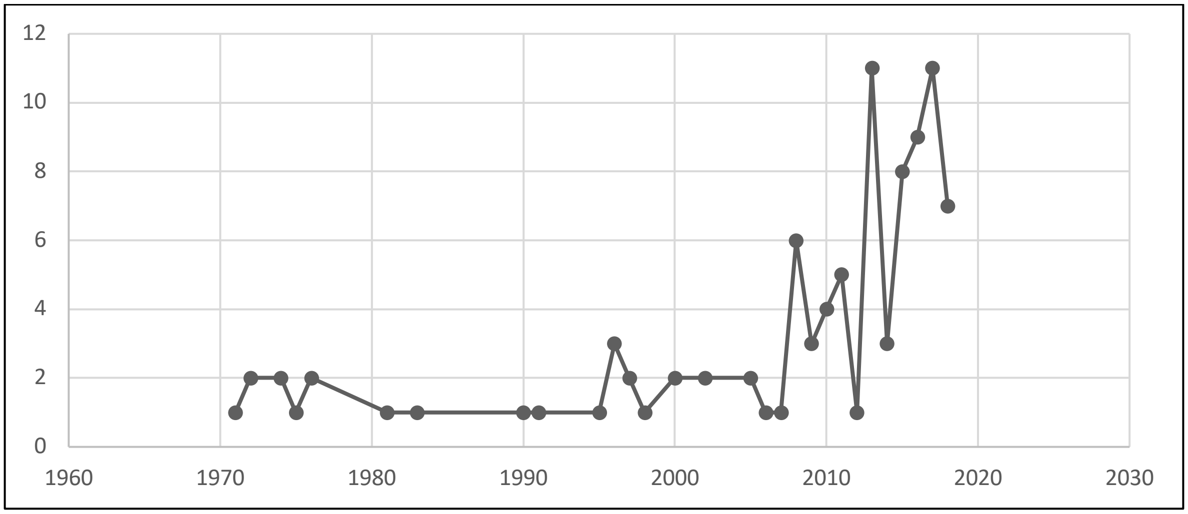
Our analysis process includes the following phases: 1) Data organization, consisting of ordering papers chronologically and preparing papers for comparison; 2) Theme classification and coding, in which we determine topics and codes to classify papers; and 3) Interpretation and validation, in which descriptors and codes are synthesized and ordered by theme.

4. Results

4.1 Descriptive analysis: Overview of the research on the valley of death

Results from the bibliometric analysis represent a panoramic view of the valley of death that includes time, areas, authorship and keywords. Figure 2 shows the trend across time of publications about this topic; after the first publication in 1971, the number of publications increased slowly until 2008, after which we observe a rapid increase of publications.

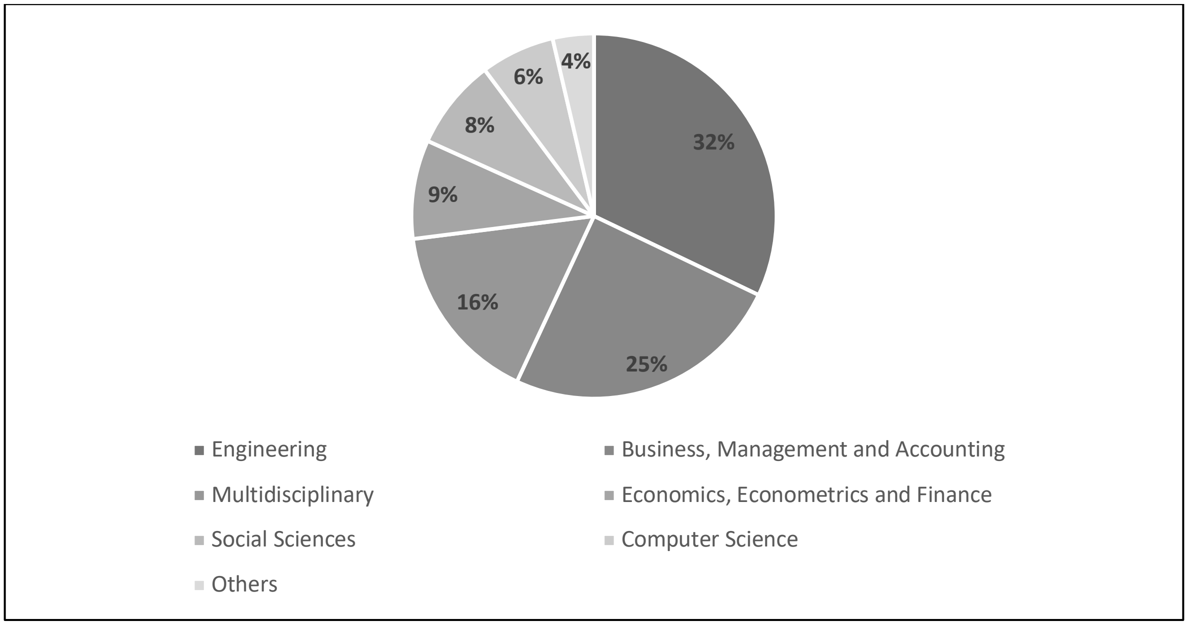
Figure 2. Trend of publications per year



The areas involved in the study of the valley of death are varied. Figure 3 presents publications grouped by the principal disciplines. It is important to mention that we discarded some areas due to confusion regarding the use of the term valley of death (e.g., geology, medicine). Results show a major concentration of documents in Business and Engineering. Also, a multidisciplinary approach is common in articles of this kind (e.g., engineering and business; Barr et al., 2009).

Another interesting indicator to better understand the problem of commercialization is to identify the origins of publications. Our analysis indicates that the majority of papers are from the US, follow by UK, Japan, Canada, and the Netherlands.

Figure 3. Publications by subject areas

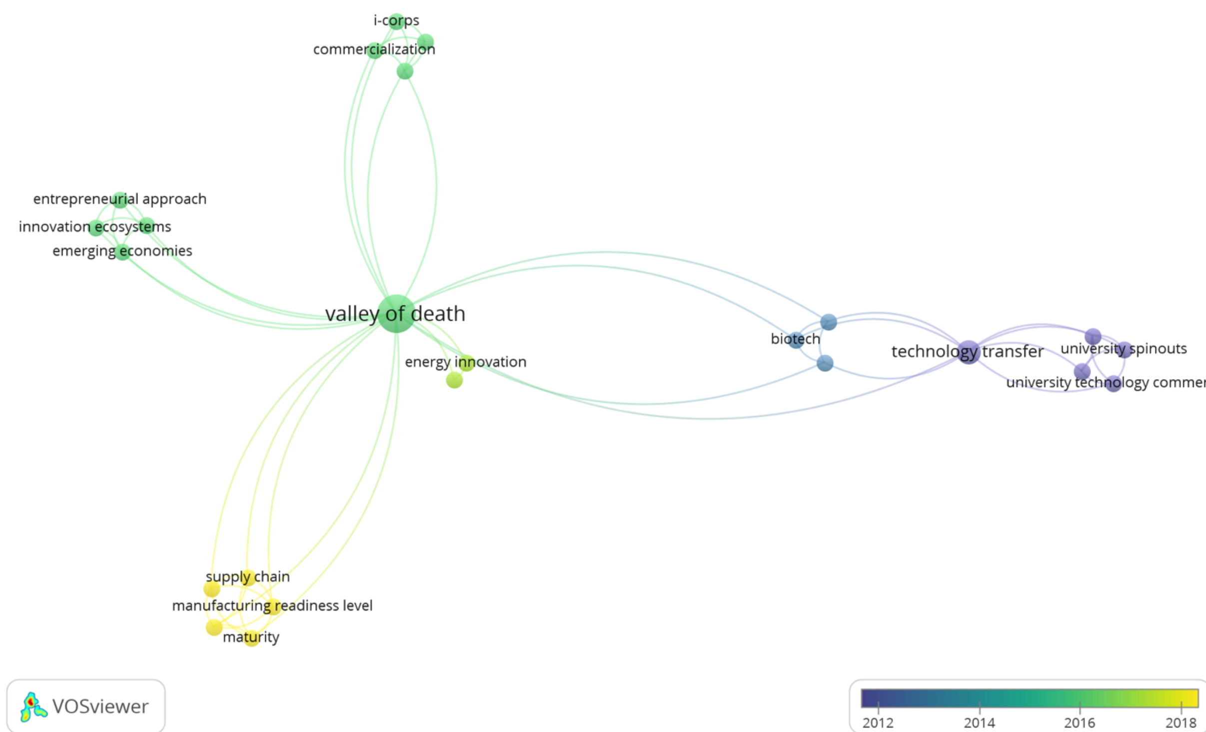


Using the mapping tool VOS Viewer, we obtained a graph representing the density and connection of keywords. Figure 4 shows the most used terms related to the valley of death. We found that the main keywords are: “commercialization,” “I-corps,” “entrepreneurial approach,” “innovation ecosystems,” “technology transfer” and “energy innovation.” Also, Table 1 shows the most used terms per year. The years are limited to 2012-2018, as this is the only period where the connection between names is validated. This finding is logical, since this period contains the majority of publications. These results are relevant to understanding the evolution of the phenomenon and observing the tendency of the research scope.

Table 1. Principal keywords in each year

Period	Principal Keywords
2012	Technology transfer, University technology commercialization, University spinouts
2014	Biotech
2016	I-corps, Commercialization, Entrepreneurial approach, Innovation ecosystems
2018	Energy innovation, Supply chain, Manufacturing

Figure 4. Co-occurrence of keywords

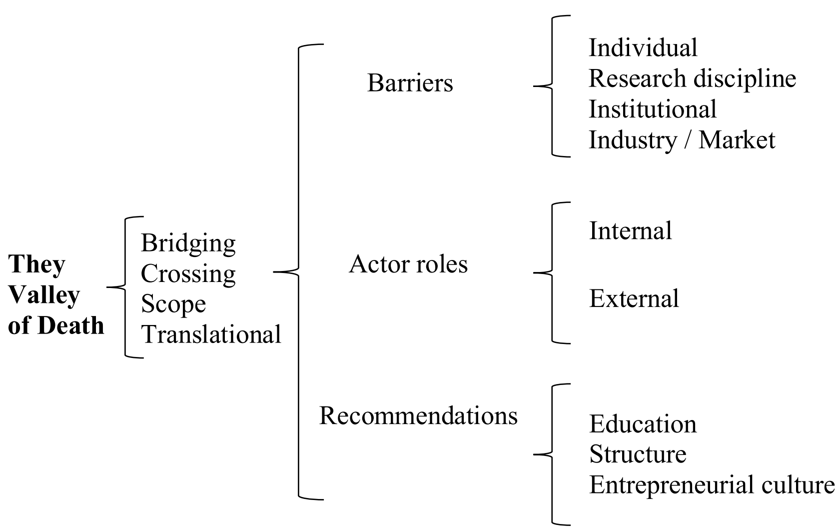


4.2 Literature review: State of the valley of death

For the second phase of this study, we selected 44 articles for in-depth review and analysis. Our revision covers a scope from 1996 to 2019. Also, this selection includes papers published in top journals according to the Scimago Journal & Country Rank (Q1 and Q2). The documents are from different disciplines: business, computer science, biochemistry, economics, energy, and medicine. We classified papers according to their methodological approach as conceptual and empirical (quantitative and qualitative). We found that the majority of the articles are conceptual; some of these papers conceptualize the valley of death (Coller & Califf, 2009; Markham, 2002). Likewise, empirical research is mostly qualitative, case studies and interviews are the main methods implemented (Auerswald & Branscomb, 2003; Maughan et al., 2013; Nemet et al., 2018). A smaller number of publications have a quantitative approach, and in these we observed that surveys are the most common data collection method (Markham et al., 2010; Meslin et al., 2013; Wu et al., 2014).

After organizing and selecting documents by time and approach, we moved on to theme classification and coding. We constructed a thematic map for organizing the content of each document. Figure 5 illustrates each theme addressed by this study; it is essential to clarify that one document can be classified in more than one topic. The classification and organization represent a critical process to build an integrated framework and a panoramic view of the topic scope. We develop three aspects of the valley of death to address: 1) Barriers, 2) Actor roles, and 3) Recommendations.

Figure 5. Thematic map



4.2.1 Barriers to translate research to the market

We classified as barriers all aspects that impede or hinder the transition from research to the commercialization phase. We identify three levels of barriers: 1) Individual (barriers that are associated with the mindset and skills of scientists); 2) Research discipline (some areas have some obstacles due to their nature, e.g., medicine); 3) Institutional (we found obstacles related to the research center or public policies); and 4) Industry/market (these barriers refer to characteristics of a specific market).

Individual

Motivation: this barrier refers to the lack of personal motives to commercialize research. For example, according to Upadhyayul (2018), scientists perceive that institutional incentives (from the government or research centers) hinder commercialization, as they are required to publish articles instead of other activities to maintain their financial benefits. Scientists need motivation that boosts their interest to relate to commercial activities.

Lack of commercial skills: for some investigators, the lack of marketable or business skills is an essential barrier to bridging the valley. Commercial skills consist of abilities and knowledge beyond their scientific discipline, such as business skills, intellectual property, and market segmentation knowledge (Frank, 1996).

Prejudice: there is a stigma about commercialization, which represents a barrier to the translation of research to market (Yu, 2016). For example, for some scientists the idea to translate their research to products is not a pathway.

Research discipline

Some investigators can have abilities and support from their research center; even so, there are barriers beyond the scientist and institutions. Some research has obstacles associated with the nature of the projects and the research discipline. For example, in medicine, projects need extensive time and funding, and even after great effort there are no guarantees that they will move from research to the market (Nemet, 2018). Also, some disciplines obtain more funding and government support than others because of public objectives or private interests.

Institutional

Culture: one obstacle to commercializing science involves government-industry cooperation; for some scientist, the link between institutions and the industry is not well perceived (Wessner 2005). Furthermore, research centers can spread the stigma of commercialization.

Funding: one of the most mentioned barriers for commercializing research is the lack of financial resources; for many centers, financing depends on sponsor and political support (Adams, 2012; Cardozo, 2019; Frank et al., 1996).

*Incentive*s: this barrier is closely related to motivation; it refers to incentive structure, which many centers of research base on the number of published research studies and funding attraction. The lack of incentives to promote commercialization leads scientists to stay in their comfort zone and limit entrepreneurial activity inside research centers.

Structure and organizing: the process for commercializing research is unclear and not transparent to the community. Also, some institutions support some research projects over others without a selection process (Friedl, 2006; Mossberg et al., 2018).

Industry and market

Market or industry conditions can impose some obstacles. For example, even when research is translating successfully into a product, commercial success is not necessarily guaranteed due to market preferences. Also, commercial expertise and budget to reach the market are necessary, and for some researchers a lack of expertise in this area represents an important limitation (Adams, 2012).

4.2.2 Actor Roles

There are different actors immersed in the process of translating resources from the research to the commercialization phase, such as technology transfer offices, government or research centers. These actors play different roles. We analyze these actors to understand their functions, scope, and limitations.

Internal

Internal actors are part of the research center or institution; for example, the *technology transfer office* (TTO) is a support office significant implication in the commercializing process. Weckowska (2015) analyzed the approaches of TTO and identified two: transactional and relational. The main function of TTO is supporting researchers to transfer their products. Limitations related to TTO include founding, expertise, and networking.

External

Government and public policies: a crucial actor involved in the commercializing process of science is the government, as public policies support and promotes the transfer of research. Their role has been studied through case studies to understand how public policies boost or hinder research transfer (Bourelos et al., 2012; D'Amico et al., 2013).

Business incubators and accelerators: these centers emerge as support for young investigators during the initial steps of leading researchers to commercial partnerships or new companies (Gamo et al., 2017). Through them, scientists can receive business advice and support to validate their ideas. These institutions promote programs and activities to help different kinds of ventures. Among their principal activities are intellectual property, business plans, financial performance and infrastructure. We also identify consulting services as an external actor. They, like the incubators, act as supports for the research transfer. They are focused on market and business expertise.

4.2.3 Recommendation for bridging the valley of death

One of the purposes of understanding the valley of death is to avoid falling into it. Previous works examine how to transition through the valley of death successfully. We grouped different recommendations to provide ways to reduce and eliminate the barriers (Auerswald & Branscomb, 2008; Finkbeiner, 2010; Frederickson, 2012; Wolfe et al., 2014)

- *Motivation*: scientists need to be motivated during the commercializing process in order to reduce and handle the frustration they face. Scientists need to align their goals with the incentives from their institutions.
- *Incentives*: it is necessary to stake out a system of rewards/promotions in academia to reduce the difficulty in assessing outcomes of commercialization of research and to reward effort.
- *Education*: researchers have scientific expertise, but they lack business and commercial skills. Some programs and institutions serve as a bridge to

cross the valley of death. These help scientists to acquire additional expertise in management and marketing.

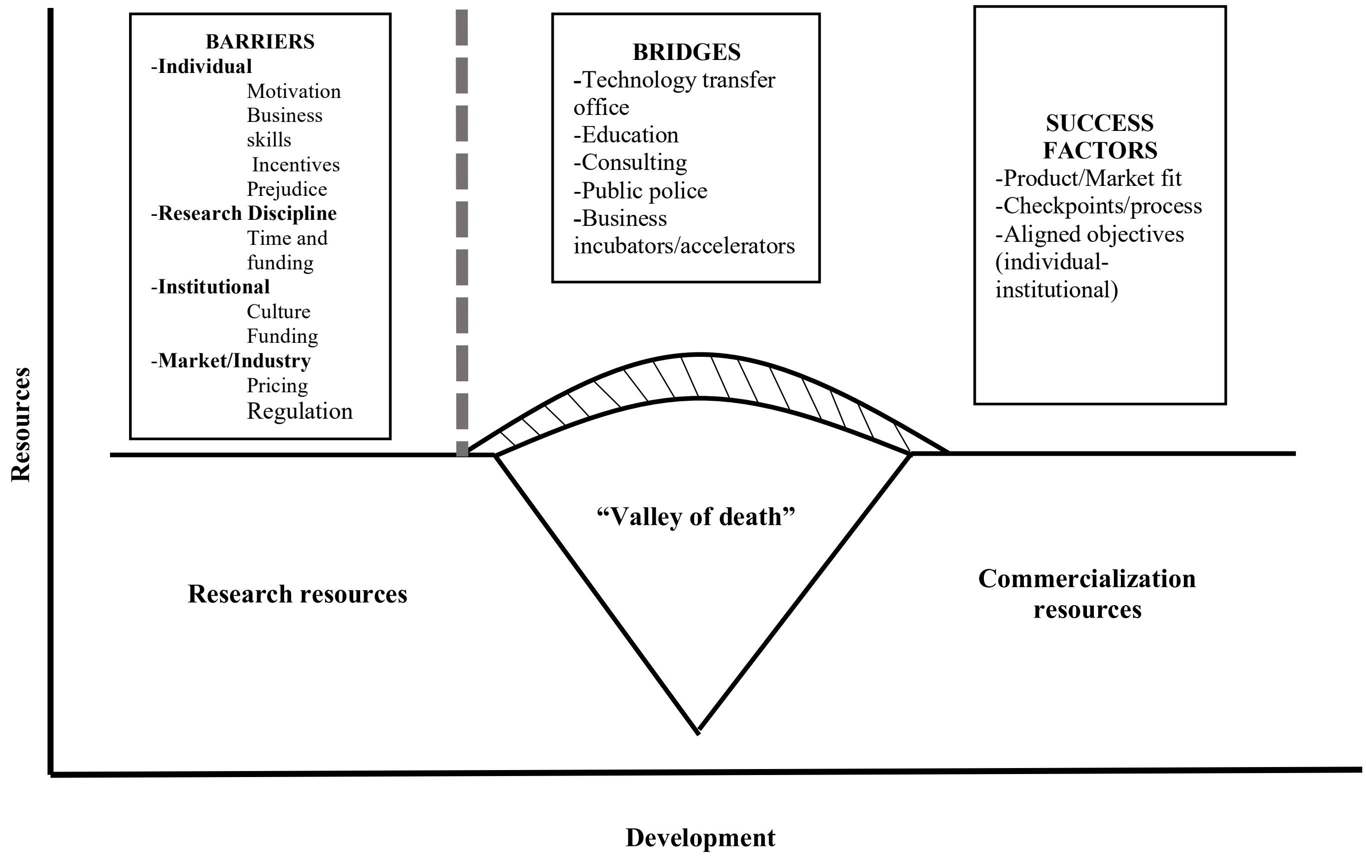
- *Culture*: entrepreneurial culture is a necessary element for motivating and increasing commercialization. Currently, the stigma of science commercialization represents a significant barrier. Thus, for institutions, it is important to promote a culture of entrepreneurship, thus developing a friendly environment that encourages research while validating researchers' ideas beyond the laboratory.

5. Discussion and Conclusion

We develop a model of the valley of death based on our results, which integrates barriers, bridges and success factors (see Figure 6). This model provides a compilation of elements and actors immersed in the valley of death from different disciplines. We contribute to the understanding of the valley of death through the analysis of previous work to compile an integrated framework. Although prior studies have proposed models for the phenomenon of the valley of death, these models are limited to one context or a specific research discipline (Emmert-Buck, 2011; Osawa and Miyazaki, 2016; Upadhyayula, 2018). This study extends the scope of analyzing and classifying the actors and factors that hinder or facilitate bridging the valley.

Figure 6. The valley of death framework

This research highlights the bridges proposed previously (Novickis, 2017; Yu,



2016).

We analyzed different recommendations from previous research to develop a classification of success factors and bridges (Gamo et al., 2017; Wolfe et al. 2014). There is a lack of empirical research that allows for reaching conclusions about the effects of bridges on successful commercialization. This study identified different actors (e.g., incubators, technology transfer office, consultors) that serve as bridges, but their impact is unknown. Also, we contribute to the literature by proposing a classification at the level of barriers and recommendations. This classification allows for analyzing each level according to their characteristics and conditions. We provide a framework to study variables for future research.

Finally, we argue that the research on the valley of death needs more practical efforts to understand the dynamics between actors and conditions. We thus call for studies that examine the different contexts. Currently, most research focuses on the context of developed countries that have a well-established public policy of science and technology. Research from other contexts provides an excellent opportunity to identify differences and particularities of the valley of death phenomenon in different settings. Also, this phenomenon requires a multidisciplinary perspective. This study represents an effort to integrate different visions to analyze the valley of death and provide recommendations to face it.

5.1 Implications

This study highlights two main implications for practitioners and policymakers. First, we provide a reference to understand a problem that affects not only academia, as many industries depend on discoveries and advances of research. We offer a better understanding of the process of science commercialization and the valley of death. This research could help to link academia and industry to work together to build bridges between them. Second, we suggest actions to implement public policies successfully. Policymakers could use this framework to understand the needs and barriers for each actor immersed in the valley of death; based on this, they can design programs that are more specialized, taking account of the research discipline, culture and funding, among other factors.

5.2 Limitations and future research

This study presents some limitations that serve as directions for future research. First, regarding the selection criteria and scope, we selected a representative sample of research of the valley of death under relevant criteria for the purpose of this research. However, despite the systematic review and documentation of the process, some important articles could be left out. Second, the classification and patterns of actors, barriers, and bridges are subjective and limited by the review. We recommend that future research test variables using a quantitative approach to develop measures and theorize about the effect of variables as policies, scientific mindset, and barriers on the process to cross the valley of death.

Chapter 3

Bridging the valley of death: Lessons from a government program

1. Introduction

There is a lack of success in commercializing research. Many public and private institutions have designed programs to boost research and entrepreneurship focused on science and technology. However, despite these efforts, a problem still exists with achieving the successful commercialization of science-based entrepreneurial ideas. As Frank and colleagues (1996) contend, most of these firms end up with no profitable products. Academic research gives no conclusive insights into the current benefits of such programs. As of today, few studies have analyzed the impact of programs and policies in stimulating science-based entrepreneurial activity (for exceptions, see Autio & Rannikko, 2016; Markham, 2013).

Currently, many centers, institutions, and universities produce science and technological research, but they usually lack the skills to commercialize their products successfully. This problem related to the successful marketing of products—to which all entrepreneurs are vulnerable—is called the "valley of death." According to Markham et al. (2010), this metaphor conceptualizes the problem of moving from research to the market. Relatedly, and continuing with the metaphor, there exist some mechanisms that work as bridges for crossing the valley of death. These mechanisms provide academics and researchers with the necessary tools for ending up with a successful commercial product.

We analyze the program of NoBI (Binational Innovation Nodes) as a support mechanism for science-based new firms to cross the valley of death. Specifically, this government support aims at technologies that have passed the test concept as a minimum requirement. The NoBI program follows an I-Corps methodology, prioritizing the customer discovery process. We collected and analyzed data from several sources: interviews, participant observation, documents, and records of the projects immersed in the NoBI program.

The NoBI program is an initiative of the Mexican government, whose objective is to provide the skills and knowledge necessary to market technologies from Mexican scientists. Behind this program, there are many efforts to incentivize technology and innovation in this country and increase the rate of commercialized technologies.

We contribute to the understanding of the valley of death by, first, exploring how entrepreneurial programs serve as a bridge to cross the valley. Also, we contribute to examining the impact of this program on scientists, an important consideration to explore how research can cross to commercialization.

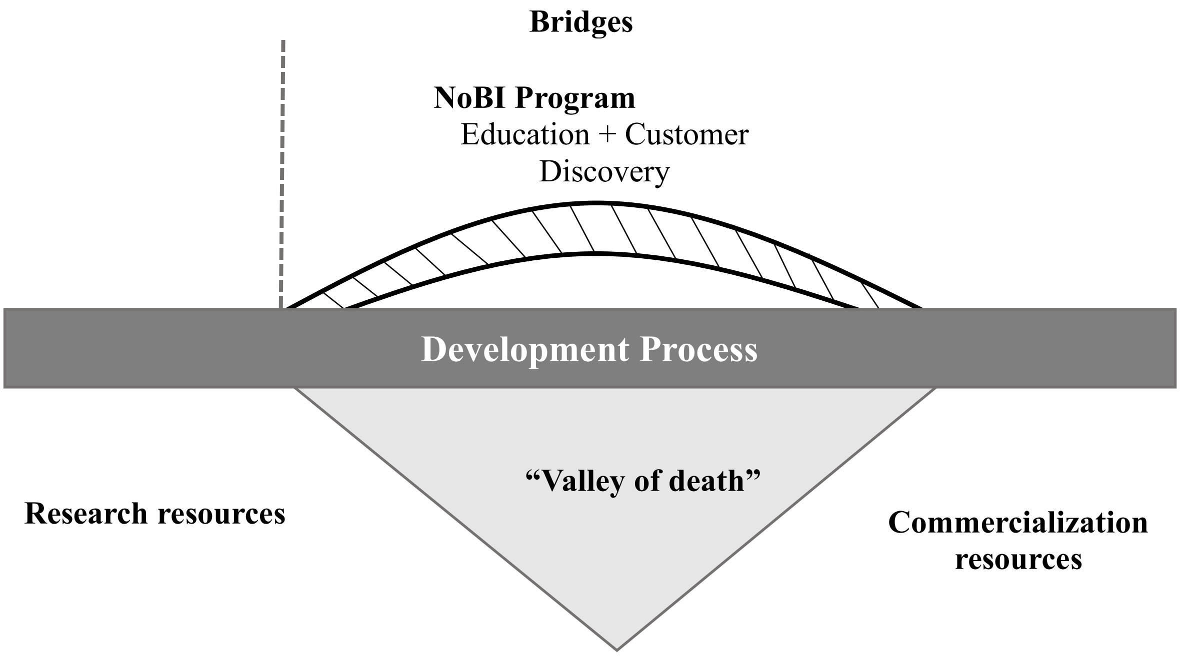
Our findings show how a governmental program helps scientists to identify their market and validate their technology or invention with a real customer. The NoBI program as a bridge has two important functions. The first is to help scientists withdrawal research on time, if it is necessary, thus avoiding unnecessary consequential expenses. Second, this program is a bridge to improve research and prepare the commercialization phase.

2. Bridging the Valley of Death

In considering the problem of bringing research to the market, some mechanisms emerge as a bridge between research and the market. Some examples of these bridges are consortia, business incubators, and accelerators, which provide entrepreneurs with different methodologies comprising knowledge, experience, feedback and mentoring (Gamo et al., 2017). Furthermore, there are many efforts from governments, such as the laws of science and technology or public policies focused on support the commercialization. Most government programs have to do with financing.

To understand how the bridges work is important in order to analyze the problem. There are many barriers to commercialization of technologies and research, including inadequate analysis of technology needs or market size and a lack of entrepreneurial management, funding, and incentives, among others (Adams, 2012; Frank et al., 1996; Nemet et al., 2018). Even though funding programs helps scientist, it is not enough in itself, because of the lack of other necessary expertise to cross the valley.

Figure 1. The Valley of death



The relevant question is how a program, public or otherwise, transmits expertise for scientists beyond funding. Following this premise, we found that education also emerges as a bridge. Previous research suggests that scientists need to acquire knowledge that facilitates their commercializing process (Frederickson, 2012; Gamo et al., 2017). We analyzed the NoBI program, an initiative combining education and practical methodology, to validate the ideas from research.

3. Design

We follow a qualitative approach to analyze this program. Our study aims to describe and explore how a governmental program serves as a support for crossing the valley of death, what are the principal activities related to bridging the valley, and what is the impact of this program on the technology projects.

We selected the NoBI (Binational Innovation Nodes) program as a subject because of its uniqueness. This program is one of the first governmental programs and part of a new technology and innovation policy in Mexico to boost technology and science-based entrepreneurship. The program started with a pilot test in 2016 with a single node. We analyzed the program during 2017 and 2018; during this period, the program included eight different nodes in the country.

We obtained data for our analysis from participant observation, interviews with different participants, documents and archival records analyses. Participant observation consisted of assisting in a face-to-face closing session. We collected a total of 21 interviews. Documents include the governmental announcement, websites of nodes, reports of results and news reports. Archival records of projects were obtained from the virtual platform of the NoBI program; these include descriptions of projects and final videos of projects. We analyzed and codified the data to obtain relations and classifications of activities, relationships and the impact of the final results of the program. We integrated this analysis with documents and archival records analysis to complement and contrast the data.

4. The NoBI Program

The NoBI program is an initiative of the *Consejo Nacional de Ciencia y Teconología* (CONACYT) National Council for Science and Technology) of Mexico in partnership with the National Science Foundation (NSF) of the United States of America. This program aims to train groups of researchers (scientists) and entrepreneurs in the exploration of the market for technologies developed in Institutions of Higher Education (IES) or Public Research Centers (CPIs) of

Mexico. The goal of this program is to help the participants acquire the skills and knowledge necessary to market the technologies that they have developed and to direct their next scientific research towards a specific market.

The NoBI program started in 2016 with a pilot node. In 2017, the number of nodes increased to 5, and for the 2018-2019 period it increased to 8 nodes. A node is a set of scientific, academic, and business institutions. There are two kind of nodes, sectoral and regional. Sectoral nodes are sector- or industry-specific (e.g., medicine or manufacturing). Regional nodes represent a geographical zone of the country (e.g., north or southeast).

NoBI invites scientists from different Mexican research centers through a call on their website. Selected participants are then grouped. According to the program's administration, the grouping of participants considers different factors: similarity between projects, participants' background, and availability. This program targets technologies and research projects past the concept test phase.

4.1 Composition of the NoBI teams

NoBI is directed to Institutions of Higher Education or Public Research Centers; undergraduate and graduate students; and entrepreneurs, executives or individuals related to science-based entrepreneurship, commercialization, and technology transfer in Mexico.

The NoBI teams are composed of 1) a principal investigator, who is a scientist or the inventor of the technology; 2) an entrepreneurial leader, who is an undergraduate or graduate student who has knowledge about the proposed technology; and 3) a mentor, who is an expert in the industry, innovation or technology transfer. Also, some teams have 4) a support student, who is an undergraduate student.

The program is implemented by members of an I-corps certified teaching team, who impart the lectures at the kick-off and closing face-to-face sessions and webinars, moderate presentation sessions, provide feedback through the platform and cover office hours.

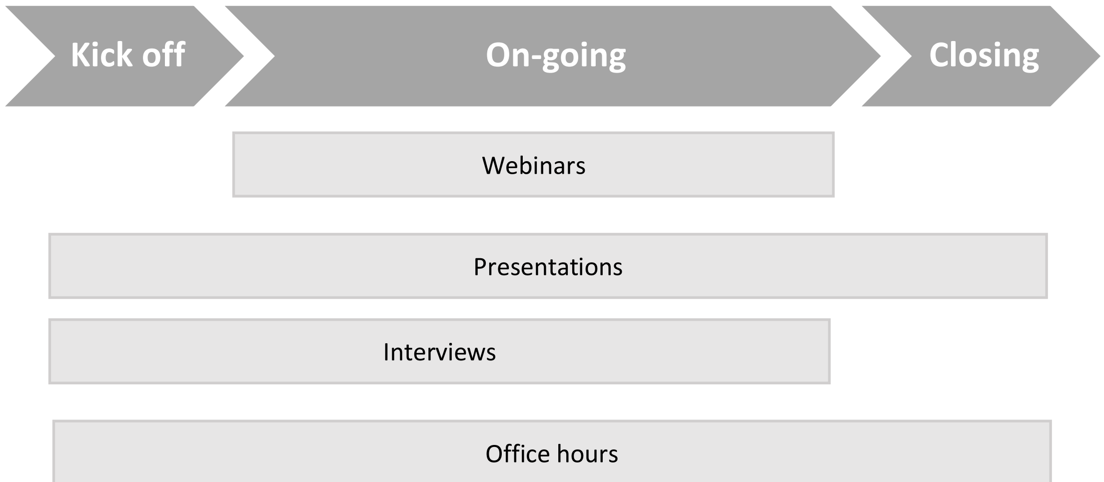
4.2 The methodology

The NoBI program follows the Innovation Corps (I-Corps) methodology. This method consists of the following steps: 1) Identification of the problem solved by the technology or invention; 2) Customer discovery; 3) Commercial validation of the technology or invention; and 4) Final decision of whether or not to proceed with the research. This methodology is iterative and intensive. The program lasts nine weeks.

The program consists of three phases: 1) Kick-off, 2) On-going, and 3) Closing. Each stage includes lectures and activities. Figure 2 shows the process and events of the implementation of the NoBI program. The interviewing activity represents the validation process when participants go out of the building and meet the market. The teams have to conduct one hundred interviews with customers and make a final video presentation for the closing session. They have a goal of fifteen interviews per week.

Classes are either face-to-face or virtual and cover the following topics: 1) business model canvas; 2) customer discovery; 3) best practices for conducting interviews; and 4) customers, buyers and ecosystem.

Figure 2. NoBI program activities



5. Lesson Learned

5.1 Scientific mindset

At the beginning of the program, the participants presented resistance to learning and making the activities. The first shocking moment was the first interviews, after going out of the building and looking for customers, when they discovered that this process is complicated, even for those who have a good number of contacts related to the industry. They described this situation as frustrating, particularly when someone canceled an interview, or they did not have access to institutions and people from the industry.

A second aspect associated with the entrepreneurial mindset is the capacity to explain their technologies in business terms. During the kick-off activities, each team presented their projects and received feedback about their value proposition; the principal critique was about the drafting and explanation of their technology and the problems with understanding the idea, despite the level of expertise of the teaching team and the rest of participants. For scientists, it is difficult to translate their ideas into the common language used in the market.

Also, participants manifested resistance through disgust when asked about the utility and the market. We heard phrases like “everybody is my market,” “I have many different markets for my technology,” and “We think that this project will change the industry.” These kinds of expressions reflect high confidence in their technologies. Additionally, they defended their ideas with force even when the evidence showed contradictory results.

5.2 The confrontation: face the reality

After some interviews and feedback with the teaching team, we found that teams fell in a phase of confrontation. This phase consists of having information that confronts their ideas about everything related to their technology to the reality: market, industry, sales, business plan. There was a moment of the truth—for example, during an interview or the lectures and feedback—when the participants realized that they needed to change their ideas to adjust their technologies to the market. During this phase, they obtained responses from the market such as “we do not have a problem that your technology can solve”; “I have the problem, but I am not interested in solving it”; If this is not obligatory, I will not do it”; and “I am comfortable with the current solution”.

We found different aspects related to the confrontation.

- *Market fit:* the majority of teams did not have information about their customers, including who they are and what they need; they worked to develop their research without taking account of the market. They tried to sell their ideas, but they did not have clarity about the identity of the buyer.

- *Lack of industry knowledge*: some ideas have a market, but the teams did not know the rules of the industry (e.g., regulations or requirements to sell in this market).
- *Competitors*: many scientists think that their technology is unique. During the program, they came to understand the competitors' size and, in some cases, the fact that the problem that they were attacking had already been solved.
- *Feasibility of technology*: many participants left the laboratories to discover that their technology was expensive or needed many requirements that the market or industry could not cover.

5.3 Changing the mentality

Finally, after the program, we observed a change of the mentality. First, the participants expressed that, after the program, they realize the limitations of their technology and the reality of the market, using phrases such as "I believed that everyone wanted my technology", "I thought I was going to become a millionaire", "I thought they (the market) were going to fight to buy my patent". These expressions reflect the fact that because they started with ideas outside the reality of the market, they gradually limited their projects. In the final sessions, the participants expressed: "Now I understand the importance of knowing the market", "This program changed my life as a researcher", and "Now I know what I need to validate my ideas."

This change of mentality conveys a transformation of the participants' mindset to include a scope beyond the research. Also, we observed that participants wanted to share this new expertise with their colleagues; during the final session they mentioned that it is necessary to bring programs of this kind to all the research centers of the country. They manifested plans to show this methodology in their institutions; for example, investigators that are professors expressed their desire to teach this methodology to their students.

6. Conclusions

Our findings show that the main impact is on the principal investigators, who underwent a paradigm shift about the research connected with the market. This study highlights how a program can serve as a bridge between research and commercialization. This program focused on changing the participants' mentality, which we consider a crucial factor to cross the valley of death. The combination of education and the process of customer discovery provided the participants with a series of lesson about markets and business models. This new knowledge provoked a change and a new perspective toward their research.

We found three pathways for scientists after the implementation of this program. First, after the technology validation, they decide to abandon the research. This decision reduces time and avoids unnecessary expenses. Second, this program serves as a bridge to improve research and prepare participants to go to the commercialization phase. In this case, scientists decide to follow the process to launch their technologies to the market. Finally, there are scientists that after the validation discover a market but still need to work more in their technologies. They decide to come back to the lab to improve their projects and align them with the new findings from the interviews.

This research has important implications for practice. First, science-based new ventures can develop a business model that validates the market quickly, implementing a lean startup approach. This process serves as a bridge to cross the “valley of death.” Our results complement and give insights to traditional frameworks in order to contribute to the discussion on the particularities of science-based new ventures. Additionally, because our research is based in a developing country’s institutional set-up, the implication for policy is very relevant. Many developing countries seek to invest in science but also face challenges in their ability to commercialize and benefit from the economic impact of science (Miozzo & DiVito, 2016). This challenge is more critical in developing economies that necessarily need to invest in more pro-market initiatives.

Chapter 4

The Role of Mentoring in a Lean Startup Program for Science-based Entrepreneurs— A Case Study

1. Introduction

The lean startup methodology has become very popular for performing entrepreneurship activities (i.e., starting a new business). Today, several organizations use this method as part of their process (e.g., General Electric and Intuit) and entrepreneurship programs (Blank, 2013). This method has become widespread due to implementation advantages, such as reduction of costs and time. However, studies of the lean startup methodology from a scholarly perspective remain scarce.

Previous research compares the processes of traditional business plans with a lean startup methodology and propose a conceptual framework based on this methodology (Ghezzi, Cavallaro, Rangone, & Balocco, 2015; Harms, 2015). Most of these studies have focused on the results of the lean methodology at a project level. Also, the main methods that have been used to understand the lean methodology are experimental studies in several contexts, such as education (Armstrong, 2017).

This method provides a tool to validate markets and test products in a short time. These advantages position this methodology in different kinds of entrepreneurial ventures. In the scientific context in particular, the lean startup methodology could bring an answer for the commercialization problem. There is an important gap between research and the market (Markham et al., 2010). Through this method, scientists could obtain responses directly from the market.

In this study, we analyze one actor involved in the lean startup process under the science-based entrepreneurship context: the mentor. Research about mentoring in the entrepreneurship field is becoming more common. Mentoring has become popular as a support mechanism to start and run new ventures, resulting in increased interest from researchers. For example, recent studies concern the delimitation of mentors' activities and goals, as well as the impact of mentors on entrepreneurial activity (Delanoë 2013; Gimmon, 2014).

Important advances in mentoring research reveal a positive impact of mentors on the mentee's activity. St-Jean and Audet (2012) suggested that the benefits of mentoring include increasing management knowledge and skills, validation of entrepreneurial identity, and increasing self-efficacy, among others.

This study provides a perspective on mentoring in a lean startup program. According to Bisk (2002), the outcomes of mentoring differ with the context and the mentor-mentee dyad immersed in the entrepreneurial process. For this reason, it is important to study mentoring phenomena imbued in a specific context and framework. We follow qualitative research in seeking to understand the particular activities that the actors involved in the lean methodology, including the mentors, perform in a day-to-day context. This study aims to contribute to the limited literature by describing the role of mentors under the lean methodology and the consequences for science commercialization. Our research questions are: What is the role of mentors in a lean startup program? How does the mentor's participation impact each actor and the projects of his/her respective team?

We follow an embedded case study design (Yin, 2013). This design allows for the examination of subunits (mentors) in a single case (program). We analyze a program called Nodos Binacionales de Innovacion, translated as Binational Innovation Nodes or NoBI, an entrepreneurial program implemented in the northeast of Mexico. This program is based on a lean startup methodology and customer discovery methodology initially implemented in the United States by the National Science Foundation. Our empirical data are derived from eleven semi-structured interviews with mentors, as well as a structured questionnaire completed by team members, each from a particular entrepreneurial team. We complemented the interviews and questionnaire with participant observation and document analysis.

Our findings expand the definition of entrepreneurship mentoring under a lean startup method context. Our results highlight that activities such as networking and developing impression management abilities are more representative of this methodology than support or guidance. Our main contribution to the entrepreneurship field is the potential role conflict generated in the given context—in this case, when the mentor is part of the team. This conflict increases when the mentors focused on communication and business skills and not on the ultimate purpose of the lean methodology, which is to create a minimum viable product for customers.

In the remainder of this study, we first discuss literature on the lean startup method and entrepreneurship mentoring, followed by the research methods. Then, we present our findings. The study ends with a discussion and conclusion.

2. Theoretical Background

In this section, we review the literature to conceptualize entrepreneurship mentoring and the lean startup method. This review allows to identify and categorize the characteristics, activities, and backgrounds of the mentors related to the lean startup method.

2.1The Lean startup method

The lean startup method is a methodology for starting a venture commonly used in various institutions, such as universities, incubators, and accelerators. This methodology allows entrepreneurs to build their entrepreneurial ventures faster and at a lower cost (Harms, 2015). It does so by adding more flexibility and customer participation in the business process creation compared to traditional business planning. For this study, the lean startup method (LSM) is defined as a process to create and manage startups based on producing a minimum viable product for customers (Blank, 2013; Ries, 2011).

Beyond the definition, it is important to understand the attributes and actions related to the method. Ries (2011) provides a set of five principles to define the lean startup method: 1) entrepreneurs are everywhere, 2) entrepreneurship is management, 3) validated learning, 4) build-measure-learn, and 5) innovation accounting. Also, Mansoori (2017) describes the lean startup method as a process of three main steps: 1) mapping of entrepreneurs' business idea, 2) testing the assumptions (validation), and 3) product-market fit.

In academic research, previous studies of this method aimed to create a conceptual framework for the lean startup as a new entrepreneurship methodology. For example, Armstrong (2016) analyzed this methodology through experiments in an educational context. His study shows and describes how to implement this methodology in a controlled environment. Following the same line, Harms (2015) examined entrepreneurial learning in a lean startup environment.

Comparative studies contrast differences between the lean startup method and the traditional business plan (Ghezzi et al., 2015; York & Danes, 2014). These studies show the advantage of the lean startup over conventional methods and some entrepreneurial barriers. Table 1 summarizes the principal characteristics and activities associated with the lean startup method.

TABLE 1

Characteristics and activities associated with the lean startup method

LSM Attributes	Characteristics	Advantages
Failure perception	Expected and fix by interactions (Blank, 2013)	Create a psychologically safe atmosphere (Harms, 2015)
Validation	Test hypothesis or the assumptions of the business models; minimum viable product (Blank, 2013; Mansoori, 2017)	Reduce time and costs (Harms, 2015)
Customer development	Get the desired product into customers' hands faster (Ries, 2011)	Entrepreneurial biases alert (York and Danes, 2014)

2.2 The role of mentors in entrepreneurial activity

A mentor is an experienced person who provides guidance and support in a variety of ways, by being a role model, guide or confidant (Western, 2012, 43). Mentors have become important actors in entrepreneurial research, particularly entrepreneurial education research. Entrepreneurial education research analyzes the role of the instructor and mentor of entrepreneurial programs and courses, giving rise to the term entrepreneurship mentoring.

According to St-Jean and Audet (2012), entrepreneurial mentoring involves a supportive relationship between an experienced entrepreneur (the mentor) and a novice entrepreneur (the mentee) to provide personal development. This definition concurs with business mentoring definition by Western (2012), in which a mentor is a colleague in the same or a parallel organization with a mentee. Business mentors are commonly associated with the development of leaders.

Mentors' activities associated with entrepreneurship include increasing entrepreneurial activity as a motivator and improving managing. Research on this topic is mostly oriented to organizations and entrepreneurship education, as mentioned previously. In the first area, studies aim to enhance organization activities through mentoring intervention. For entrepreneurship, mentoring is focused on developing entrepreneurial activity or improving the results of the firm (St-Jean & Audet, 2012).

In entrepreneurship education, studies include research on the instructor or professor role as a form of mentoring practice. In general, these studies highlight the positive effect of this actor on entrepreneurial activity (Ahsan, Zheng, DeNoble, & Musteen, 2018; Gimmon, 2014; Radu & Redien-Collot, 2013). Specifically, scholars have studied the effect of mentors on the entrepreneurial intention of students. Ahsan and colleagues (2018) found that effective mentoring has a positive impact on the transition of students to entrepreneurs.

Some studies about mentors focus on the cognitive level. For example, St-Jean and Audet (2012) suggest that mentors can have an impact through cognitive learning and affective learning. Their study indicates that mentors' benefits include increasing management knowledge, improving business vision, and increasing self-efficacy, among others. In the same line, Gimmon (2014) found a positive effect of mentoring on students in entrepreneurial programs. Specifically, participants reported improvement in their entrepreneurial abilities and higher self-efficacy. More focused on startups and science-based entrepreneurs, Delanoë (2013) suggests that support actors can contribute to startup projects getting launched, and thus they are important for entrepreneurial activities. More recently, St-Jean, Radu-Lefebvre, and Mathieu (2018) analyze the effect of similarities between mentees and mentors regarding self-efficacy and learning goal orientation. Their findings highlight the importance of the similarity between mentors and mentees to improve the relationship between them.

Based on prior research and the classification of functions proposed by St-Jean and Audet (2012), we develop an initial classification of attributes and activities of mentors. Table 2 shows each activity and attribute that emerged from the entrepreneurship literature; we include activities from the lean startup method related to mentoring.

Despite recent studies of entrepreneurship mentoring, there is a lack of understanding of the mentoring role in a different context and how this context provides new functions and roles to the definition of mentoring. In this study, we investigate the mentors' role in the lean startup method in a new venture program and the impact of each mentor on the students' respective team.

(2013).

TABLE 2

Entrepreneurial mentoring

Mentoring factors	Attributes or Activities
Characteristic of mentor	Expertise and experience (St-Jean & Audet, 2012)
Integration and motivation	Mutual trust and liking experience (St-Jean & Audet, 2012) Structural relationship (Radu Lefebvre & Redien-Collot, 2013)
Support	Organization and planning (Radu Lefebvre & Redien-Collot, 2013)
Confrontation	Challenging, shocking (Levesque, O'Neill, Nelson, & Dumas, 2005)
Reflector	Role model (Western, 2012)
Lean Startup Method	Matching one's business project with market expectations and practices (Radu Lefebvre & Redien-Collot, 2013)

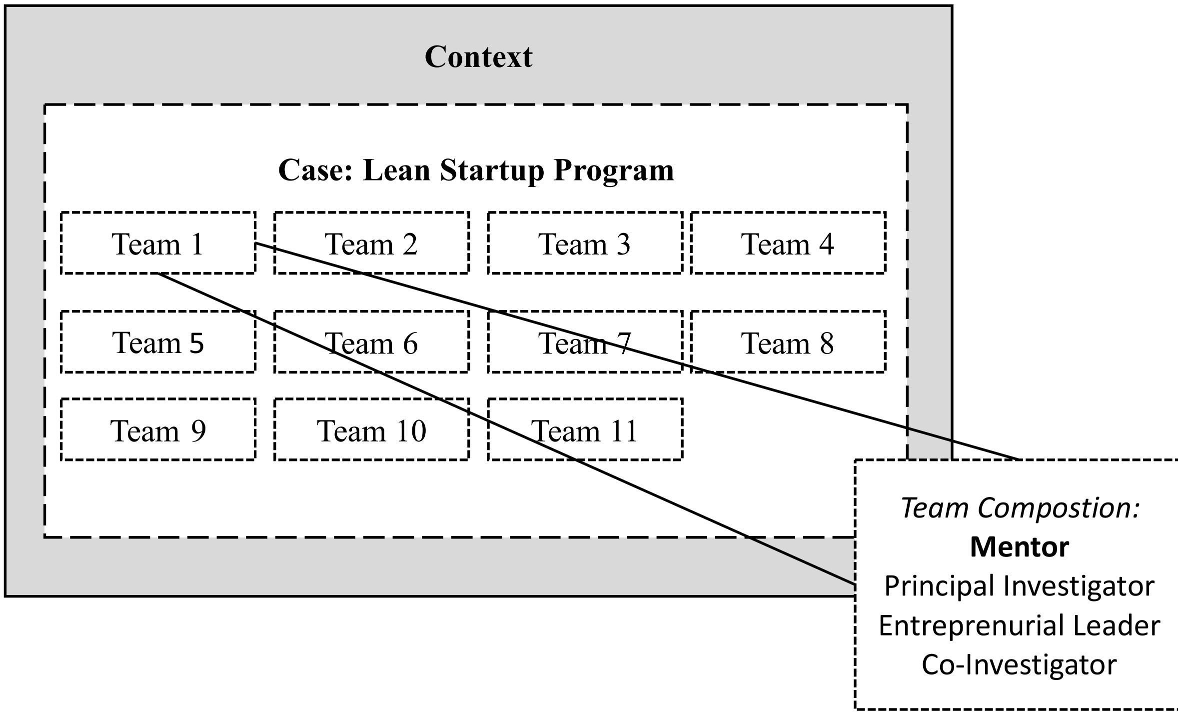
3. Methodology

3.1 Research design and case description

We conducted an embedded case study, which is a particular method to understand perceptions and behaviors, for this study of the role of mentors in a specific context with different units or subunits of analysis (Yin, 2013). The case context is the lean startup method and projects using it. Our sample is composed of eleven mentors (subunits of analysis) participating in this program. Also, we analyzed the mentees of each mentor. Our methods include qualitative interviewing, participant observation, and document analysis (Brinkmann, 2013; Maxwell,2013). Figure 1 shows a representation of the case study based on Yin (2013).

FIGURE 1

Representation of the case study



Our case study involves the analysis of mentors and their mentees who participated in a program called the Binational Innovation Nodes (NoBI) directed by NSF and the Mexican Council of Science and Technology (CONACYT). This program aims to teach science-based entrepreneurs the essentials of the customer development methodology under the lean startup method. Team composition includes the principal investigator, an entrepreneurial leader and/or co-investigator (student), and a mentor (assigned by the institution that manages the program). Together, the teams learn to collaborate and validate their business hypotheses in seven weeks through different activities to validate the market.

According to the program's mentor recruiting campaign, the mentor's role is to serve as a business counselor for the teams. The program also considers mentors as team members. The call for the program mentions the following main functions: sharing experience and knowledge to the team, providing guidance on business areas and customer discovery, and sharing contacts to facilitate validation of the market. Requirements include being an entrepreneur, being an executive or otherwise involved in business, and having previous experience in science-based entrepreneurship.

We select NoBI's program because of its characteristics (Stake, 2016). First, this program involves an important subject for entrepreneurship: science-based entrepreneurs. Second, this program follows a new and popular method to start a business and validate the idea and market: the lean startup method. Finally, the composition of teams allows for the analysis of an important actor for the entrepreneurship field: the mentor.

3.2 Data collection

We collected data through eleven semi-structured interviews with mentors. We classify the mentors according to different experiences, expertise, and venture projects. Table 3 shows the characteristics of each mentor and their teams. The interview was structured as follows. First, we asked the mentor to introduce themselves and the project; we included questions about their background, previous experiences with entrepreneurship, and the lean startup method. Then, we asked about the lean startup methodology: specifically, how they used the methods during the program, barriers, and facilitators. Finally, we asked about their role in the final performance of their participants. We also obtained data from the participants (rest of the team). For this purpose, we used a structured open questionnaire, which asked about their experience in the program, their experience and knowledge of the lean startup method and customer discovery process, the implementation of this method during the program, the match between the mentor's profile and the team/project, and the role and impact of the mentor on the team and project.

Additionally, we complement our data with participant observation during the pitch session to triangulate our results. These sessions consist in a final presentation of the project and a summary of the experience during the program, in which all teams share not just the results related to the project but also their experience as teams and individuals. Furthermore, we also had access to teams and mentors in work sessions. Our document analysis includes videos from each team's project, information from projects and results provided by the program.

TABLE 3

Mentors and teams

Mentor	Gender	Age	Team Composition	Project's Industry
A	Female	33	Principal investigator (Male) Entrepreneurial leader (Male)	Agriculture
B	Male	34	Principal investigator (Male) Entrepreneurial leader (Male)	Technology/ Transportation
C	Male	41	Principal investigator (Female) Entrepreneurial leader (Male)	Pharmaceutical
D	Male	45	Principal investigator (Female) Co-Investigator (Male) Entrepreneurial leader (Male)	Pharmaceutical
E	Female	39	Principal investigator (Male) Co-Investigator (Male) Entrepreneurial leader (Female)	Pharmaceutical
F	Male	35	Principal investigator (Male) Co-Entrepreneur (Male) Entrepreneurial leader (Male)	Materials
G	Male	35	Principal investigator (Female) Entrepreneurial leader (Male)	Food industry

H	Female	46	Principal investigator (Male) Co-investigator (Female) Entrepreneurial leader (Male)	Technology
I	Female	41	Principal investigator (Male) Entrepreneurial leader (Female)	Biotechnology
J	Male	43	Principal investigator (Male) Entrepreneurial leader (Male)	Technology
K	Female	30	Principal investigator (Female) Entrepreneurial leader (Male)	Food industry

3.3 Data analysis

For data analysis, we first transcribed each interview and prepared documents and field notes to integrate the data. We used a qualitative analysis software program (Atlas Ti), following Friese (2014), for qualitative data analysis. Next, we codified the data following a process coding strategy (Saldaña, 2016). For this step, we used the categorization from our literature review on entrepreneurship mentoring. For example, the category of mentors' background includes subcategories of mentors with entrepreneurial experience, mentors with professional expertise, mentors with academic expertise, mentors with previous mentoring experience, and mentors with experience in similar programs.

Following the codification process, we designed tables that allow us to visualize the main activities of each mentor and his/her impact on the entrepreneurship group. In addition, we considered the demographic characteristics of the mentors. With the main coding process, we tried to find patterns in the mentors' backgrounds, activities, and impact. Our last analytical step was to design a conceptual network to theorize about the effects (i.e., type and magnitude) of mentors on entrepreneurs and their venture projects.

Specifically, we theorized about the mentors' impact on entrepreneurs' management ability, entrepreneurial skills, and the design of the product and processes techniques.

We followed the same process for the data from the questionnaire. In this case, we focused more on classifying the results of the program and mentors.For example, we categorized participants with vs. without experience with the lean startup method.

4. Results

4.1 Mentors' background

We identified previous experience and knowledge of mentors related to the lean startup method. Table 4 shows the background of each mentor, identifying similarities and differences between mentors. We identified different kinds of experiences:

Entrepreneurial experiences: mentors who have experience as entrepreneurs in the past or currently (e.g., owners of a family business).

Professional experiences: mentors who have worked or work in institutions or areas of firms related to entrepreneurship (e.g., business incubators).

Academic experience: mentors with experience in the academic field (e.g., as professors).

Mentoring experience: mentors who have previously mentored.

Program experience: mentors who have participated in entrepreneurial programs similar to this case.

TABLE 4

Mentors' Background

Mentor	Entrepreneurial experience	Academic experience	Professional experiences	Mentoring experience	Program experience
A		X	X	X	X
B		X			X
C	X	X			
D	X	X			
E	X	X	X	X	X
F	X	X	X	X	
G	X	X	X	X	X
H	X	X	X	X	
I	X	X	X	X	
J	X	X	X	X	X
K	X	X	X	X	X
Total	9	11	8	8	6

The following quotes are examples of entrepreneurial experience and academic experience, respectively:

> "Personally, I was an entrepreneur, and right now I'm not. I had a couple of restaurants before working professionally." Mentor G
>
> "It has been all academic, nothing practical; I know what is innovation, the science of knowledge, entrepreneurship." Mentor B

According to the results, mentors from this program have a varied and sufficient background to mentor. These antecedents match with the program's requirements. To triangulate these results, we contrast the responses with the opinions of the other team members. They expressed satisfaction with their assigned mentor.

> "The mentor's knowledge not only of business issues but also on the technology that we are developing was of the utmost importance." Participant team E

Most of the mentors combined academic experience with entrepreneurial or professional experience. More than half of the mentors had previous experience as mentors, as well as experience participating in entrepreneurial programs. All of them expressed not having had prior training by the program's staff. However, this does not represent a problem for them because of their previous antecedents. Table 5 presents some quotes related to these results.

4.2 Mentors' role

We found that some of the principal activities carried out in this program are similar to those in the literature review, while others differ in terms of importance and frequency. The most mentioned activities in this study are networking, developing communication techniques, and managing projects. Networking activities include providing contacts to validate the market and starting communication with some contacts. Developing communication techniques implies activities such as teaching how to interview and how to use colloquial language and familiar concepts with possible customers. Managing projects refers to tasks like organizing the agenda, program interviews, and defining activities for the team. This last activity represents a conflict for mentor roles. Some mentors expressed that they did activities outside the mentor's role. This means that this activity or role does not match with what mentors considered being a mentor. Table 5 shows some quotes related to principal mentors' activities.

TABLE 5

Mentors' Role

Activities	**Representative quotes**
Manage Project	"Organize, coordinate the team with respect to the project." Mentor C "Integration of the work team, integrating their strengths to see what the team's dynamics are and what would be the best way to approach the achievement of the objectives." Mentor I
Networking	"Provide contact to interview." Mentor A
Communication Techniques	"A mentor in this topic is like a translator; the researchers speak a language; the entrepreneurs speak another language and the market another language." Mentor D
Exposure	"I was participating, but there was a moment where I let them g." Mentor E

Additionally, other activities were also mentioned, such as guidance, focusing, and exposure. Exposure is an activity related to confrontation, an important element of the lean startup and scientific entrepreneurship. Mentors described confronting reality as an important step to aim that the scientists realize about the importance of market.

4.3 Mentoring and the lean startup method

These results include mentors' experience with the lean startup method, as well as activities, facilitators, and barriers for implementing the lean startup method in the NoBI program. Table 6 summarizes the results. We classify experience as *theoretical* when the mentor knew the concept but only in theory; *practical* if the mentor had used the methodology; *practical with another name* if the mentor mentioned having used the method or similar techniques but not with this name; and *none* if the mentor had no experience.

TABLE 6

Lean startup method experience

Mentor	**Theoretical**	**Practical**	**Another name**	**None**
A			X	
B			X	
C				X
D	X	X		
E	X	X		
F		X		
G		X		
H		X		
I		X		
J			X	
K		X		
Total	2	7	3	1

We classify activities related to the lean startup process based on a literature review. *Facing reality:* mentors mentioned that an important stage of participation was facing reality. This happened when the scientists had their first interviews with the potential market to validate their business idea. *Out of the laboratory*: this phrase was repeatedly mentioned both in the interviews with the mentors and in the work sessions we observed. The following quotes are examples of these moments during the implementation of the program:

> "The great advantage of this methodology is that it throws you against reality—that is, [it makes you] go and do interviews and [face] reality." Mentor E
>
> "The researcher does not want to leave his place; he wants to be in his laboratory; they do not want to change their minds." Mentor H

Mentors mentioned trust, interpersonal relations, and openness to learning as facilitators of the lean methodology and this specific program. Mentors believed that they could improve and manage these activities. In contrast, mentors mentioned as the main barriers activities and situations related to the project or the scientists such as time, lack of business skills and entrepreneurial experience, and different visions about the project.

> "The challenge was that my team was not closely related to the pharmaceutical industry, and there are certain rules." Mentor C
>
> "The entrepreneur who already had his company since 2007 ... so he did not have enough time for this program" Mentor

4.4 Impact of the mentors under lean startup method

The main finding of our study is that the mentoring impact on entrepreneurs and the project is principally related to the development of impression management abilities in their mentees. Specifically, they taught them communication techniques, how to dress, how to conduct interviews, and so on.

> "[In one case] the entrepreneur arrived too informal, and I directed him… I bought him a shirt." Mentor C
>
> "You can ask this; you can do this interview, suggest what questions you could ask, also how to present yourself depending on who you were going to greet." Mentor B

Interestingly, despite the mentors' background and team's composition, none of the mentors had an impact on entrepreneurial competencies nor improved the product's design and process techniques. Our document analysis also confirms that the main contribution of the project was merely superficial rather than substantive. However, for some science-based entrepreneurs, the contribution was significant; for example:

> "They were very well trained, in addition to contributing with ideas based on their experience and not speculating." Participant of team D

In contrast, some participants expressed a lack of mentor compatibility with the project, in terms of the mentor's match and contribution.

> "The experience of the mentor must be compatible with the theme of the project or the technology for better use." Participant of team F
>
> "I think that there should have been more interaction and that the mentor, perhaps, should first know the technology [in order to give]

a better explanation of the participatory technology in the program.

Participant of team G

In sum, these results suggest different activities and roles proposed by previous research, but these findings are coherent with the functions and activities described by the program.

5. Discussion

Concerning the conceptualization of entrepreneurship mentoring, our findings are in line with St-Jean and Audet (2012). We found different roles and benefits in terms of mentors' interaction with and effect on mentees — for example, managing knowledge, motivation, and personal skills. Also, our results highlight confrontation, in line with previous research (Levesque et al., 2005). We suggest extending previous definitions of entrepreneurship mentoring to include different kinds of entrepreneurship experience (e.g., academic and professional), as our results indicate that experience is a very important factor to consider.

According to the lean startup methodology, the principal activities of this method include validation and development of a minimum viable product for customers (Ries, 2011; Blank, 2013) that allows for customer participation (York & Danes, 2014). Following this line, the role of mentoring under this method suggests that the mentor's role includes helping the entrepreneurs to match their business project with market expectations and practices (Radu & Redien-Collot, 2013). Specifically, customer validation was a shock for participants and even mentors, who needed to manage frustration and motivate the teams.

Nevertheless, our findings suggest other activities that could be as important as developing communication skills, such as networking and developing the ability to map the market. These activities also help with the program's implementation.

We identify three main activities that extend entrepreneurship mentoring conceptualization and open the door to debate about the impact of the mentor's role under the lean methodology (Jean & Audet, 2012; Radu & Redien-Collot, 2013). These activities are networking, communication, and project management. The participants have different conceptions of the mentor role, and these ideas are not in the same line as the lean startup method. The impact of these activities on participants and the project is limited to impression management skills (e.g., how to dress, how to speak) and does not extend to a substantial contribution to improving the project. On the other hand, another relevant but less mentioned activity involves issues related to confronting the mentees with challenges and unplanned situations (Levesque et al., 2005). We consider this activity to be related to the role of the mentor under the lean method. In this context, many mentors had the task of exposing their mentees to the reality of the market.

This study provides us with a context that allows us to analyze facilitators and barriers to implementing the lean startup method and achieving its goals in a science-based context. We identified facilitators including interpersonal relations, trust, and entrepreneurial experience, which help the teams to achieve their goals. The main barriers are related to a lack of clarity about functions, time, and business experience. These findings suggest that future research should explore these factors as variables.

5.1 Implications

Our research makes two contributions to the field of entrepreneurial mentoring and lean startup research. First, we describe the mentor's role in this lean project. We extend the definition and activities related to entrepreneurial mentoring. Our second contribution is the conceptualization and theorization of how the mentor influences the performance of the team and projects.

Our implication for practice is directly related to policymakers and entrepreneurial programs. First, we recommend for future entrepreneurial programs include in the instructions and announcements a description of the mentor's role and their activities before starting a program. Also, it is imperative to delimit the role of each participant. Second, institutions and practitioners that implement the lean startup method need to focus on generating a product and not only on testing the market.

5.2 Limitations and future research

Our research has three main limitations that can serve as directions for future studies. First, we conducted interviews, document analysis, and observation at one point in time. Further research could follow up mentor-mentee relations over time. Second, we analyzed a particular program under a specific context of the lean startup methodology. These particularities imply that the characteristics of our sample need to be taken into account when interpreting and generalizing the results. For future research, we recommend a quantitative approach that includes different contexts. Finally, our research's focus was on mentors; we took into account other actors, but the results were related to the mentor's role. Future research could analyze an integrated sample.

6. Conclusion

The mentor is an important actor in the context of entrepreneurial activity; previous research had demonstrated the impact of mentors on entrepreneurs and entrepreneurial projects. However, it is important to take into account the context and type of entrepreneurial program, as the effect of mentoring varies according to the program, methodology, and kind of entrepreneurial project. Specifically, for science-based entrepreneurship, mentors play a role that provides new perspectives and skills. Moreover, the lean startup method will continue to be increasingly popular. It is thus essential to increase research focusing on this topic beyond the understanding of the methodology and comparison.

Chapter 5

Moving Products Out of the Lab! An Examination of Lean Startup Method for Science-based New Ventures in a Developing Economy

1. Introduction

In the last decade, research on “academic entrepreneurship” has increased dramatically. A sub-group of these activities, science-based entrepreneurship, is receiving particular attention because of the expected economic impact (Steffensen, Rogers, & Speakman, 2000; Gilsing, Van Burg & Romme, 2010; Soetanto & Jack, 2016). In consequence, public and private programs that support and promote this activity are increasing around the world (e.g., I-Corps in the USA, Institute for Translational Medicine with 60 institutions worldwide, etc.).

Even though the support for science-based entrepreneurship has advanced, many research centers, institutions, and universities do not have the in-house mechanisms to commercialize the outputs of their research. In many cases, it is necessary to give support to scientists through intermediating entities that emerge as bridges between scientific research and the market, such as technology commercialization consortia, business incubators, and accelerators, to name a few (Gamo et al., 2017). At the same time, the emergence of different techniques and methodologies that provide new ventures with the skills, mechanisms, and methods to boost entrepreneurial activity is helping to close the gap between science, technology, and innovation. One of these methodologies is the lean startup method.

The Customer Development Model (CDM) or lean startup (Ries, 2011; Blank and Dorf, 2012) has emerged as one of the most popular methodologies to enhance entrepreneurship worldwide (Blank, 2013, Blank and Engel, 2013). Although the methodology has been criticized as being informal, intuitive and prone to biases and heuristics (York and Danes, 2014), Lean Startup-based tools and techniques continue to expand, helping entrepreneurs to identify a market for their inventions in relatively less time and with relatively lower costs (Ries, 2011; Blank & Dorf, 2012).

In this study, we analyze the effect of an entrepreneurial program called Binational Innovation Nodes (NoBI) designed to develop entrepreneurial skills for the scientific community in Mexico. For nine weeks, participants of the NoBI program received training from experts in business, science, and technology to validate their ideas in the market. We evaluate the effect of this education program on the participants' entrepreneurial self-efficacy (ESE), business model learning, and entrepreneurial intention (EI). We performed a two-stage longitudinal study applying a survey to 317 individuals. We used a Wilcoxon Matched-Pairs Signed-Rank non-parametric test to analyze the data. Our research is one of the first attempts to systematize the knowledge about interactions between the customer development model and science-based entrepreneurship in the context of an emerging economy.

We found that the participants' entrepreneurial self-efficacy (ESE) and business model learning increased after this program. We also found that this entrepreneurial program did not impact the participants' entrepreneurial intention. This study provides valuable insights into how entrepreneurial programs can develop participants' skills and raise their intention to start a business in the scientific community. This study contributes to the discussion on entrepreneurial education in scientific contexts in an emerging economy where entrepreneurial programs and methods like the lean startup method are becoming popular but not extensively applied.

The rest of the study is organized as follows. In Section 2, we review some relevant concepts about scientific entrepreneurship and the specific context of our setting. Section 3 describes the methodology. In Section 4 we present the main results. Finally, Section 5 discusses practical and theoretical implications, limitations and ideas for future research.

2. Conceptual Framework and Research Approach

2.1 Scientific Entrepreneurship

Science-based new ventures have some peculiarities and a variety of approaches that distinguish them from other academic entrepreneurship activities (Autio, 1997). As Miozzo and DiVito (2016) indicate, some of these characteristics relate to (1) the academic/scientific inventors (presumably the founders) that can facilitate knowledge transfer interactions; (2) science-based firms that engage in the advancement of science; and (3) projects that need a long-term strategy and research and development (R&D) funding (e.g., 10-15 years in the case of the biopharmaceutical industry).

Entrepreneurship is a non-routine activity for scientists (Gudmundsson & Lechner, 2013). Traditionally, scientific entrepreneurship has been limited to the outcome of technology transfer offices (TTOs), whose results indicate that only a handful of universities perform well in scientific entrepreneurship (Audretsch, 2014; Paço et al., 2017). However, scientists' commercialization actions appear to be more influential (Audretsch, 2014), a situation that has been neglected by the TTO model. This omission is particularly relevant considering that most higher tech company founders are science- and technology-savvy, while their commercial expertise is limited, and thus entrepreneurship support services become instrumental (Menzies, 2012).

More often than not, the general perception is that scientists are reluctant to engage with entrepreneurship and its associated support mechanisms. Menzies (2012) has identified a variety of factors that encourage this behavior, notably those listed below:

- Scientists may recognize in themselves poor entrepreneurial attributes or be averse to accepting that third parties question their ways of doing.
- Both scientists and entrepreneurs seek originality in their work outcomes, but while the former seek institutional prominence, the latter focus on market success.
- Some scientists need to face different value perceptions, confronting business profit ends to social value creation; in the case of such a conflict, entrepreneurship can hardly be carried out.

The engagement of the scientist in starting a new business (i.e., entrepreneurial commitment) determines the startup's success (Parente & Feola, 2013); hence, there are a variety of institutional efforts to transform the scientific mindset about entrepreneurship. Scientists require entrepreneurship support programs and intermediaries, which can help them surmount any information and resource asymmetries (including some cognitive aspects like self-efficacy, which affect their willingness to undertake new venture creation) caused by their biased approach as scientists (Clayton et al., 2018).

These support programs can create specific competencies for scientific entrepreneurship, in the hope that universities and research centers will improve their levels of innovation. For instance, Menzies (2012) proposes a model in which the key competencies to be encouraged in the scientific entrepreneur include science, entrepreneurship, and social skills, which would create higher-order attributes (meta-competencies) that interrelate business, and scientific worlds. In particular, CDM-lean Startup has become the de-facto methodological standard for entrepreneurship education and has also been adapted for scientific entrepreneurship, as we discuss below.

2.2 Lean Startup: the methodology

The word *lean* in lean startup dates back to the concept of lean manufacturing in the production lines of automobiles. Nowadays, the term has been widely applied in the business world to express the quick learning that an entrepreneur must engage in to focus on the activities that create value for the client (Ries & Euchner, 2013). This approach has been categorized as a nontraditional method in entrepreneurial education (Monds, 2015). Conversely, in the traditional entrepreneurial model, the entrepreneur develops a business plan to present to investors and then begins its operation. However, this formula has been widely criticized in that startup projects get launched without validating market-product fit, which may partially explain the 75% failure rate of startups (Blank, 2013).

According to Blank (2013), no business plan will resist the first contact with the client; that is, the original business plan document will have notable differences from reality. In this stage, the entrepreneur must focus mainly on creating value for her client, rather than on activities that are unlikely to generate it. This approach is based on the principle that assumptions about the business model hypotheses must be validated iteratively through customer feedback, matching the product to customer problems as much as possible (Heitmann, 2014). These explicit assumptions can be tested in an empirical “real world” setting (Harms, 2015). Consistently, the lean startup methodology favors experimentation, iteration, and customer learning (Blank and Dorf, 2012). In other words, lean startup or CDM is a process to “validate” intuition (York & Danes, 2014).

Other conceptualizations complement the lean startup method, such as the business model canvas, created by Osterwalder (2004) and massively disseminated by Osterwalder and Pigneur (2010), in which business models are translated into a quick tool. Though the CDM uses all nine blocks of the Canvas model, evidence suggests that validations need to focus on customer segment, customer channel and value proposition, which improve validation outcomes and, consequently, the methodology's performance (Ladd, 2016). Lean startup also incorporates some elements of Design Thinking, a method created to modify the traditional process of generating products and services. Design Thinking demands that any design should focus on human needs (i.e., client focus) and not on the product; that is, it is necessary to understand and to empathize with the problem and focus on the prior requirements for prototype elaboration (Brown, 2008).

Criticism of the methodology is also relevant, as some scholars find that the entrepreneurial team's success is not determined by the number of validations. Ladd (2016) argues that excessive iterations with the same customers result in counterproductive false negatives, making it unclear to entrepreneurs when to stop pivoting. Moreover, since the methodology relies strongly on intuition, it is subject to the entrepreneur's biases and plagued with inaccuracies (York & Danes, 2014). As indicated by York and Danes (2014), intuition would be reliable if the entrepreneur has gained enough expertise in predictable environments, considering that the entrepreneur would be looking at opportunities in a well-known domain (path dependency) (Holcomb et al., 2009). In the absence of expertise, however, judgment biases can be expected. Additionally, biased or poor interpretations of the customers' insights can lead to decisions that deviate from the real opportunity.

On the other hand, the effectiveness of lean startup for disruptive innovation has been called into question, as some scholars claim that the methodological approach to small iterative steps appears more appropriate for incremental innovation. Further objections point out that initial validations target early adopters, whose characteristics differ from those of mainstream customers (Heitmann, 2014).

Despite these criticisms, however, lean startup still appears to be an improvement over the traditional business plan, considering its client focus and relative cost-effectiveness to discover new business models. These advantages match what scientific entrepreneurship claims to be one of the scientists' handicaps: identifying real business opportunities for their brand-new technologies. Programs like I-Corps in the USA have customized this methodological approach by creating meta-competencies in the scientific community. One of these meta-competences is self-efficacy, as we discuss after.

a. Entrepreneurship education

Since the first entrepreneurship course at Harvard University in 1947, the popularity of entrepreneurship education has been increasing, not only in areas related to management but also within other disciplines (e.g., medicine, agriculture, and engineering). An entrepreneurial program is a curricular or extracurricular program that includes activities that teach entrepreneurial management, strategy, innovation, and venture development in a university setting (Rideout & Gray, 2013). Some programs adopt different formats to teach the aforementioned skills beyond the traditional curricular style.

Nowadays, entrepreneurship education goes beyond teaching and learning in the classrooms. Specifically, we can now observe education programs like boot camps, contests, pitching and coaching sessions, and so forth. Consequently, scholars and practitioners have started to inquire about the tangible benefits of such programs. Such research, however, is scarce and inconclusive. Entrepreneurship education plays an important role as a crucial process to develop skills and attitudes that potentially help to increase the number of science-based firms.

Scholars of entrepreneurship education have recently gone beyond researching the adoption and implementation of programs, instead focusing on the consequences of such programs. For example, some studies have analyzed the effects of entrepreneurial programs on the entrepreneurs' attitudes, intentions, or actions (Chen et al., 2015; Honing, 2004; Oosterbeek, Van Praag, & Jjsselstein, 2010).

2.4 Entrepreneurial self-efficacy in the scientific community

Entrepreneurial self-efficacy (ESE) is a concept that refers to the specific individual confidence in one's abilities to perform entrepreneurship tasks and activities. ESE can influence people's willingness to engage in future entrepreneurial behavior (Chen, Greene, & Crick, 1998; De Noble, Jung, & Ehrlich, 1999; Hsu, Wiklund, & Cotton, 2017; McGee, Peterson, Mueller, & Sequeira, 2009). Many empirical studies have demonstrated a positive relationship between ESE and entrepreneurial career intentions (McGee et al., 2009; Zhao et al., 2005).

Additionally, scholars have found that entrepreneurship education programs develop a better perception of self-efficacy in individuals that participate in them (Fayolle et al., 2007; Naia et al., 2015; Rideout & Gray, 2013), leading to entrepreneurial intention (Barbosa et al., 2007; Liñán, 2004). Rideout and Gray (2013) highlight that self-efficacy in entrepreneurship evolves through repeated performance, indirect experience, verbal encouragement, and physiological stimulation, whose educational provision can improve the student's outcome expectations and entrepreneurial behavior.

Hence, would-be entrepreneurs with low self-efficacy levels, like scientists, may improve their meta-competences through entrepreneurial education (Rideout & Gray, 2013) and recognize new market prospects, leading to a sort of "opportunity-identification self-efficacy" (Barbosa et al., 2007). Since science commercialization is critically dependent on the scientist's individuality, including self-efficacy beliefs (Fini et al., 2018), it is essential to assess whether entrepreneurial education can influence personality attributes that eventually result in more effective entrepreneurial intentions; thus, this is the research question addressed in this study.

3. Methods

3.1 Sample – the NoBI Program

To answer our research question, we set up a two-stage longitudinal study design in the Binational Innovation Nodes (NoBI), a science-based entrepreneurial program implemented in Mexico. This program emerges from a joint effort of the United States' National Science Foundation (NSF) and the Mexican Council of Science and Technology (CONACYT) to transfer The Innovation Corps (I-Corps™) program to Mexico. The program seeks to sensitize scientific personnel about the importance of the market and to encourage them to take their prototypes out of the laboratory (Venture Well, 2018). Similar to the I-Corps approach, Mexican teams are typically composed of the principal investigator (inventor of the technology), an entrepreneurial leader (usually a student) and a business mentor (usually provided by the institutions that manage the node). For nine weeks, the teams receive training and mentoring, getting out of the lab to validate potential customers' needs and performing at least 100 interviews with potential clients, which allow them to find and understand their target customers.

3.2 Data collection

We conducted a two-stage survey. Surveys evaluated entrepreneurial self-efficacy, entrepreneurial intention, and business model canvas learning. We invited the participants (the group under observation) to complete an online survey. The first survey was conducted at the beginning of the NoBI program (T1), and the second survey was conducted one week after the end of the nine-week program intervention, thus re-evaluating the participants to capture the changes in their assessments and perceptions about their projects (T2). Because both surveys were anonymous, the subjects were asked to list their dates of birth on both questionnaires to match their survey from the two stages. We consider only the scientist participants (principal investigators and entrepreneurial leaders). A discarding inconsistent case with missing values or incomplete information, we obtained a final matched sample of 66 individuals for year one (2017) and 253 individuals for year two (2018). We combined both years for a final sample of 317 individuals.

A combined methodology has been used to increase the internal validity of the analysis. First, we performed a comparative analysis between T1 and T2 using the following protocol:

One group Pre-test, Post-test

Pre-test	Treatment	Post-test
O (T1)	X (NoBI program)	O (T2)

We compare the differences in the participants' evaluations of their business model development and their entrepreneurial self-efficacy (ESE). The latter is a good proxy to measure the propensity of scientists to choose to follow or not to follow entrepreneurial career intentions (Liñán & Chen, 2009; Zhao et al., 2005; Hsu et al., 2017). We expected better evaluations in both business model variables and ESE at T2. Second, with the survey information, we performed a series of regressions to measure whether the variables related to the development of the business model in T1 and T2 predict ESE. The logic behind this approach is that after the intervention, both ESE and business model knowledge could increase in their evaluations. That is, if scientists acquire better competences (T2) to recognize and apply the core components of the business model design (a good proxy of entrepreneurial experience gained by the NoBI program), their ESE would increase, thus increasing our model's predictive power.

Entrepreneurial self-efficacy measures:

We adapted Zhao et al.'s (2015) 4-item measure of ESE. The participants were asked to rate the four statements on a 7-point Likert scale (1 = totally disagree; 7 = totally agree). At T1 and T2 we posed the introductory phrase: "Please evaluate your confidence to perform the following activities successfully" followed by the four statements: (1) I can recognize business opportunities; (2) I can create and develop new products and services; (3) I can think in creative ways to solve problems; and (4) I can market an idea or a new development.

Business model development measures:

We also adjusted the elements described by Osterwalder and Pigneur (2010) related to the core components of a business model. We developed an 8-item measure on a 7-point Likert scale (1=total ignorance; 7=totally known). At T1, we started this section with the statement: "Indicate your knowledge of the following concepts." Next, we listed the nine components: (1) Value proposition; (2) Customer Segment; (3) Channels; (4) Relationships;[1] (5) Key Partners; (6) Key Activities; (7) Key Resources; (8) Cost Structure; and (9) Revenue Streams. At T2, a similar set of items was presented but with a different introductory statement: "AFTER your experience working on your NoBIs project, indicate how much knowledge you have of the following concepts." Next, we elaborated in more detail the components of the business model in order to assess whether participants understood these components and applied them to their projects.

Entrepreneurial intention:

We adapted the scale proposed by Liñán & Chen (2009). The participants were asked to rate the six statements on a 7-point Likert scale (1 = totally disagree; 7 = totally agree). At T1 and T2, we posed the introductory phrase: "Indicate your level of agreement with the following statements": 1) I am ready to do anything to be an entrepreneur; 2) My professional goal is to become an

[1] In the first round of NoBI program (2017), the component "Customer Segment Relationships" has been merged with the "Customer Channels." So, at T1 we have only eight components and at T2 we evaluate the nine components, but we cannot pair these specific components. By this reason our analyzes are based on eight variables.

entrepreneur; 3) I will make every effort to start and run my own firm; 3) I am determined to create a firm in the future; 4) I have very seriously thought of starting a firm; and 5) I have the intention to start a firm someday.

Control variables:

For the regression analyses, we controlled by gender, age, and education level (university/college bachelor's, master's, or doctoral degree). This variable helps to address any predisposition to undertake an entrepreneurial endeavor. For example, some literature has found entrepreneurial intention varies with gender and age (Estrin et al., 2013; Stephan et al., 2015).

4. Results

4.1 Longitudinal approach

Table 1 shows the descriptive statistics of ESE and business model variables at T1 and T2. Descriptive statistics of demographic control variables are included in Table 2.

Table 1. Descriptive Statistics of ESE, Business Model and Entrepreneurial Intentions Variables at T1 and T2

Variable	N	T1 Mean	T2 Mean	T1 Std. Deviation	T2 Std. Deviation	T1 Min.	T1 Max.	T2 Min.	T2 Max.
ESE Business opportunity	317	5.07	6.05	1.449	1.958	1	7	2	7
ESE Create new products	317	5.44	6.14	1.427	1.128	1	7	2	7
ESE Solve problems	317	5.81	6.37	1.259	.770	1	7	3	7
ESE Commercialization	317	4.92	5.90	1.585	1.147	1	7	2	7
Value proposition	317	4.42	6.33	1.924	0.839	1	7	2	7
Customer Segment	317	4.48	6.39	1.831	0.833	1	7	3	7
Customer Relationships	251	4.18	6.01	1.831	0.989	1	7	1	

Channels	317	4.23	6.12	1.845	1.013	1	7	2	7
Key Partners	317	4.27	5.95	1.850	1.104	1	7	2	7
Key Activities	317	4.37	6.21	1.850	0.980	1	7	2	7
Key Resources	317	4.32	6.07	1.830	0.970	1	7	3	7
Cost Structure	317	3.89	5.85	1.998	1.128	1	7	2	7
Revenue Streams	317	3.90	5.95	1.967	1.117	1	7	2	7
Entrepreneurial intention	249	5.77	5.68	1.229	1.321	1	7	1	7

Table 2. Descriptive Statistics of Demographic Control Variables

Variable	Responses	Frequency	Percent
Education Level	1 High School	7	2.2
	2 Bachelor's degree	89	28.1
	3 Master's	113	35.6
	4 Doctoral	108	34.1
	Total	317	100.0
Gender	1 Female	129	40.7
	2 Male	188	59.3
	Total	317	100.0

Variable	N	Mean	Std. Deviation	Min	Max
Age	316	37.82	12.114	19	76

A general overview of the descriptive statistics shows that there are differences between T1 and T2, with higher averages and lower standard deviations at T2. In general, the participants evaluated their entrepreneurial self-recognition more highly and perceived that they had more knowledge about the components of their business model after the program. To corroborate these differences, we used a series of Wilcoxon Matched-Pairs Signed-Rank nonparametric tests as an alternative to the two-related samples T-tests.[2] The results are reported in Table 3. We obtained statistically significant differences between all pairs of the variables for ESE and business model. These differences confirm that after the NoBI program, on average, participants increased their ESE and learned and applied the concepts about their business models more effectively when these variables are compared with their general knowledge at T1. In contrast, we did not obtain statistically significant differences between all pairs for entrepreneurial intentions.

Table 3. Wilcoxon Matched-Pairs Signed-Rank Test for ESE, Business Model Variables and Entrepreneurial Intention

Variables		N	Mean Rank	Rank Sum	Z	Sig
ESE Business opportunity	Negative ranks	33	75.11	2478.50		
	Positive ranks	186	116.19	21611.50		
	Ties	98				
	Total	317			-10.372	0.000
ESE Create new products	Negative ranks	46	81.07	3729.00		
	Positive ranks	160	109.95	17592.00		
	Ties	111				
	Total	317			-8.303	0.000
ESE Solve problems	Negative ranks	43	68.57	2948.50		
	Positive ranks	135	96.17	12982.50		
	Ties	139				
	Total	317			-7.576	0.000
ESE Commercialization	Negative ranks	36	75.22	2708.00		
	Positive ranks	175	112.33	19658.00		
	Ties	106				
	Total	317			-9.692	0.000
Value proposition	Negative ranks	19	63.05	1198.00		
	Positive ranks	231	23.39	772.00		
	Ties	67				
	Total	317			-12.754	0.000
Customer Segment	Negative ranks	21	45.02	945.50		
	Positive ranks	233	134.93	31439.50		
	Ties	63				

[2] We also performed T tests regarding the same variables, and the results were nearly identical. Nevertheless, we cannot assume a normal distribution between ESE and Business Model variables; so we decided to use nonparametric tests to obtain more robust results.

	Total	317			-13.103	0.000
Customer Relationships	Negative ranks	13	56.54	735.00		
	Positive ranks	186	103.04	19165.00		
	Ties	52				
	Total	251			-11.412	0.000
Channels	Negative ranks	24	69.42	1666.00		
	Positive ranks	233	135.14	31487.00		
	Ties	60				
	Total	317			-12.584	0.000
Key Partners	Negative ranks	37	72.49	2682.00		
	Positive ranks	228	142.82	32563.00		
	Ties	52				
	Total	317			-11.751	0.000
Key Activities	Negative ranks	18	82.72	1489.00		
	Positive ranks	231	128.29	29636.00		
	Ties	68				
	Total	317			-12.457	0.000
Key Resources	Negative ranks	31	70.50	2185.50		
	Positive ranks	226	137.02	30967.50		
	Ties	60				
	Total	317			-12.159	0.000
Cost Structure	Negative ranks	35	57.43	2010.00		
	Positive ranks	223	140.81	31401.00		
	Ties	59				
	Total	317			-12.314	0.000
Revenue Streams	Negative ranks	25	65.20	1630.00		
	Positive ranks	236	137.97	32561.00		
	Ties	56				
	Total	317			-12.736	0.000
Entrepreneurial Intention	Negative ranks	105	105.86	11115.50		
	Positive ranks	97	96.78	9387.50		
	Ties	44				
	Total	246			-1.040	0.298

Related to ESE, results show that business opportunity recognition is one of the variables with the largest upgrading in its evaluation. Given the nature of the projects, this is a relevant finding, because it suggests that scientists that have a relatively low score to entrepreneurship activities could improve their ESE with more commitment to “translate” their research activities to a market-oriented new business opportunity (Parente & Feola, 2013). This result also supports one of the goals of NoBI programs (and the original I-Corps program), related to improving the entrepreneurial skills of scientists/technicians, increasing ESE levels and helping scientists feel more competent and comfortable with entrepreneurial activities (Hsu et al., 2017).

Regarding business model variables, the more significant differences point to the financial components: cost structure and revenue streams. This outcome is consistent with the notion that scientists are predominantly focused on the features of their inventions, rather than developing a business model that prioritizes financial components and market orientation (Menzies, 2012). Results also confirm that the NoBI program, on average, allows scientists to acknowledge the essential components of the business model, specifically, potential customer segments and value proposition of their inventions. Comparing the two outcomes, ESE and business model components, it can be observed that after their participation in NoBI, scientist entrepreneurs consider their entrepreneurial skills and knowledge about how to structure a business model to have increased significantly. Again, this finding relates to one of NoBI's primary goals, in that it appears to contribute positively to a scientific product or service commercialization attitude among participants.

4.2 Regression models

Our second empirical approach consists of a series of regressions aimed to predict that better knowledge about the components of a business model determines the ESE of the NoBI participants. Because of the number of matched cases (317), we were particularly careful about the model reliability, as we wanted to ensure enough degrees of freedom to allow for more accurate results. One strategy is to reduce the number of variables, calculating latent variables precisely related to ESE and business model. We validated the internal consistency and reliability of these measures (based on the sample from 2017) using a standardized Cronbach coefficient, considering the four items of ESE (Zhao et al., 2005) at T1 (Cronbach a=0.865) and at T2 (Cronbach a=0.899). Similarly, we consider the nine business model variables to be strongly correlated with the definition and configuration of the business model design (Osterwalder & Pigneur, 2010; Zott and Amit, 2017) at T1 (Cronbach a=0.949) and at T2 (Cronbach a=0.932). Our measures sufficiently satisfy Nunnally and Bernstein's (1994) guidelines, which recommend 0.7 as a benchmark for internal consistency.

To confirm that, we can group both ESE and business model. We performed a Principal Component Analysis (PCA)[3] of these sets of variables at T1 and T2. For ESE at T1, we find that one component (one latent variable) explains 72% of the variance with a Kaiser-Meyer-Olkin Measure of Sampling Adequacy[4] (KMO) of 0.746. At T2, the explained variance with one component is 79%, with KMO=0.811. This coefficient partially explains that T2 has better internal consistency. With business model variables at T1, one component explains 74% of the variance, with KMO=0.881. At T2, one component explains 70% of the variance, with KMO=880. After confirming that our data can be summarized, we averaged ESE and business model variables at T1 and T2. Summarized variables'

[3] PCA can be defined as a method to do a linear combination of optimally-weighted observed variables (orthogonal components), which is used to reduce the dimensionality of the data set to a lower dimension to reveal latent constructs, simplified structures that often underlie it.

[4] The Kaiser-Meyer-Olkin Measure of Sampling Adequacy is a statistic that indicates the proportion of variance in a set of variables that might be caused by underlying factors. Values close to 1.0 generally indicate that a factor analysis may be useful with the data. Values less than 0.50 indicate that factor analysis probably is not useful.

and control variables' statistics and correlations at T1 and T2 are presented in Table 4 and Table 5.

Table 4. Descriptive statistics and correlations at T1

Variable	Mean	Std. Dev.	Min	Max	ESE	Business Model	EI	Age	Education Level	Gender
ESE	5.309	1.193	1.25	7	1.000					
Business Model	4.24	1.678	1.00	7	0.511**	1.000				
EI	5.77	1.229	1.50	7	0.310**	0.178**	1.00			
Age	37.82	12.114	19	76	0.189**	0.122*	-0.134*	1.000		
Education Level	3.02	0.844	1	4	0.054	1.136*	-0.123	0.499	1.000	
Gender	1.59	0.493	1	2	-0.008	0.10	-0.047	0.091	0.511**	1.000

** P <.01
** P <.05

Table 5. Descriptive statistics and correlations at T2

Variable	Mean	Std. Dev.	Min	Max	ESE	Busines s Model	EI	Age	Education Level	Gender
ESE	6.113	0.830	3	7	1.000					
Business Model	6.103	0.740	3.55	7	0.580**	1.000				
EI	5683	1.321	1	7	0.407**	0.293**	1.00			
Age	37.82	12.114	19	76	0.215**	0.248*	-0.072	1.00		
Education Level	3.02	0.844	1	4	0.089	0.092	-0.085	0.511**	1.000	
Gender	1.59	0.493	1	2	-0.048	-0.021	-0.036	0.077	-0.007	1.000

** P <.01

OLS hierarchical linear regression was performed. The results are presented in Table 6. In model 1, the T1 control variables were included. R2 was .197 (p < .1). The independent variable, business model, was entered in model 2;

business model was positively related to ESE (β = .393; $p < .001$). We followed a similar procedure with T2. Model 3 include control variables. We obtained a R2 .219 ($p < .001$). Finally, model 4 with business model, R2=.588 ($p < .001$) also was positively related to ESE (β = .633; $p < .001$).

Table 6. Regressions of Business Model to Entrepreneurial Self-Efficacy

	T1				T2			
	Model 1		Model 2		Model 3		Model 4	
Age	0.024	***	0.014		0.016	***	0.005	
Education Level	-0.082		-0.067		-0.025		-0.001	
Gender (Female=1)	-0.061		-0.038		0.051		0.0891	
Business Model			0.393	***			0.663	***
Constant	4.831	***	2.598	***	5.522	***	1.922	***
R2	.197		0.307		0.219		0.588	
ΔR2			0.094				0.345	

* Coefficient significant at .10, ** coefficient significant at .05, *** coefficient significant at .001.
N = 317.

Both Models 2 and 4 corroborate that the business model variable explains ESE, and after the intervention (T2) we have a better-fitted model that demonstrates that when the scientists increase their business model knowledge, they also improve their ESE, a relevant objective for NoBI's purpose.

3. DISCUSSION

Our research highlights a Lean Startup-based entrepreneurial program that has positively impacted science-based prospective entrepreneurs. Results indicate that the NoBI program has effectively increased the participants' business model knowledge and entrepreneurial self-efficacy. To some extent, NoBI's experiential learning approach has reached its educational objectives, substantiating the effectiveness of CDM among scientists, which may also encourage them to apply the methodology as an influencing criterion in the development of future technologies.

In contrast, after the program, most scientific teams' entrepreneurial intentions did not increase. This is a surprising finding. Nevertheless, we found a positive effect of business model knowledge on entrepreneurial intentions. This finding confirms that participants in the program acquire business skills and this new knowledge triggers a mindset change.

Additionally, this research contributes to improving our contextual understanding of the relation between ESE and the business model canvas(Keane et al., 2018). In general, improving a scientist's comprehension of a business model appears to have a strong impact on her entrepreneurial expectations. This relationship can be explained if scientists and entrepreneurial leaders have freely joined NoBI because of their personal ambitions to start their own science-based businesses but lacked sufficient self-efficacy, as suggested by Rideout and Gray (2013). In this scenario, the entrepreneurial education that scientists received from NoBI fills a business understanding gap for participants and also serves as a motivational factor that increases their level of ESE and subsequent entrepreneurial behavior.

5.1 Implications

As one of the few studies in scientific entrepreneurship that originates in a developing economy, this research has important implications for theory and practice. From a theoretical perspective, findings highlight the significance of entrepreneurial education in encouraging new venture creation in a scientific community that is typically unfamiliar with, and sometimes reluctant to engage in, entrepreneurship. Scholars can expand on these results to develop scientific entrepreneurship models that include client-focus entrepreneurship training, complementing or replacing parts of the traditional frameworks, which would lead to a fresh discussion of the particularities of science-based new ventures in developing countries. Additionally, the causal link between the business model and ESE poses more research questions about the nature of such relationship.

For practitioners, results provide a rationale that supports the application of lean startup or CDM in entrepreneurship education. Aspiring entrepreneurs with science-based new venture ideas can take advantage of NoBI-like programs to improve their understanding of business models, client problems and value proposition, hypothesis validation, and other related concepts to reach a better understanding of the market potential and achieve product-market fit quickly.

In terms of policy implications, it is well known that science and technology (S&T) investment in most developing countries tends to be significantly lower than in more developed economies, a difficulty that increases if we take into consideration the significant challenges that these countries face in their ability to commercialize and benefit from their scientific production (Miozzo and DiVito; 2016). If implemented as a criterion for prioritizing S&T investment, the use of CDM would allow for a more focused use of scarce national resources in those scientific proposals that can demonstrate a certain level of customer validation and problem-solving potential.

Additionally, to face social challenges and improve the outcomes of public policy's S&T investment, it becomes necessary to design programs that boost science commercialization. This research has identified some of the benefits of a program that encourages science-based entrepreneurship through the lean startup approach, the results of which are promising, at least from an educational and skill development perspective.

5.2 Limitations and future research

The present study has some limitations. First, its analysis is bounded to a specific lean startup program (NoBI) and a particular context (Mexico). Second, the research focused on evaluating educational advancements in the target sample before and after program intervention. Further research should consider a larger timespan by including follow-up surveys after program participation. It would be relevant to investigate factual results regarding new ventures' incorporated, the entrepreneur's startup experience and challenges, and the status of the relationship with her home institute, among others.

From a methodological perspective, as a longitudinal study, this research is also limited in its explicatory power, since no real control group has been included to contrast results. The explicatory power could be extended by considering different comparison groups: programs (lean vs. traditional), style of entrepreneurship (traditional vs. science-based), country development level (developing vs. emergent economies). Additionally, since the design centered around a specific scientific entrepreneurship program (NoBI) following a purposive sampling tactic, our research faces some internal and external validity challenges, indicating a certain degree of exploratory character in our results. If NoBI-like entrepreneurship programs become widely disseminated in the scientific community, it would be possible to design randomized experiments that would allow for more robust validity (Lee & Lemieux, 2010).

Finally, our research was specific to analyzing business model comprehension with subsequent impacts on ESE and EI. Further research can take a broader scope by including other types of knowledge and entrepreneurial skills, such as interviewing, networking, and business model conceptual understanding appraised by third-party evaluators, among others.

5. Conclusions

This study has analyzed how a scientific entrepreneurship lean startup program could improve perceived knowledge of business model concepts in a group of scientists immersed in a time-intensive customer discovery methodology, which eventually leads to a higher level of entrepreneurial self-efficacy. More importantly, our results suggest that by providing deeper experiential comprehension about entrepreneurship (business models in our research, but other concepts may be applicable as well), scientists can increase their entrepreneurial self-efficacy. Improving individuals' self-efficacy thus is instrumental in encouraging entrepreneurship, and the CDM in the form of NoBI appears to be an effective tool to foster the entrepreneurial transformation of the scientific mindset from implementation to customer validation.

Our findings provide insights for decision makers involved in scientific entrepreneurship programs, suggesting that scientists need to be encouraged to get out of the laboratory and validate real client problems before turning their ideas into functional prototypes. Finally, this study extends the research on lean startup and the business model canvas to the science-based context in a developing economy, suggesting more questions for entrepreneurship research.

Chapter 6

Conclusions

This thesis provides an integrated framework of the commercialization process for scientific research. The core part of this dissertation includes four chapters that encompass a series of studies that analyze the complementary elements of science-based entrepreneurship activities in a unique empirical setting in Mexico. Table 1 summarizes findings from this dissertation. The first of these chapters (Chapter 2) identifies barriers, bridges, and success factors associated with the valley of death from previous research. Next, Chapter 3 presents the results of the analysis of an entrepreneurial public program for the scientific community. I analyzed the impact of an entrepreneurial program to cross the valley under a qualitative approach. Results suggest a changing mentality after the program. mainly for the principal investigators, in terms of limitations, market, idea validation, and commercialization.

Chapter 4 offers an empirical study of the mechanisms that serve as bridges to cross the valley of death, to change the scientific mindset. Specifically, I analyzed the mentoring role under a lean program. This study extends previous mentoring research. Also, this research provides insights to better define the role of mentors for entrepreneurial programs and the scientific context — for example, the mentor's entrepreneurial and scientific background, and the match between the mentor's experience and mentees.

Table 1. Main findings

Chapter	Method	Main findings
Ch. 2: From research to commercialization: A systematic review on the valley of death	Systematic literature review 1. Bibliometric analysis 2. Literature review	-Classification at the level of barriers and recommendations. -Integrated framework of the valley of death that includes barriers, bridges and success factors.
Ch. 3: Bridging the Valley of Death: Lessons from a government program	Qualitative approach -Interviews -Participant observation -Documents	-Impact of a governmental program on scientists to identify their market and validate their technology or invention with a real customer. - Main impact is on the principal investigators, who undergo a paradigm shift about the research connected with the market.
Ch. 4 The Role of Mentoring in a Lean Startup Program for Science-based Entrepreneurs— A Case Study	Embedded case study design -Semi-structured interviews -Structured questionnaire -Participant observation -Documents	- Role of mentors when the mentor is part of the team. -Role of mentors under lean program: communication and business skills. - Facilitators of methodology: experience and interpersonal relations.
Ch. 5 Moving Products Out of the Lab! An Examination of Lean Startup for Science-based New Ventures in a Developing Economy	Two-stage longitudinal design -Online survey	-Positive effect after program on entrepreneurial self-efficacy (ESE), and business model learning increased after this program. - Entrepreneurial program did not impact the participants' entrepreneurial intention.

Finally, in Chapter 5 I present a fourth study following a quantitative approach. Results highlight how entrepreneurial programs have a positive impact on scientists in terms of business knowledge, entrepreneurial behavior, and customer validation. However, this effect is not sufficient to motivate the entrepreneurial intention of scientists. This main finding shows that the scientific mindset needs more motivation. Results suggest that if scientists increase their business knowledge, this will have a positive effect on entrepreneurial intention.

This study contributes to the understanding of entrepreneurial behavior in a scientific context.

The main conclusion of the integration of the different studies that comprise the thesis is related to the fact that is possible to move scientists from research to the market. It is necessary to understand the barriers and bridges to crossing the valley of death of science commercialization. Specifically, this study focuses on the individual scientists and the mechanisms that help to break the barriers. This study found a positive impact of a program on their participants in terms of business knowledge, entrepreneurial behavior, and customer validation. Also, this research contributes to understanding the context and public policies related to science commercialization in developing economies.

While each chapter offers a series of implications for theory and practice, the next section will summarize the main points from an integral point of view.

Implications

This thesis is one of the few studies focusing on science-based entrepreneurship and science commercialization in a developing economy. By consequence, there are important implications for theory and practice, from the perspective of this type of economy. For academia, the findings highlight the significance of entrepreneurial education in encouraging new science-based venture creation and its role for the commercialization process of science. Scholars can depart from these results to develop models that help scientific entrepreneurs to cross the valley of death. This research provides various insights on the function of bridges and methodologies to integrate actors and methods in a single framework for science commercialization.

For practitioners, this research provides a framework to support the application of lean methodology and customer discovery in entrepreneurial programs for the scientific community, beyond an academic perspective. Likewise, results from this study highlight the role of mentors in entrepreneurial programs and support the effect and relation between mentors and mentees for the entrepreneurship community.

Finally, for policymakers, this research shows the effect of a public initiative for the scientific community. As mentioned earlier, the investment in research and development (R&D) in most developing countries tends to be significantly lower than in developed economies. This study shows the impact of support mechanisms for science and innovation. Specifically, a customer discovery process provides the scientific community with a fast response from the market regarding whether or not they should continue to invest in a given line of research. This revelation offers the scientific community possibilities to improve the commercialization phase.

Limitations and Future Research

Despite the notable findings of this study, there some general limitations to address. This research only includes a specific program (NoBI) and a particular context (Mexico) in a specific period. Further research should consider different kinds of programs and economies to measure the long-term effect after program participation. Also, this research analyzes science and technological research from different disciplines as a whole. Future research should consider including a sector division (e.g., medicine versus biotechnology or engineering).

Moreover, this research studies scientists from higher education institutions and public research centers. An interesting contrast for future research could include, for example, the private sector versus academia. Finally, the empirical setting presents a self-selection bias, as the program is nonmandatory (i.e., the participants decided to take part in the program).

To extend the findings and continue the research line, I am interested in taking some further steps. First, I would like to continue to quantitatively analyze the impact of entrepreneurial programs through the integration of new variables and different methodologies. Second, I want to extend the follow-up with teams and projects of NoBI to obtain a longitudinal study and extend the research to the operational stage. Finally, in the short term, I am interested in extending entrepreneurial mentoring research using a quantitative approach.

Recommendations

This research offers a series of recommendations for several actors immersed in the phenomenon of science commercialization and science-based entrepreneurship. Each chapter discusses specific recommendations. However, here I summarize the recommendations that can be generalized to the whole dissertation.

Policy decision makers

- Continue to introduce programs in support of science-based entrepreneurship oriented to the first stages of creation.
- Develop policies, rules, and regulations that allow for a rapid commercialization process (e.g., the law of science and technology, investigators' economic participation, the agile process of intellectual proprietary, support of new science-based firms).

- Integrate entrepreneurial programs like NoBI as a filter for public funding or next benefits.

Entrepreneurial community

- Create a social network that integrates the scientific community of NoBI with the entrepreneurial ecosystem. This link could serve as a mentoring or consulting source.
- Design models and events for science-based entrepreneurship that consider its particularities.

Academic and educational institutions

- Continue to develop entrepreneurship programs for the scientific community at different levels.
- Design programs that involve scientists in entrepreneurial activities as part of their formation, not just to validate the research.

I hope that this thesis, independent of its conceptual and empirical merits, can help to foster more innovative new ventures and enhance the entrepreneurial culture in our region. Entrepreneurs, and especially science-based entrepreneurs, are key actors that not only dynamize the competitiveness of the markets but contribute to the social and economic development of their communities.

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Appendix A: Survey T1

Cuestionario de Entrada

CONACYT solicita de su apoyo contestando esta encuesta. Ésta tiene la finalidad de evaluar los resultados del programa Nodos Binacionales de Innovación. Esta investigación es un esfuerzo conjunto de las instituciones participantes. Su tiempo, contribución y apoyo son muy valiosos para este estudio. CONSENTIMIENTO ELECTRÓNICO: Por favor seleccione su elección a continuación: Seleccionar “De acuerdo” indica que:

- Ha leído la información anterior.
- Voluntariamente acepta a participar.
- Tiene por lo menos 18 años.

Si no desea participar en el estudio, por favor rechace su participación mediante la opción de “No estoy de acuerdo”.

○ Sí acepto participar

○ No acepto participar

El papel desempeñado por usted en el equipo NoBI es:

○ Investigador Principal

○ Mentor

○ Líder Emprendedor

○ Otro ____

¿Cuál de los siguientes enunciados describe mejor su rol profesional?

○ Director/ administrador de programas/ proyectos (Institución Académica)

○ Profesor/Investigador

○ Estudiante

○ Administración

○ Emprendedor

○ Profesional en negocios

○ Gobierno

○ Otro ____

¿Cuál de los siguientes perfiles lo describe mejor?

- ◯ Perfil 1: Quiero ser un emprendedor y tener éxito con una nueva empresa mundial.
- ◯ Perfil 2: No estoy interesado en iniciar mi propia empresa. Quiero escalar y sostener mi innovación dentro de mi contexto y en mi profesión actual.
- ◯ Perfil 3: Quiero escalar y sostener mi innovación. Tener éxito en ambos la nueva empresa y mi profesión/trabajo actual.
- ◯ No aplica

¿Cuál de las siguientes categorías describe mejor el área de su investigación o tecnología?

- ◯ Materiales avanzados e instrumentación
- ◯ Manufactura Avanzada y Nanotecnología
- ◯ Tecnologías Biológicas
- ◯ Tecnologías químicas y ambientales
- ◯ Hardware electrónico, robótica y tecnologías inalámbricas
- ◯ Tecnologías y aplicaciones educativas
- ◯ Tecnologías de información y comunicación
- ◯ Semiconductores y fotónicos. Dispositivos y materiales
- ◯ Salud y tecnologías biomédicas
- ◯ Otro ____

El mínimo producto viable (MVP) de mi equipo es principalmente un...

- ◯ Producto
- ◯ Programa o servicio
- ◯ Ambos igualmente
- ◯ No estoy seguro

¿Ha participado previamente en el programa NoBIs?

- ◯ No
- ◯ Sí. ¿Cuál fue su rol? ____

¿Cuál de los siguientes enunciados describe mejor el estado de su innovación?

- ◯ Etapa temprana: Concepto solamente o MVP sin descubrimiento de clientes.
- ◯ Descubrimiento de clientes: Tienen identificada la propuesta de valor y los segmentos de cliente, ajuste del producto al mercado, y el problema/solución.
- ◯ Modelo de negocios: Han completado el Business Model Canvas o algún otro modelo, mostrando a expertos en negocios y/o inversionistas su potencial.
- ◯ Evidencia de negocio: Han demostrado la eficacia de su modelo de negocio con al menos 10 ventas, y/o han sido premiados o reconocidos para desarrollar o implementar su innovación.
- ◯ Escalamiento: Han demostrado con éxito la eficacia de su modelo, el equipo se ha centrado en escalar la innovación a través de ventas, inversionistas, adopción institucional y corporativa, y continúa obteniendo premios y soporte.

Indique cual es su conocimiento/dominio de los siguientes conceptos. Siendo 1 Desconocimiento Total y 7 Dominio total del tema.

	Desconocimiento Total 1	2	3	4	5	6	Dominio Total 7
Propuestas de valor	○	○	○	○	○	○	○
Segmentos de mercado	○	○	○	○	○	○	○
Relaciones con los clientes	○	○	○	○	○	○	○
Canales de distribución	○	○	○	○	○	○	○
Socios estratégicos	○	○	○	○	○	○	○
Actividades clave	○	○	○	○	○	○	○
Recursos clave	○	○	○	○	○	○	○
Estructura de costos de un negocio.	○	○	○	○	○	○	○
Flujos de ingresos	○	○	○	○	○	○	○

Evalúe su confianza en realizar con éxito las siguientes declaraciones. Siendo 1 Total Desconfianza y 7 Total Confianza.

	Total Desconfianza 1	2	3	4	5	6	Total Confianza 7
Puedo reconocer las oportunidades de negocios.	○	○	○	○	○	○	○
Puedo crear y desarrollar nuevos productos y servicios.	○	○	○	○	○	○	○
Puedo pensar maneras creativas para resolver mis problemas.	○	○	○	○	○	○	○
Puedo comercializar una idea o un nuevo desarrollo.	○	○	○	○	○	○	○

Indique si esta usted de acuerdo con las siguientes declaraciones. Siendo 1 Totalmente en Desacuerdo y 7 Totalmente de Acuerdo.

	Totalmente en desacuerdo 1	2	3	4	5	6	Totalmente de Acuerdo 7
Estoy decidido a formar en el futuro una empresa a partir de los resultados de este programa.							
Mi meta profesional es llegar a ser un emprendedor.							
Voy a hacer todo lo posible por crear y dirigir mi propia empresa.							
Tengo la firme intención, de algún día, formar una empresa.							
He considerado seriamente establecer mi propia empresa.							
Estoy dispuesto a hacer cualquier cosa para convertirme en un emprendedor académico.							
Es muy probable que en los próximos cinco años ponga en marcha mi propia empresa.							
Convertirme en un emprendedor me reportaría más ventajas que inconvenientes.							
Me resulta atractivo ser un emprendedor-investigador.							
Si tuviese la oportunidad y los recursos, me gustaría crear una empresa.							
Ser un emprendedor me reportaría una gran satisfacción personal.							
Entre varias opciones, preferiría ser un emprendedor.							
Mi familia directa aprobaría mi decisión de crear una empresa (padres, hijos, pareja, hermanos).							
Mis amigos cercanos aprobarían mi decisión de crear una empresa.							
Mis compañeros o colegas de trabajo aprobarían mi decisión de crear una empresa a partir de los resultados de investigación.							

Crear una empresa a partir de los resultados de investigación o programa y mantenerla en funcionamiento sería fácil para mí.	○	○	○	○	○	○	○
Estoy preparado para poner en marcha una empresa viable a partir de los resultados de este programa.	○	○	○	○	○	○	○
Puedo controlar el proceso de creación de una empresa.	○	○	○	○	○	○	○
Conozco detalles prácticos necesarios para poner en marcha una empresa.	○	○	○	○	○	○	○
Sé cómo desarrollar un proyecto de emprendimiento.	○	○	○	○	○	○	○
Si tratase de poner en marcha una empresa, tendría una alta probabilidad de lograrlo y mantenerla en funcionamiento.	○	○	○	○	○	○	○
En general, sería capaz de controlar totalmente las circunstancias para poner en marcha una empresa.	○	○	○	○	○	○	○

¿Tiene experiencia en gestión/administración de empresas?

○ Sí

○ No

¿Tiene experiencia en el mismo sector al que pertenece el proyecto que va a desarrollar en el NoBI?

○ Sí

○ No

¿Ha participado como asesor o consultor empresarial?

○ Sí

○ No

Número de patentes que ha solicitado en los últimos 5 años.

____

¿Ha desarrollado una patente relacionada proyecto del programa NoBI?

○ Sí

○ No

Número de patentes que le han sido otorgadas en los último años.

____

¿Ha creado usted o participado en la creación de una empresa spin-off, es decir una empresa creada por profesores / investigadores que se desprende de una universidad o centro de investigación como resultado de procesos de investigación o programas de emprendimiento?

○ Sí

○ No

¿Ha creado usted o participado en la creación de una empresa?

○ Sí

○ No

¿Ha sido dueño o socio de alguna empresa que haya fracasado (el fracaso significa que la empresa haya tenido que suspender sus operaciones o cerrar debido a la falta de recursos y/o dificultades financieras y/o de gestión)?

○ Sí

○ No

Nombre

____

Segundo Nombre (Si aplica)

____

Primer apellido

____

Segundo apellido

____

Género

○ Femenino

○ Masculino

Fecha de Nacimiento

	Mes	Día	Año
Selecciona	▼ Enero ... Diciembre	▼ 1 ... 31	▼ 1900 ... 2049

Nombre del proyecto.

____

Número de proyecto / Equipo NoBI

____

Grado Académico

○ Preparatoria

○ Licenciatura

○ Maestría

○ Doctorado

Institución a la que pertenece (Universidad / Empresa)

____

Antigüedad en la institución (Años)

____

Appendix B: Survey T2

Cuestionario Salida

DESPUÉS de su experiencia trabajando en su proyecto NoBI. Indique qué tanto conocimiento y dominio tienes de los siguientes conceptos. Siendo 1 Desconocimiento total y 7 Conocido Totalmente.

	Desconocimiento Total 1	2	3	4	5	6	Conocido totalmente 7
Puedo determinar claramente cuál o cuáles son los segmentos de clientes y los arquetipos de mis consumidores.	○	○	○	○	○	○	○
Puedo identificar posibles soluciones a los problemas de los clientes y satisfacer sus necesidades mediante propuestas de valor.	○	○	○	○	○	○	○
He logrado identificar los canales de comunicación, distribución y venta para llegar a los clientes	○	○	○	○	○	○	○
Puedo establecer los tipos de relaciones que necesita cada segmento de mercado. La relación puede ser personal o automatizada.	○	○	○	○	○	○	○
Puedo identificar las fuentes de ingreso que puede tener el proyecto en relación con el/los segmentos de clientes.	○	○	○	○	○	○	○
Puedo identificar claramente a mis socios claves que me pueden ayudar tanto con recursos como con actividades complementarias.	○	○	○	○	○	○	○
Puedo identificar las actividades claves necesarias para el desarrollo del proyecto.	○	○	○	○	○	○	○
Sé identificar los recursos clave que permiten crear y ofrecer una propuesta de valor, llegar a los mercados, establecer relaciones con segmentos de mercado y percibir ingresos	○	○	○	○	○	○	○
Puedo identificar los costos relevantes de mi proyecto.	○	○	○	○	○	○	○

Evalúe su confianza en realizar con éxito las siguientes declaraciones. Siendo 1 Total Desconfianza y 7 Total Confianza.

	Total Desconfianza 1	2	3	4	5	6	Total Confianza 7
Puedo reconocer las oportunidades de negocios.	○	○	○	○	○	○	○
Puedo crear y desarrollar nuevos productos y servicios.	○	○	○	○	○	○	○
Puedo pensar maneras creativas para resolver mis problemas.	○	○	○	○	○	○	○
Puedo comercializar una idea o un nuevo desarrollo.	○	○	○	○	○	○	○

Indique el nivel de acuerdo con las siguientes declaraciones. Siendo 1 Totalmente en Desacuerdo y 7 Totalmente de Acuerdo.

	Totalmente en Desacuerdo 1	2	3	4	5	6	Totalmente de Acuerdo 7
Estoy totalmente decidido a formar en el futuro una empresa a partir de los resultados de este programa.							
Mi meta profesional es llegar a ser un emprendedor.							
Voy a hacer todo lo posible por crear y dirigir mi propia empresa a partir de los resultados de este programa.							
Tengo la firme intención, de algún día, formar una empresa a partir de los resultados de este programa.							
He considerado seriamente establecer mi propia empresa a partir de los resultados del programa.							
Estoy dispuesto a hacer cualquier cosa para convertirme en un emprendedor académico o emprendedor.							
Es muy probable que en los próximos cinco años ponga en marcha mi propia empresa a partir de los resultados del programa.							
Convertirme en un emprendedor me reportaría más ventajas que inconvenientes.							
Me resulta atractivo ser un emprendedor o emprendedor-investigador.							
Si tuviese la oportunidad y los recursos, me gustaría crear una empresa a partir de los resultados del programa.							
Ser un emprendedor me reportaría una gran satisfacción personal.							
Entre varias opciones, preferiría ser un emprendedor.							
Mi familia directa aprobaría mi decisión de crear una empresa (padres, hijos, pareja, hermanos).							
Mis amigos cercanos aprobarían mi decisión de crear una empresa.							
Mis compañeros o colegas de trabajo aprobarían mi decisión de crear una empresa a partir de los resultados de mis investigaciones.							
Crear una empresa a partir de los resultados de una investigación o este programa y mantenerla en funcionamiento sería fácil para mí.							

Estoy preparado para poner en marcha una empresa viable a partir de los resultados de este programa.	○	○	○	○	○	○	○
Puedo controlar el proceso de creación de una empresa a partir de los resultados del programa.	○	○	○	○	○	○	○
Conozco detalles prácticos necesarios para poner en marcha una empresa a partir de los resultados del programa.	○	○	○	○	○	○	○
Sé cómo desarrollar un proyecto de emprendimiento a partir de los resultados del programa.	○	○	○	○	○	○	○
Si tratase de poner en marcha una empresa a partir de los resultados de este programa, tendría una alta probabilidad de lograrlo y mantenerla en funcionamiento.	○	○	○	○	○	○	○
En general, sería capaz de controlar totalmente las circunstancias para poner en marcha una empresa a partir de los resultados de este programa.	○	○	○	○	○	○	○

Derivado del programa indique el nivel de acuerdo con las siguientes afirmaciones. Siendo 1 Totalmente en desacuerdo y 7 Totalmente de acuerdo.

	Totalmente en desacuerdo 1	2	3	4	5	6	Totalmente de Acuerdo 7
He evaluado adecuadamente la preparación de mi tecnología /invención para su comercialización.	○	○	○	○	○	○	○
He identificado un camino viable para la comercialización de mi tecnología/invención.	○	○	○	○	○	○	○
He desarrollado un modelo de negocios escalable.	○	○	○	○	○	○	○
Voy a aplicar a fondos o con inversionistas en los próximos 12 meses.	○	○	○	○	○	○	○
Estoy interesado en iniciar mi propia empresa.	○	○	○	○	○	○	○
Estoy interesado en trabajar en unastartup con base tecnológica.	○	○	○	○	○	○	○
Tengo un mínimo prototipo viable definido para mi producto.	○	○	○	○	○	○	○
He identificado y validado el mercado para mi producto.	○	○	○	○	○	○	○

Indique el nivel de acuerdo con las siguientes afirmaciones sobre el programa NoBI. Siendo 1 Totalmente en desacuerdo y 7 Totalmente de acuerdo.

	Totalmente en Desacuerdo 1	2	3	4	5	6	Totalmente de Acuerdo 7
En general las actividades del programa estuvieron bien alineadas a los objetivos de este.	○	○	○	○	○	○	○
El equipo de instructores proporcionó retroalimentación/crítica relevante a los participantes.	○	○	○	○	○	○	○
El equipo de instructores promovió apropiadamente la participación de los participantes.	○	○	○	○	○	○	○
El equipo de instructores motivo a los participantes a hacer su mejor trabajo.	○	○	○	○	○	○	○
El clima general del programa propicia un ambiente de aprendizaje.	○	○	○	○	○	○	○
La creación del video de equipo fue un componente valioso del programa.	○	○	○	○	○	○	○

¿Cuántas entrevistas realizó el equipo?

	Número de entrevistas
Usted personalmente	
Total del equipo	

¿Cuál de las siguientes afirmaciones describe mejor el estado actual de su proyecto?

- ○ GO: Se validó una propuesta de valor para un segmento de mercado, y/o se identificó una alineación a una necesidad puntual que vale la pena atender.
- ○ No GO: Nuestro proyecto/investigación no está listo para la comercialización.

Usted menciona que menciona que su proyecto no va (NO GO), entonces:

- ○ Regreso al laboratorio/ centro de investigación para diseñar un nuevo proyecto.
- ○ Regreso al laboratorio/centro de investigación a seguir trabajando en mi tecnología para buscar un nuevo segmento.
- ○ Cierro la línea de investigación.

Después de este programa ¿Qué relación piensa tener con su equipo NoBI?

- ○ Trabajaremos juntos y en 6-12 meses tendremos un nuevo proyecto / mejoraremos la tecnología/ nueva línea de investigación.
- ○ Eventualmente trabajaremos juntos, pero a largo plazo (más de un año).
- ○ No estamos seguros de que seguiremos juntos.

¿Qué relación piensa tener con su equipo NoBi actual?

- ○ Mantenerlo, trabajaremos juntos en los próximos meses.
- ○ Mantenerlo, trabajaremos juntos, pero a largo plazo (dentro de un año).
- ○ No estamos seguros de continuar trabajando juntos.
- ○ El proyecto sigue, pero no con este equipo.

Podría compartirnos cuál considera es la experiencia y/o conocimiento más valioso que te proporcionó este programa.

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Podría compartirnos cuál considera fue la experiencia menos valiosa, o área de mejora sobre la implementación de este programa.

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Indique el nivel de acuerdo con las siguientes afirmaciones sobre el programa NoBI. Siendo 1 Totalmente en desacuerdo y 7 Totalmente de acuerdo.

	Totalmente en desacuerdo 1	2	3	4	5	6	Totalmente de acuerdo 7
Aplicaré la metodología aprendida en el NoBI para futuras validaciones de tecnología.	○	○	○	○	○	○	○
La metodología aprendida me ha permitido evaluar mejor mí línea de investigación.	○	○	○	○	○	○	○
Considero importante transmitir está metodología con otros colegas y compañeros de trabajo.	○	○	○	○	○	○	○
La metodología aprendida en NoBI me ayuda a seleccionar mejores proyectos y a asignarles recursos.	○	○	○	○	○	○	○
Considero que la metodología aprendida hace una diferencia para mi forma de trabajo.	○	○	○	○	○	○	○

Nombre ____

Segundo Nombre (Si aplica) ____

Primer Apellido____

Segundo Apellido____

Número de equipo____

Appendix C: Interview Guide for Mentors

1. Do you have some professional or personal experience related to entrepreneurship, is an entrepreneur or has undertaken?

2. Have you participated as a mentor or tutor before? Could you talk about your experience?

3. How did I join the NoBI program? Have you previously participated?

4. Could you talk about your collaboration during this program

5. Did you know the methodology of the program previously? How? What opinions did you have about her? What ideas do you have now?

6. Consider that this methodology is the most appropriate for the program. Reasons

7. Could you tell us about the main challenges for the implementation of the program, as well as for your participation as a mentor?

8. There were conflicts in the interaction of the actors. Which ones? How did you solve them?

9. Could you mention what you think facilitates the implementation of this program, which helped you to work better with the team?

10. How do you evaluate the performance of your team? How do you measure progress?

11. In general terms, what are the main barriers to the commercialization of research in Mexico? Facilitators?

12. View of the program as a bridge to commercialization

13. Close recommendations

Appendix D: Questionnaire of Mentor´s Performance

Cuestionario- Desempeño Mentores

Indique el nivel de acuerdo con las siguientes declaraciones. Siendo 1 Totalmente en Desacuerdo y 7 Totalmente de Acuerdo.

	Totalmente en Desacuerdo 1	2	3	4	5	6	Totalmente de Acuerdo 7
El conocimiento aportado por el mentor para el programa le pareció adecuado.	○	○	○	○	○	○	○
Las habilidades de negocio y asesoría por parte del mentor de su equipo le pareció adecuado	○	○	○	○	○	○	○
La participación del mentor aportó favorablemente al desarrollo del equipo.	○	○	○	○	○	○	○
La participación del mentor para mi equipo fue de suma importancia para el desarrollo del proyecto	○	○	○	○	○	○	○
Las interacciones con el mentor del equipo fueron suficientes	○	○	○	○	○	○	○
El conocimiento aportado por los instructores del programa le pareció adecuado	○	○	○	○	○	○	○
Las habilidades de negocio y asesoría por parte de los instructores del programa le parecieron adecuados	○	○	○	○	○	○	○
Las interacciones con los instructores del programa fueron suficientes	○	○	○	○	○	○	○

Comparta algún comentario referente a los mentores e instructores del programa.

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Mencione 3 aspectos positivos o los que más le gustaron del programa, 3 aspectos negativos o los que menos le agradaron del programa, y 3 sugerencias para la mejora del programa.

	Positivos	Negativos	Sugerencias
1			
2			
3			

La metodología lean startup le pareció adecuada para el programa. ¿Por qué?

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