UNDERSTANDING THE IMPACT OF POLICIES FOR RESEARCH TRAINING: EVIDENCE FROM AN INTERNATIONAL MOBILITY INSTRUMENT IN MEXICO

A thesis submitted to The University of Manchester for the degree of Doctor of Philosophy in the Faculty of Humanities

2019

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Total Word Count (including footnotes and excluding references and appendices): 78,680

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LIST OF ABBREVIATIONS

Conacyt –Mexican Council of Science and Technology

HE&RIs –Higher Education and Research Institutions

S&T –Science and Technology

STI –Science, Technology and Innovation

UNESCO – United Nations Educational, Scientific and Cultural Organization

STEM –Science, Technology, Engineering and Mathematics,

OECD –Organization of Economic Cooperation and Development

SEP –Ministry of Education

PNPC –National Quality Postgraduate Programme

NRS –National Researchers System

RF&PS –Research fields and policy spaces

NIS –National Innovation Systems

ABSTRACT

This thesis offers a qualitative examination of the impacts of the Scholarship Programme, an instrument of the Mexican government that sends nationals to pursue doctoral training overseas. The thesis focuses on the contextual conditions on which the Programme works and what it offers for its beneficiaries.

Regardless of the increasing body of literature on international mobility –contextualised as an imperative factor for the development of national research capacities– the effects that this type of programmes can deliver are underrepresented. The study of the effects that can be associated with policy instruments are not analytically driven; for the most part, these are influenced by the brain drain outlook that focuses on losses and gains. The dominance of the literature has left a gap concerning the understanding of how policies work in reality. This gap inspired this study, which sees international mobility as a dynamic process, shaped by policy pressures and mobile researchers, who are governed by the norms of their scientific community. The concept of research spaces and research fields has been selected as the most appropriate framework for characterising the Scholarship Programme, its direct and indirect beneficiaries. The findings are analysed in terms of the variety of motivations and effects on the nanotechnology sector.

This study finds that the international mobility of researchers in the Mexican context has significantly affected the practices and approaches to scientific research. It has also provided domestic employers with access to research infrastructure and funds. The study claims that international mobility policies are essential in the scientific profession, but that their effects are differentiated across the beneficiaries and are transferred as embodied knowledge upon their return. Research- related ambitions and agendas had a crucial role in the occurrence of effects reported in this research.

The study offers several suggestions for future research, particularly on the process of absorption of the capital of mobile researchers. This study encourages further research on the possible effects of mobility on the configuration of knowledge creation. It concludes that this type of programmes can be conducive to improvements in scientific research, i.e. to enable researchers to acquire the skills and structures to become global researchers, which can also be beneficial for the sender country. The effects of this type of instruments for the sender countries are mediated by the conditions of the national research system, the academic culture of global and local researchers, and research funding arrangements.

Using the case of the nanotechnology sector in Mexico as an empirical case added new contributions to the study of international mobility. The study provided an in-depth examination of the characteristics of mobile researchers, which helps explain the intricacies of the relationship between policy-led effects and the effects of international mobility. Nanotechnology has significant political importance and is a window of opportunity for developing countries to strengthen their research systems. This study shows that in the absence of an explicit public intervention in this sector in Mexico, mobile researchers, HE&RIs and companies are shaping its development.

DECLARATION

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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ACKNOWLEDGEMENT

I would like to express my deepest gratitude and thanks to my supervisors, Prof Maria Nedeva and Dr Paul Cunningham, for their guidance, academic support and encouragement. They have been incredibly kind and supportive, and are among the sources of my reflection in this work. Without their advice, this journey would have been quite difficult. I consider myself privileged to be their student. I am and will always be indebted to Dr Paul Cunningham for accepting to supervise my research in the first place. Dr Duncan Thomas was another source of guidance and reflection in this process. I am grateful to him for his trust and support.

Many thanks to all the staff at the Manchester Institute of Innovation Research. Thanks to Kieron Flanagan and John Rigby for making the time to listen. I would also like to thank Prof Philip Shapira and Jakob Edler for giving me the opportunity to collaborate in some of their exciting projects. Many thanks to Barbara Ribiero and Debbie Cox for their support.

Special thanks also go to the Mexican Council of Science and Technology (Conacyt), the Ministry of Education in Mexico (SEP), Alliance Manchester Business School and R&D Management Association (RADMA) for sponsoring my PhD, fieldwork visits, external training programmes and conference attendances. Without such financial help this PhD would have been impossible. I am grateful to all the participants who informed the study.

Last but not least, I would like to thank my husband, Ignacio, for his unconditional support and encouragement. Thank you for your patience and understanding from the very beginning of this journey. Lastly, this thesis is dedicated to my parents, siblings, and friends who have supported and motivated me throughout my PhD journey.

CHAPTER 1 INTRODUCTION

This chapter sets out the rationale of the study, states the contributions to knowledge this study can claim, presents the research questions and offers an overview of the methodological choices. Finally, it outlines the structure of this thesis.

In a nutshell, this study contributes to a more nuanced understanding of the capacity of S&T policy to affect change in a research system by analysing the effects of a specific policy instrument for mobility, e.g. the Scholarship Programme. Hence, as set out below, the study also makes contributions to the literature on the nature of effects of international mobility of researchers on various aspects of the 'sender' country.

1.1RATIONALE

This study examines the development of policy effects by adopting an international mobility instrument as the unit of analysis.

Policy interventions have for long been recognised as fundamental forces that shape the landscape in which science and technology matters exist. The capacity of S&T to produce wealth and other benefits for society is the main driver behind the design and investment of public resources in instruments that would lead to S&T and the economy to thrive. Claims for greatest possible economic and social outcomes from policies require something more than good intentions; since these rely on public financial resources to operate, they need to be reviewed. This means that policymakers and other stakeholders are in constant need for evidence about the performance of the initiatives to legitimise the use of public funds in such efforts, to validate the decision-making and to produce the necessary adjustments if required.

The interest of policymakers in policy evaluation has been accompanied by academics, whose concerns relate to the understanding of how policies work, how they affect the production and organisation of research, and in devising appropriate methods for its study (Benner & Sandström, 2000; Bozeman & Gaughan, 2007). Academics recognise that S&T policies are hard to assess systematically due to their inherently complex nature, and to conceptual and practical frameworks that are not yet well developed to achieve such a task (Nedeva, 2010; Schoenefeld & Jordan, 2017).

There is a strong tradition in current S&T policy evaluation approaches to focus on the capacity of policies to the targeted issues, namely, increase the quantity and quality in research outputs. For the most, policy evaluation experts have tried to measure the impact of policies on the outputs produced by its direct beneficiaries. These measurements are linked to outcomes, and other evidence on the success or failure of policies, namely, on the expected improvements policies can generate on the broader research system, and economy and society (Smits et al., 2010). This underlying reasoning in S&T policy evaluation can be explained by the pro-growth bias in policymaking that dominates evaluation practices and the interpretation of policy effects.

The study of S&T policies faces some challenges. For instance, there is a current debate about the extent to which it is possible to conceptualise, identify and attribute changes in the research system to these policies (Bozeman & Sarewitz, 2011; White, 2010). Another challenge is the extent to which current evaluation approaches provide a realistic picture of how policies work, considering the multiple goals of S&T policy and the wide-ranging spectrum of possible scenarios that can occur around a policy instrument (Boden et al., 2006).

In this regard, some scholars assert that viewing policies as instruments that solve failures can limit not only the possible empirical choices when conducting evaluations, but can also influence policymakers' views on the power of policies and set unrealistic expectations in their potential to produce change (Flanagan et al., 2011; de la Mothe, 2003). Furthermore, there is not one single widely accepted method to evaluate policy efforts in heterogeneous contexts. Most evaluation scholars encourage the development of quantitative methodologies of the measurable outputs attributable to policy interventions due to their potential generalisability of application in different settings. This tendency, however, neglects the presence of other hidden effects (Milzow et al., 2018; Reale et al., 2014), requires intensive and long-term data collection and analysis and ignores the structural and historical differences of the context where the evaluation takes place (Molas-Gallart & Davies, 2006; Pawson & Tilley, 1997).

Policymakers have a wide range of policy options to influence the behaviour of the actors in the research system. These can include financial incentives for research infrastructure and long-term research projects; support for collaboration and networks; direct support for individuals to improve their research skills, and direct support for research organisations to improve their activities, among others (Edler et al., 2016). In this regard, the interventions directed at improving research skills are recognised as essential for building the capacities that can lead nations to produce better knowledge and to perform better in their productive activities (Corolleur et al., 2004; OECD, 2011b).

Countries rely on their research base to conduct state-of-the-art scientific research and mobilise financial funds for improving the production and use of knowledge. However, researchers, who also seek the progress of knowledge, and follow the norms and values of their scientific communities, may have conflicting interests to those in national policies. In other words, researchers respond to policy pressures as well as those from science. In this respect, it is possible to assert that the capacity of policies to produce change will depend on how these are aligned or tap into the characteristics of their targeted constituencies. Their influence will also depend on whether policies are accompanied by the necessary resources to meet their set goals, which will represent the signals that they send to their potential beneficiaries.

In this context, this study examines the interplay between the mentioned policy instrument and changes produced on the direct beneficiaries. This study is not an evaluation exercise that aims to link policy objectives to outcomes, as is common in programme-theory evaluation. This study extends the effects to domestic employers and pays particular attention to the mechanisms that enabled effects to occur in the particular context of nanotechnology in Mexico.

The reasons for this empirical choice are presented in further sections in this chapter. This study evaluates the instrument by integrating the following levels of analysis:

1) The interests of the national funding body for S&T and its capacity to produce change in light of the organisation of national research.

2) The rationale behind it and its implementation, and paths for impact by looking into the characteristics of the beneficiaries, and
3) The changes or effects reported by the beneficiaries because of their participation in this instrument.

By doing this, the study aims to capture the mechanisms generating change in the research system, and the contextual conditions in which the policy instrument is inserted and that affect its implementation.

The motivation for this study is two-fold. First, the increasing interest of governments, including Mexico, in being part of the knowledge economy has increased the need for policies to transform the national research system efficiently (Grillitsch et al., 2019). This represents the new social contract between science and society, in which scientific research is at the core of social and economic progress. Second, budgetary pressures, along with new public management approaches that emphasise accountability focused on performance measures, are also at play and strengthen the demands for efficient and effective policies (Edler et al., 2008; Youtie et al., 2017).

However, despite the increasing emphasis on the need for more evidence-based policies and more reliable assessments (Delvaux & Mangez, 2008; Edler et al., 2016; Sanderson, 2002), prevailing evaluation practices do not reflect how policies work comprehensively in connection with the ongoing changes in scientific research (Langfeldt et al., 2019). This can be because policy evaluations are mainly conducted through quantitative measures, guided by normative views on policy interventions and efficiency that are unable to provide a richer picture of how the policy process and effects unfold and why (Diercks, 2017; Molas-Gallart & Davies, 2006). For the most, current evaluation practices place great importance on the impacts intended for policy, despite the limited empirical evidence about "what works" and under what conditions.

For instance, evaluations tend to use established criteria to assess possible variations in research, innovation and economic development (OECD, 2014c). Increased salaries, productivity, revenues, publications and patents and innovative solutions are the most common measures used to explore policy effects (Edler et al., 2012, 2016).

However, there is little systemic evidence about the intricate workings of policy and its link with the emerging changes in research. This is true even in developed countries that have a well-established evaluation culture, but it is more prominent in developing countries, where evaluation efforts are still emergent, and struggle with underdeveloped research systems and insufficient financial resources to spur the expected change. Ultimately, most measurements rarely question the development of the reasoning that underpins policies, and the implications that these policies can have outside the spectrum of their intent.

The aspects mentioned above constitute a policy problem as well as a research problem. At the policy level, publicly funded programmes are required, by funding agencies and the wider society, to be accountable for their impacts (Edler et al., 2016). At the research level, the problem resides in the lack of comprehensive evidence about policy impact, notably, about how the effects among beneficiaries relate to policy intentions. This is because although it is widely accepted that policies are mechanisms through which governments intend to change or produce certain behaviours (Flanagan & Uyarra, 2016; Reale & Seeber, 2013), the relationship between policy interventions and actual change has been left unexplained. Practical use of signalling theory can be of some use to identify the impact and explain it as a combination of iterative negotiations between policy enabled changes and the interpretation and decisions of their beneficiaries in a particular context (Connelly et al., 2011; Francois, 1998; Ghalwash, 2007).

Another component of this research problem is that there are not yet well-developed interpretative frameworks that will allow for thorough and critical assessments of policy interventions (Amanatidou et al., 2014; Molas-Gallart & Davies, 2006; Reale et al., 2014). In this regard, Nedeva (2013) has recommended exploring the changes that policies enabled to develop, using a realistic framework that relates the opportunities in policies with the motivations of its beneficiaries and workings of scientific research. This will help understand how a policy instrument affected its beneficiaries at the individual and aggregated level, instead of reinforcing the assumption that science is fully responsive to policy. This proposition is new; thus, there is little empirical work considering the conditions through which impact can be manifested.

This study presents a qualitative research study, the primary aim of which is to investigate the impact of a policy instrument by looking at the following elements: 1) the S&T policy arena and the development of the national research system, 2) the policy intentions and implementation – funding arrangements and beneficiaries, and 3) the interactions between these two. This study can be best seen as a research effort that aims to explore the responses of direct and indirect beneficiaries to the opportunities offered by a policy instrument, and the effects of such responses.

At a general level, the aims of this research are:

1. To explore the changes perceived by the beneficiaries of an international mobility instrument implemented by the Mexican government and explain how they perceive and react to the opportunities offered in this instrument.
2. To identify the factors that enabled specific effects on the beneficiaries, and the extent to which these effects can be attributed to the instrument or to other factors.
3. To explore the interplay between the changes (benefits or challenges) on the direct beneficiaries and indirect beneficiaries.
4. To link these changes to a specific policy intervention and to other pressures for change within the science and technology environment.
5. To understand the extent to which pre-existing policy structures enable the identified change.

1.2SCOPE OF THE STUDY

Research skills may determine the capacity of countries to face technological and societal challenges, and the responsibility of building national research capacities is that of national governments, who draw on policies to promote their creation and sustained development (Schot & Steinmueller, 2018). Consequently, one of the dimensions in these policies is to develop a continuous supply of talented researchers, i.e. doctoral training (Borrás & Edquist, 2015). Like most S&T policies, the driving motivation for the existence of instruments fostering doctoral training is that they should provide the skills that will enhance the research and economic performance of a nation (Borrás & Edquist, 2015; Edler & Fagerberg, 2017; Edler et al., 2011).

The slow development of research and innovation capacities in Mexico has mostly been attributed to a reduced level of critical mass (Dutrénit & Puchet, 2011; OECD, 2008a). However, this condition is not due to a lack of policy intervention. Mexico was the first country in the Latin American region to establish policy instruments to improve domestic research. Each year, since 1971, Mexico has sent its national students to the most prestigious universities abroad to pursue advanced research training. It is also one of the top countries providing highly talented people to the global labour market (Delgado-Wise et al., 2015; OECD, 2002a; Tuccio, 2019). There is, however, little evidence about the impact this initiative has produced on Mexico's research. This situation begs for answers as to how the policy environment and policy thinking can explain the reduced scientific workforce and the high levels of migration? In other words, little is known about the discrepancy between investing in research training and the reduced scientific base in Mexico. An instance of this discrepancy is that Mexico's research capacities are not yet as competitive as those of more dynamic developing countries, as measured through science, technology and innovation indicators (OECD, 2018) and their capacity to attract talented researchers (Tuccio, 2019).

This research captures and examines the development of policy effects by exploring in-depth the case of Mexico through the "Scholarship Programme"; the most important funding scheme for doctoral education outside Mexico. This research chooses a multi-actor perspective to provide a comprehensive assessment of the Programme at different levels of social aggregation: individual and research. This will involve a description of the origins and development of the Mexican S&T system. It will also examine what the Programme aims to do, and its financial capacity and position in the national S&T policy structure. Finally, it defines the effects of the Programme on its beneficiaries, both direct and indirect.

The assessment of policies in the context of developing countries, which tend to struggle to produce significant changes in their research system, makes this a relevant exercise. This study examines S&T policy in a resource-constrained environment, where unresolved issues in the research system may influence the perceptions and behaviours of the beneficiaries, which can also explain why policies operate in the way they do in these countries.

1.3 RESEARCH QUESTIONS

Policies are legitimised measures to produce change in the target population, namely, direct beneficiaries. However, there is little evidence about how the international research experience affects the responses of researchers to national policies, and the effects that these can produce. In the particular instance of international scientific mobility, little research has been done in regard to how the implications of policies at the individual level move or are transferred at aggregated levels in the research system. These two are gaps that this study will try to cover in the following chapters.

Primarily, this research aims to contribute to the knowledge on S&T policy by addressing the following overarching question: What impacts do international mobility policy instruments offer for the sender countries? This question was divided into sub-questions to explore the potential benefits in a disaggregated manner. The specific research questions were as follows:

- What impacts do international mobility instruments offer for their direct beneficiaries?
- What impacts do international mobility instruments offer for their indirect beneficiaries?
- What factors can explain these impacts?

The second question addressed in this thesis was concerned with the factors that could explain the benefits of international mobility policy instruments, namely, to what extent the identified changes can be attributed to policy instruments or other factors influencing their emergence?

A general assumption in this study is that the perceived opportunities in policy instruments affect the responses and expectations of their beneficiaries. With this in mind, this study brings some responses to the questions above by interpreting the impacts as a combination of interactions between policy forces, science-related incentives or norms, and individual interests.

1.4 SIGNIFICANCE OF THE STUDY

The central motivation of this study is the somewhat unrealistic foundations for claims about how policies contribute to significant changes in S&T, particularly concerning the international mobility of researchers and its effects in the sender countries. On the one hand, the literature concerning international mobility is mostly driven by the human capital framework that assumes binary effects, i.e. losses or gains. The strong focus of this literature on the accumulation of skills, technological change and economic growth cannot explain the variety of effects that unfold from the international mobility of researchers in the sender countries. This study aims to fill this gap by investigating how an international mobility policy instrument works.

Thus, the significance of this study is twofold. First, it contributes to the understanding of international scientific mobility by examining the characteristics of mobile researchers and introducing constructs that follow from the international experience which have not yet been discussed. These are global identity, de-familiarisation and re-adaptation. Second, this study contributes to a better understanding of the policies' contribution to changes in science. This is because as a theory-informed examination, this study shows that research is not fully responsive to policy pressures; researchers' aspirations also influence the workings of policies and effects.

1.5 RESEARCH APPROACH

The Programme rationale, the unit of analysis in this thesis, rests upon the notion that the improvement of human capital in researchers, via international mobility in this particular case, serves also as a capacity-building mechanism. This is a widely spread policy reasoning across countries, as international mobility has received significant attention among academics and policymakers for several years due to its potential implications for science, innovation and growth (Appelt et al., 2015; Docquier & Rapoport, 2012; Laudel, 2005).

This research studies a programme that is affected by the national conditions of research, notably, domestic context, policy priorities and funding arrangements. The responses of the beneficiaries also influence the Programme's potential effects, as their reactions to it would consider the incentives and norms in their scientific communities, and the incentives in external policies. For this reason, this study first explores the effects produced on the researchers sponsored by the Programme (fellowship holders/fellows). It then moves to explore the effects on domestic employers to identify what individual effects are transferred to them, and the interplay of this transfer with incentives out of the scope of intervention of the Programme.

This research does not focus on the commonly expected effects of international mobility, which are typically studied under the assumption that mobile researchers will experience better career progression and better wages than their non-mobile peers (Hayter & Parker, 2019; Müller et al., 2018; Pedersen, 2015; Recotillet, 2007). Also, scholars tend to focus on productivity and quality indicators in the research outputs of mobile researchers, who are expected to produce more publications of international quality and increase collaborations with their international colleagues (Baruffaldi & Landoni, 2012; Jonkers & Cruz-Castro, 2013). In the long-run, these improvements in research would produce beneficial impacts at higher levels of social aggregation – in the form of research capacities, innovation and economic competitiveness – in the countries that can better utilise the added-value in mobile researchers (Corrado & Stryszowski, 2009; Fassio et al., 2019).

This study does not characterise effects in terms of losses and gains, which is a common practice in migration and international mobility studies. Instead, this study adopts a holistic analytical model proposed by Nedeva et al. (2012) and looks at effects that are the result of multiple factors, such as 1) the characteristics of the Programme itself, and 2) the characteristics of the beneficiaries.

A central assumption in this work is that the beneficiaries can interpret policies in varied ways and that, in consequence, international mobility policies can trigger reconsiderations of career plans and further mobility or migration plans. This research posits that beneficiaries act upon the opportunities that policies offer, and that their actions also shape the effects that can be attributable to policies (Lepori et al., 2014; Reale et al., 2014). Thus, this study aims to contribute to the understanding of policies as non-static artefacts, from which implications arise from the reactions of its beneficiaries within a distinctive context (Nedeva et al., 2012; Pawson & Tilley, 1997; Reale et al., 2014).

This study distances itself from the concept of rationality in policies and actors (Bird & Smith, 2005), and, instead, it looks at policies as processes where the social behaviour is adaptive (Mytelka & Smith, 2002; Smits et al., 2013). This idea was addressed by Reale et al. who proposed that policies do not necessarily generate desirable nor good effects, or that these may be of a different magnitude to those intended (Reale et al., 2014).

It is expected that through this exercise, international mobility policies can be understood as instruments that are governed by a diversity of elements and which produce outcomes that are not static and not always wanted. Ultimately, this can help to understand the process of international mobility beyond the assumed beneficial (brain gain) and detrimental effects (brain drain) for the affected countries.

This study follows the recommendation of Reale & Seeber (2013), who suggest that in order to gain a deeper understanding of policies, studies should examine policies through their process of implementation. This is because implementation shows policies as a process of continuous interactions within a configuration of S&T.

1.5.1 Research approach and methodology

This thesis relies on an interdisciplinary deductive examination and reflective analysis (Srivastava & Hopwood, 2017). It draws on two bodies of literature: 1) policy analysis in the field of science policy and innovation policy and 2) studies on the international mobility and migration of researchers.

1.5.1.1 Policy intentions vs impact

This study sees policy instruments as a set of intentions and incentives that are transmitted to potential beneficiaries, and that may or may not match their characteristics and expectations. In other words, beneficiaries react to policies according to the opportunities they anticipate these will deliver for them. Their personal and professional ambitions can underpin their reactions. For instance, a potential beneficiary applying to the Programme may envisage a well-paid job and international networks after completing their doctoral training in a prestigious university. He/she may also be driven by the prestige that comes with international mobility.

In line with this, this study posits that mobile researchers are a particular group that is exposed to the norms and practices of their community around the organisation and production of knowledge (Jacob & Meek, 2013; Reale et al., 2018). All these factors can affect the power of national policies to produce the desired change because while policies are national efforts, the dynamics of scientific mobility are not.

In general, the micro level aspects of policies are commonly taken for granted by the current literature on policy evaluation, which tends to focus on programme-led changes and ignores the interplay between policies and beneficiaries. This is a fundamental limitation of programme theory evaluations, usually referred to as logic models (Donaldson & Gooler, 2003; Hewitt-Dundas & Roper, 2011), and which presents reality as a simple causal relation between inputs, process model, outputs and outcomes. The study of policy instruments and their effects requires a systematic evaluation, but this is a particularly challenging task as S&T policies are multifaceted and comprise a diversity of interests. Thus, this study adopts a realistic approach (Pawson & Tilley, 1997) to provide an account of a policy instrument and how it works and brings about change.

Most commonly, in the literature of international mobility, the impact is underpinned by the assumption that policies are generally beneficial for all the involved actors.

There is, however, little evidence on the actual effects this brings for the sender countries.

Mostly, studies about international mobility of researchers draw on human capital theory and innovation systems theory (Hart, 2007; Qadri & Waheed, 2013; Smith, 2001). These tend to investigate the effects of mobility as improvements in scientific productivity, innovation and economic growth (Ha et al., 2014; Tejada, 2012; Turpin & Woolley, 2008). Due to their conceptual foundations, these studies have a strong inclination towards the possible positive effects that mobility can have on economic performance. Studies oriented towards the social aspects of this phenomenon, such as those from S&T studies have focused on the networked nature of scientific research, and the social capital that stems from advancements on individual research skills (Ackers, 2005a; Bozeman et al., 2001; Jöns, 2007).

In this study, policies are seen as open-ended processes, in which different actors with potential complementary, but also conflicting interests and values interact (Reale & Seeber, 2013; Sabatier, 2007). This study focuses on three particular dimensions of the policy process:

1) The policy rationale: this justifies the need for intervention.
2) The implementation process: this is the domain or scope of action of policy. In practice, this means looking into the activities, the resources, and the actors involved. In other words, it means looking at policy objectives, funding arrangements, and the characteristics of its direct and indirect beneficiaries.
3) The policy effects: these are operationalised in terms of the benefits and disbenefits/challenges reported by the beneficiaries.

The study of an instrument that is intended to foster training among citizens should consider that this represents a *de facto* positive effect on the direct beneficiaries.

1.6 METHODOLOGY

This research draws on a qualitative method design comprising 57 semi-structured interviews and 144 responses to a qualitative survey. A review of policy documents, institutional reports, and grey literature complemented the primary data collected through these instruments.

1.6.1 Focus on the nanotechnology sector in Mexico

This thesis examines the Scholarship Programme focusing on the nanotechnology sector in Mexico to produce an in-depth exploration of the relationship between its objectives, beneficiaries and effects. This empirical choice is theory-based, drawing on studies that suggest emerging technologies can be an opportunity for developing countries to advance their research and innovation capacities (Bozeman et al., 2007; Maclurcan, 2005a; Niosi & Reid, 2007; Shapira et al., 2011). These scholars assert that nanotechnologies will revolutionise industries and society by fostering the convergence between technologies and could lead to an increased demand for research skills.

To better capitalise on these opportunities, developing countries are seeking to increase their research capacities by investing in the training of their researchers, for they embody the required specialised skills for knowledge-based sectors (Gokhberg et al., 2016; Hung & Chu, 2006; Lee, Miozzo, & Laredo, 2010b).

A second motive for choosing to focus on the nanotechnology sector is that despite the lack of central policy, this sector shows significant potential for change in the research activities in Mexico. This is visible in the presence of sustained production of scientific research outputs in this area and on the efforts of companies, particularly the pharmaceutical and automotive sector to invest in solutions based on nanotechnology (Foladori et al., 2015). Mexico is the second producer of publications and patents in nanotechnology in Latin American and an emerging market with significant potential (Foladori, Figueroa, et al., 2015; TCI-Network, 2017; Zayago et al., 2013).

Mexico has accumulated research capacities in physics, chemistry, and biology; all of which are fields which can be linked to nanotechnology. However, how the Programme affects this emerging field is an under-researched topic. Most studies on the Scholarship Programme concentrate on brain drain effects (Arenas et al., 2001;

Castaños-Lomnitz, 2003; Jiménez et al., 2010; Tigau, 2013). Broader studies on science, technology and innovation in Mexico focus on issues of governance and resources (Alcantara et al., 2008b; Corona et al., 2014; Dutrénit et al., 2010; Peña Ahumanda & Archundia Navarro, 2006). A more detailed justification for this empirical choice is presented in Chapter 5.

1.7 STRUCTURE

The structure of this thesis consists of four parts that reflect the research steps.

Part I consists of chapters 2, 3, 4 and 5, and presents the background context and configuration of the S&T system in Mexico. Chapter 2 outlines the characteristics of the national research system, its emergence over time, the major underpinning policies and the key actors. Chapter 3 presents an overview of the research and doctoral training system. This chapter characterises the three components of that system. Chapter 4 provides a detailed review of the Scholarship Programme. This chapter aims to provide a more in-depth analysis of the Programme in order to understand its rationale and implementation. Lastly, Chapter 5 reviews the nanotechnology sector in Mexico, first in a global context and then in the context of Mexico, focusing on its current state of development and current challenges.

Part II contains Chapter 6, which analytically reviews the literature about the international mobility of researchers, giving attention to the dominant theoretical frameworks concerned with this issue. The brain drain approach stands out as the traditional analytical framework that draws on human capital theory and proposes an accumulative understanding of international research skills. The diaspora framework brings back into the debate the networked nature and connective character of knowledge and mobility. This chapter also discusses the traditional policy measures designed to address the lack of an adequate level of advanced research skills in research systems. Policies and studies in this topic show a strong emphasis on competition between developed and developing countries for talent.

Part III consists of chapters 7 and 8 and is concerned with two tasks. First, it seeks to identify an appropriate analytical framework for the study of the selected policy. In

Chapter 7, three possible frameworks have been analytically reviewed, namely, human capital theory, the concept of National Systems of Innovation (NIS), and the concept of Research Fields and Research Spaces (RF&RS). The RF&RS is the most appropriate framework; it does not overemphasise the transformation of knowledge into innovations, and thus into economic and social development. This makes it suitable for the study of Mexico which is recognised for its struggles to create innovation capacities.

Chapter 8 presents the methodology used in this thesis and describes and justifies the research methodology and selected methods used for data collection and analysis

Part IV offers the empirical results in Chapter 9 and the discussions of these results in Chapter 10. Chapter 10 summarises the main findings of the research and offers answers to the research questions. The discussion focuses on the responses of the beneficiaries, and the extent to which the benefits they report are aligned with the intentions in the Programme. This chapter discusses the implications of the findings and attempts to identify how the conclusions address the overall research question. Finally, the chapter points to where future research may be appropriate to study the international mobility of researchers.

PART I SCIENCE AND TECHNOLOGY BACKGROUND

CHAPTER 2 BACKGROUND: S&T IN MEXICO

2.1. INTRODUCTION

This chapter offers a review of the pertinent characteristics of the Mexican research system. The chapter focuses on the central actors in this system, their roles, the national policy reasoning and contextual conditions that have shaped science and technology in Mexico. The particular attention of this chapter in identifying the organisation and workings of this system will help explain its governing forces and challenges. This review will also help to explain in the following chapter the development of doctoral training in this country. This chapter draws on a review of selected scientific literature, grey literature and policy documents.

2.2 OVERVIEW OF THE CONTEXT AND ITS RESEARCH SYSTEM

The Mexican research system emerged in the industrialisation process that this country experienced between the 1950s and the 1970s. This period gave rise to and defined the majority of actors linked to the domestic knowledge production, and their roles and domain of action in the system (Katz, 2000). The government, who owned the most productive industries – oil, polymers, and electricity – in that period, played a leading role in establishing the foundations on which these actors would interact. The efforts started in this period came a halt in the 1980s, when the Latin American region and Africa experienced the most severe economic crisis as a consequence of the excessive external debt levels (Pastor, 1989; UN, 2017). This crisis left S&T in Mexico in a vulnerable position, as this was not within the pressing priorities of policymakers (Corona et al., 2014). Instead, policy efforts concentrated on macroeconomic matters, which resulted in chaotic effects for the Mexican scientific system (Canales, 2011; Cimoli, 2000). For instance, due to the severe reductions to the S&T budget, which fell from 0.46% of the GDP in 1982 to 0.3% in 1986, the number of individual grants for postgraduate training decreased from 4,340 in 1971 to 1,677 in 1989. Insufficient resources were not available to support research projects and the acquisition of infrastructure. In addition, the wages of academics dropped drastically, and scientists started leaving the country in increasing numbers. There is no data about how many scientists left, but this event had to be of considerable magnitude to attract the attention of the government, which hastly urged the implementation of the National Researchers System.

Following the conditions set by the International Monetary Fund in exchange for rescue packages to ameliorate the effects of the debt crisis, Mexico embraced the globalisation of its market (Boughton, 2001; Pastor, 1989). This was accompanied by the privatisation of the national companies, deregulation, and rationalisation of the economic system. The government believed that competition would trigger the forces of modernisation and competitiveness in the domestic industries, which would help the economy to recover and strengthen its productive advantages.

However, as a consequence of these decisions, along with the negligence of the government to protect the progress achieved in the previous four decades in S&T, the research system suffered at its core and was left in a vulnerable situation. For instance, due to the privatisation of the national industries most of the technological capacities accumulated in the public research laboratories disappeared. The companies acquired by national capital were strongly dependent on foreign technology, and the companies absorbed by multinationals did not continue to perform R&D activities. Thus, some of the national industries' laboratories became public research centres, which then operated as academic research organisations, while others disappeared. This was because multinationals came to Mexico attracted by its low production costs and by the size of its market; companies did not further the R&D capacities of that period (Casas et al., 2013).

Mexico can be better defined as a science and technology system than as an innovation system. This is because although this system has the actors that produce knowledge and the industries that could transform it into innovative solutions, this system was born fragmented (Cimoli, 2000; OECD, 2009b). Such fragmentation is rooted in the origins of this system, when the roles and resources for the main actors were defined, and their functions and interactions were placed into separated and limited domains. For instance, universities were thought of a domain that could only be affected by educational policies, while companies would only respond to industrial and economic policies. Paradoxically, although the Mexican S&T system began to be defined during the period of economic growth and industrialisation. At that time there was no obvious connection between economic development, education, and S&T policies. This situation created a long-standing sense of incompatibility and distancing between these policies Accordingly, S&T did not receive the necessary attention, in contrast to other developing countries that were also going through the industrialisation process, where S&T was prioritised and positioned at the core of the process.

Interestingly, the national policy documents of this period did recognise the social and economic value of S&T, however, underinvestment and lack of a sustained long-term strategy in these areas contradicted the narrative in those documents. It is fair to say that the subsequent abandonment of S&T related issues prolonged the separation of S&T, education and industrial policy. Consequently, interactions between national actors after the aforementioned economic events were almost non-existent, which may help explain the current challenges facing the advancement of S&T in Mexico.

Table 1 provides a general illustration of the standing of this system.

Table 1 Mexico's main indicators of S&T

Gross domestic R&D expenditure (GERD), 2017	**5,398.11 USD (million)** **% of GDP= 0.48** **Target: 1%**
R&D sources of funding, 2016, USD (million)	• Total R&D expenditure financed by government= *3,307.97* (0.30% of GDP) • Total R&D expenditure financed by business enterprise= *1,117.69* (0.11% of GDP) • Total R&D expenditure financed by other national and international sources= *714.87* (0.07% of GDP)
Expenditures on R&D by performing sector, USD (million) 2016	• Total public sector R&D expenditure (GOV&HEIs)= 32, 25.71 (0.30% of GDP) • Total private sector R&D expenditure = 2,141.53 (0.11% of GDP)
Human resources in S&T	• Human resources in S&T activities (2017): *10,900, 602*

Gross domestic R&D expenditure (GERD), 2017	**5,398.11 USD (million)** **% of GDP= 0.48** **Target: 1%**
	• Scientists & engineers[1] (2017) : *9,980,298* • Researchers FTE (2011)[2] : *35,019* • Researchers in the private sector (2012)[3]: *35,019* • Researchers in the public sector (2017) [4]: *27,186*
Research Infrastructures	• Conacyt Research Centres: *27* • Public HEIs with block funding: *7* • Sectorial RIs: *11* • Mexican Energy Centres of Innovation: *5* • International research infrastructure: *CERN* • Higher education system: *7,031*
Research outputs	*Human resources* • Doctoral students who completed their studies (2013-2017):9, 268 • Annual average: 2,317 *Publications*[5] • Total publications (2009-2018): 202,778 • Publications in the top 10% most cited worldwide: 8.5% • Publications in the top journal percentiles: 19.8% • International collaboration (publications co-authored with Institutions in other countries): 39.4% • *Patents*[6][7] • IP5 patent applications (inventors country of residence, 2015): 211.8 • Patent applications by residents: 1,334 • Patent applications by non-residents: 15,850 • PCT Top applicants (2017): • Mexichem (10) • Universidad Nacional Autonoma de Mexico (10) • Vitro (5)

1 Author, based on Conacyt (Conacyt, 2014a, 2015b, 2017a). It includes postgraduate and graduates in professional and technical jobs
2 Conacyt (2017a, p. 240)
3ESIDET survey, 2012. Retrieved March 8, 2018, from: https://www.inegi.org.mx/programas/esidet/2012/
4 Only National System of Researchers, Conacyt (EC, 2016).
5 From Scival, Scopus
6 Retrieved March 8, 2018, from OECD.stats: https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB
7Retrieved March 8, 2018, from WIPO: https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=MX

Source: Based on data from OECD Main S&T Indicators database, 2018; and Conacyt, (2017)

The following section describes the recent policy documents in regards to S&T in Mexico.

2.2.1 Peciti: central policy document in Mexico

2.2.1.1 Background

Peciti is the acronym – in Spanish – for *Special Programme for Science and Technology*, which contains the fundamental objectives guidelines for S&T policy. Peciti is not the first document of this sort in Mexico; between 1976 and 2000, Mexico had five similar initiatives all of which can be characterised by their short life[8]. This is because every new federal administration - every six years - required a new policy, which in principle was not a sign of prioritisation of S&T matters, but simply a document that would reflect the accession of a new government. Also, the economic crisis that occurred during the implementation of the *National Indicative Plan for Science and Technology* (1976-1982), the first S&T policy document to systematically define the role that S&T have in the economy and in society, left S&T to function organically. Following programmes were attempts to ease the tensions between the government and the national scientific community on how and who should organise and steer domestic research.

The first policy programmes, between the 1970s and 1980s, maintained a *Science-Push* approach, which can be explained by the low involvement of the government in the conception of S&T policies, the predominant participation of academics and the

[8] These plans were: 1) “The National indicative plan for science and technology” (1976-1982); 2) “The National programme for science and technology” (1978-1982); 3) “The National Program for Technological and Scientific Development” (1984-1989); 4) “The National Programme for Science and Technological Modernisation” (1990-1994), and 5) “The Science and Technology Programme” (1995-2000).

lack of interaction with other actors to counterbalance this approach (Dutrénit, et al., 2010; Dutrénit & Puchet, 2011). In the 1990s, the government of Salinas de Gortari introduced a business and international competitiveness policy approach, aligned to its free-market ideology. Despite the new orientation in the political narrative, the policy model was still a linear one, but now, in theory, oriented by demand requirements (*demand-pull*). A significant event here, which consolidated in the *National Programme for Science and Technological Modernisation* (1990-1994), is that this period represented a policy shift in Mexico. For the elaboration of this programme, Conacyt, commissioned by the President, conducted several exercises with industrialists and other relevant actors to include their concerns in this document. However, the programme did not reflect the concerns shared by the other actors, but only those of the government elite.

2.2.1.2 The evolution of PECITI

The 2000s was a crucial period for S&T policy in Mexico due to the policy decisions that defined the foundations of governance of this research system. The process of setting these foundations began in 1999 with *the Law for the Promotion of Scientific Research and Technological Development*, which demarcated the responsibilities of each public body involved in S&T, and aimed to foster collaboration between actors. Similarly, in this period, the term 'innovation' was adopted in all public S&T documents, and for the first time, the relationship between science, technology, and innovation was discussed at the highest policy levels.

Due to changes of the federal government that involved the election of a new political party for the first time in 71 years, this law was quickly replaced. However, it served as the basis for the new *Science and Technology Law* (2002) and the elaboration of the *Special Program of Science and Technology (PECITI)* (2001-2006). These benefited from the accumulated policy-learning of the experiences in previous decades, and from the international experience in innovation policy (Dutrénit et al., 2010). The policy discourse in this period emphasised S&T and innovation as essential for the development of Mexico. This was a period of high expectations among the scientific community and the industrial sphere, all of which thought that this administration would solve the longstanding and neglected issues associated with S&T.

Table 2 summarises the objectives of the three Special Programmes formulated over the past two decades.

Table 2 S&T policy in Mexico: 2001-2006; 2008-2012; 2014-2018

Objectives in Peciti 2001-2006
• To establish short, medium and long term state policies for the strengthening of education, basic and applied research • To promote strategic knowledge areas for the development of the country and decentralise S&T activities • To increase the national budget for S&T • To increase human resources for S&T • To promote the development of basic, applied and technological research, and improve the infrastructure for ST&I • To strengthen international cooperation • To increase private sector investment in research and development
Objectives in Peciti 2008-2012
• To establish short, medium and long term state policies for the strengthening of education, basic and applied research, and of innovation • To promote the articulation of the national innovation system by establishing a closer link between educational and research centres and the productive sector • To public resources efficiently and effectively to achieve the highest possible impact on national economic competitiveness. This will also contribute to a more precise definition of research priorities • To decentralise scientific, technological and innovation activities to contribute to regional development • To promote financing of basic and applied science, technology and innovation by increasing the participation of companies • To increase investment in infrastructure for scientific, technological activities and innovation • To promote accountability in public expenditures for the development of science, technology and innovation: high-quality human resources, training, research and development, and innovation
Objectives in Peciti 2014-2018
• To increase the investments in scientific research and technological development to reach 1% of GDP • To contribute to the formation of human capital for S&T • To promote the development of local innovation capacities for sustainable and inclusive regional development • To contribute to the transfer and use of knowledge, linking HE&Is with the public, social and private sectors • To strengthen the country's scientific and technological infrastructure

Source: (Conacyt, 2002, 2008, 2014b)

On July 1st 2018, Mexicans elected Andrés Manuel Lopez Obrador as the new president, who then appointed Dr Elena Alvarez-Buylla, an evolutionary developmental biologist, to be in charge of the national issues in S&T. This new administration released a document called: *Conacyt's Restructuring Strategic Plan to adapt to the Alternative Nation Project 2018-2024*; the first S&T policy document of this administration, and which emphasised the need for new ways to ensure a socially responsible and a responsive policy.

Table 3 shows the objectives and guiding principles contained in that document[9].

Table 3 Current S&T policy objectives and guiding principles

Objectives	Twelve guiding principles
1. **To protect national sovereignty in the generation and application of scientific knowledge and technologies** 2. **To establish a 'dialogue of knowledge' with the rural communities to protect their territories and biocultural wealth** 3. **To use science to the better understanding, prevention and solution of problems of health, food, environment, inequality, exclusion and violence** 4. **To produce frontier science and technologies to benefit society and the environment**	1. To decentralise and to restructure Conacyt 2. To make transparency, efficiency and austerity, the guiding principles in the use of resources. 3. To prioritise and consolidate fundamental science in Mexico, and to train scientists to address national needs 4. To conduct long-term planning of national scientific development to attend to the national social and economic issues 5. To redefine the evaluation criteria of national scientific activities, which involves the consolidating the use of qualitative approaches over the quantitative, and to implement a zero-tolerance policy against the misuse of resources 6. To prioritise the public benefits of science 7. To create new public research centres in regions where such infrastructure is lacking to address the local needs for S&T

[9] Translated from Conacyt (2017a, p. 266)

Objectives	Twelve guiding principles
	8. To create the National Ecosystem of Information Systems to concentrate the information necessary for the diagnosis and solution of complex national problems 9. To promote national regulations focused on respecting the precautionary principle before the development and implementation of scientific-technological projects 10. To repatriate the national scientific talents abroad, and to create international scientific fellowships in the national priority areas 11. To effectively integrate the scientific education in primary and secondary education in coordination with the Ministry of Public Education 12. To disseminate and communicate the advances in science in collaboration with the other public agencies, such as culture, environment, agriculture and energy, etc. 13. To promote the use scientific criteria in the preparation, implementation and validation of public policies and their regulatory frameworks

Source: (Álvarez-Buylla Roces, 2018)

The present administration faces several challenges, such as an ongoing reduction of the S&T budget, as the statement by Dr Alvarez reflects: "we (S&T authorities) have to function more efficiently (…) because we will have to do the same with less, we are committed to the principle of austerity'[10].

In line with the reduced budget, an additional challenge for the administration is the need to conduct detailed evaluations of the existing funding mechanisms for research.

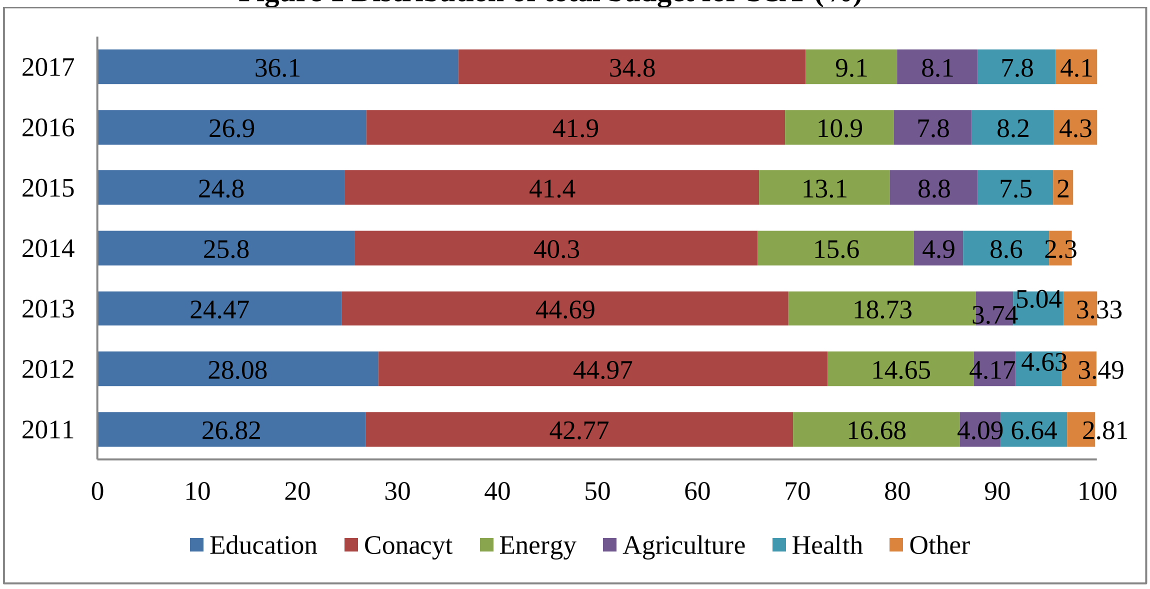
[10]Retrieved March 10, 2018, from: https://www.jornada.com.mx/ultimas/2018/12/15/el-conacyt-desarticulado-de-prioridades-para-mexico-5770.html

This is because as this study will show in further chapters, the policy measures that Mexico has in place to improve its research system have experienced very little change historically in their underlying reasoning and implementation. Additionally, at the most, these measures are evaluated only through audit revisions focused on budgetary efficiency (see section 3.5 in Chapter 3). It is fair to say that wide-ranging evaluations would generate evidence and lesson on the potential of the current programmes to generate change and improvements in domestic research. It would also allow for the design of more adequate policy responses in line with the current pressures that entering the knowledge economy entails.

2.2.2 Funding sources and their distribution

The government is the primary funder of S&T activities in Mexico, with an estimated contribution of 89.16% between 2013 and 2017, from which 98.73% came from the federal government and 1.27% from regional administrations. The private sector and international sources contribute with 10.16% and 0.38% respectively. In its majority, these resources are used within the funding source, i.e. the public entities are the primary users of the public funds and companies use the privately sourced funds, although these also benefit from the public funds. Figure 1 presents the distribution of total public funds for S&T between 2011 and 2017.

Figure 1 Distribution of total budget for S&T (%)



Sources: (Conacyt, 2012b, 2014a, 2015a, 2017b, 2018)

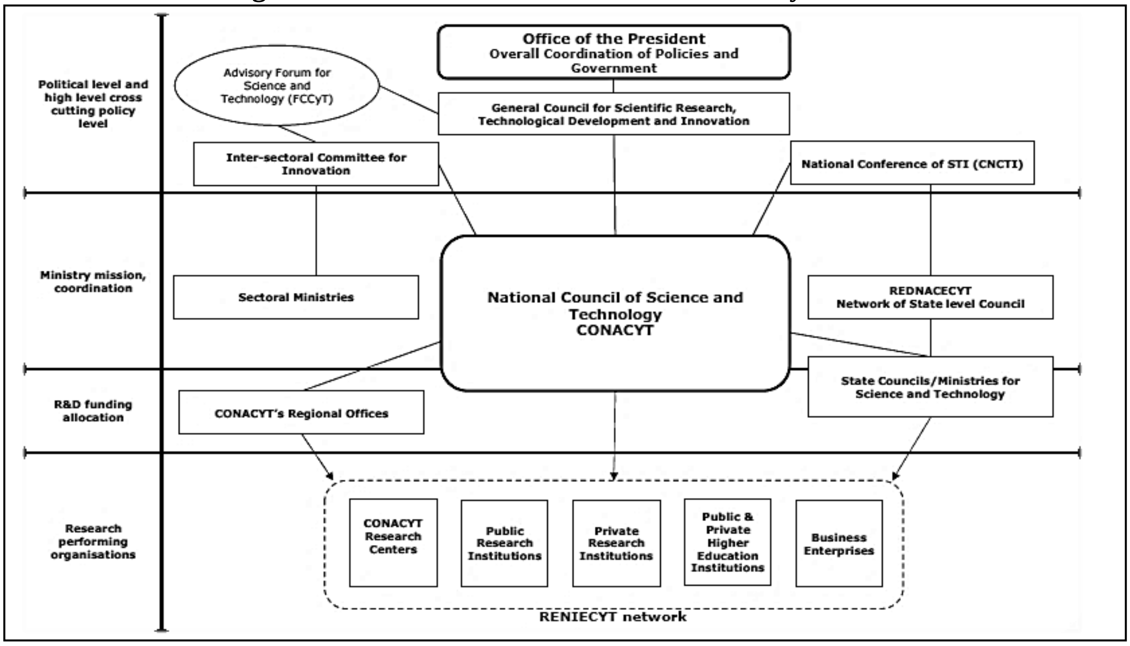
For the past three decades, the federal budget for S&T in Mexico has represented, on average, 0.48% of the GDP. The figure above shows the sectors receiving these funds, where the Council of Science and Technology (Conacyt) and the Ministry of Education (SEP) concentrate around 70%. However, while these resources are Conacyt's primary income, for SEP, these are additional to the 1.4% of the GDP that it receives exclusively for higher education issues. Putting this into perspective, it means that in real terms, the budget for S&T is only 0.16% of the GDP. The financial capacity of Conacyt - the central S&T authority - can be seen as a signal of the real value of this system to policymakers, which is also a signal of the legitimacy and power of Conacyt to steer change.

Further sections in this chapter will present how Conacyt allocates these resources to its substantive programmes.

2.2.3 The central actors in Mexico's research system

The major relevant actors in the Mexican S&T system are Conacyt, higher education and research institutions (HE&RIs), the industrial sector, intermediate institutions and financial institutions. Figure 2 illustrates the actors, their primary role, and level of interaction in the system, from decision-makers at the highest political level to the performers of research activities.

Figure 2 The structure of the Mexican S&T system



Source: European Commission (2016).

2.2.3.1 National Council of Science and Technology (Conacyt)

As shown in Figure 2, Conacyt is at the core of the S&T system in Mexico; it is the leading policy institution and major funder of research. In recent years, the government created advisory institutions to promote the involvement of industrialists and society in the definition of national policies[11]. The Ministry of Education also plays an essential role in shaping S&T in Mexico. The characteristics of its involvement will be developed in detail in the next chapter.

[11] Such as the Advisory Forum of Science and Technology (FCCyT) and the National Network of Groups and Research Centres and the National Network of Regional Councils for Science and Technology (Rednacecyt). The FCCyT is an independent entity that promotes the opinions of the scientific and technology community in policy design. It conducts evaluations of the initiatives implemented by Conacyt and advises Conacyt on S&T matters. The Rednacecyt is a permanent forum, funded by Conacyt, composed of S&T authorities from the 32 states. It aims to bring together these authorities to discuss common issues and share experiences.

The creation of Conacyt was the result of a long negotiation and a conceptualisation process between the government and the largest domestic HE&RIs that started in 1967 and ended in 1970. Its creation was motivated by the need to coordinate research activities and resources between the public research institutions and industries to achieve technological independence (Casas et al., 2013).

In order to secure the existence of Conacyt before any change in the federal administration, on December 29th 1970, the government issued the *Law to Create the National Council of Science and Technology*. In its initial phase, Conacyt's main activity was to provide financial support to the national citizens willing to pursue postgraduate education. In the first five years of operation of Conacyt, S&T expenditures went from 0.13 to 0.45 (% GDP), funded in its entirety by the federal government. Conacyt was also responsible for the design, implementation, and evaluation of the S&T policy instruments. Also, in coordination with the Ministry of Education, it supported the creation of public research centres such as the Mexican Institute for Research on Astrophysics, Optics and Electronics; the Centre for Mathematics Research, and the Centre for Advanced Chemistry Research (Dutrénit et al., 2010).

Although the creation of Conacyt was a significant step in the creation of a research system, its creation also raised some scepticisms among the academic community. Their view was based on the prolonged distance between the government and academia caused by the political turmoil of 1968[12]. Thus, for some, Conacyt was a political manoeuvre to appease and to control rather than an unauthentic concern to enhance domestic research. Others saw it as a political response to the pressures of the

[12] In 1968, in the context of the Mexican Economic Miracle (1940s-1970) -the thirty-year period during which the economy grew by an average of 6% annually, and on the eve of the XIX Olympic Games, students and academics demonstrated their resistance to the government repressions, and demanded social change: education, equality and democracy. The government reacted to the public protests with violence, arresting and shooting students and academic leaders.

international bodies lending money to Mexico (Lozano, 2001; Nadal, 1995; Wionczek, 1981). This was because the government prioritise the recommendation of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Organization of American States (OAM) over a real reflection and commitment to national S&T (Casas et al., 2013; Nadal, 1995).

Regardless of the motivations that gave origin to Conacyt, this institution is a milestone in the modern history of S&T policy in Mexico. Its creation signalled the beginning of the formal design and policy planning that would facilitate the development of science in the country. Since its creation, its role has been essential in the creation of human resources for S&T. The two oldest programmes operated by Conacyt such as the Scholarship Programme and the National System of Researchers, which are presented in the following chapter, have consolidated this institution as the bastion of research capacities in Mexico.

In 2002, the government[13] granted Conacyt a decentralised status and more autonomy over the funds for S&T through the *Law for the Promotion of Scientific and Technological Research* (2002). Before this, Conacyt was under the administrative structure of federal bodies with little relation to S&T in their mission, such as the Ministry for Communications and Transport between 1970 and 1979, and the Ministry for Programming and Budget[14] between 1979 and 1992. In 1992, it then became a department within the structure of the Ministry Education until 2002. Accordingly, this law established the legal framework that would enable Conacyt and all the actors to coordinate research efforts (Calza & Cimoli, 2015). This law states that innovation would be a national priority and that the expenditure in R&D would reach 1% of the

[13] During 71 years, the Partido Revolucionario Institutional (1929 to 2000) had governed Mexico. In 2002, Mexicans elected Vicente Fox, a businessman and the candidate of the Partido Accion Nacional, as the new president for the period 2000- 2006.
[14] Now the Ministry of Finance

GDP by 2006 with growing participation from the industry. It is possible to say that in this phase Mexico adopts the innovation policy paradigm, in which the central aim of policy moves from the research institutions towards the industry.

Conacyt has been crucial in the distribution of the federal budget for science and technology. Between 2016 and 2018, the resources administered by Conacyt represent 42% of the total federal R&D budget. See Table 4.

Table 4 Conacyt's substantive programmes and budget 2016-2018

USD Millions (2018)	**Year**			**Change (%)**	
	2016	***2017***	***2018***	***2017-***	***2018-***
Substantive programmes	**1311.54**	**1003.89**	**1001.62**	**-25.90**	**-0.17**
Scholarships Programme and Excellence Postgraduate Programme	464.86	484.50	515.10	0.90	2.23
National System for Researchers	208.31	234.60	255.00	9.00	1.48
Technological innovation to increase the productivity of companies	244.92	112.20	86.70	-55.70	-1.85
Funds to promote ST&I activities	209.66	96.09	81.07	-55.60	-1.09
Conacyt fellowships	36.09	42.89	49.29	15.00	0.47
Operational expenses	47.55	42.45	42.93	-32.90	0.00
Funds for regional development in ST&I	84.13	35.70	40.80	-58.90	0.37
Fund for sectoral development in ST&I	40.43	25.50	17.85	-38.90	-0.56
Funds for the consolidation of research infrastructure	59.23	15.30	5.10	-75.00	-0.74
Total Conacyt	**1395.18**	**1089.24**	**1093.33**	**-24.40**	**0.30**

Source: Conacyt (2016, 2017b, 2018)

In 2017, the budget allocated to Conacyt was reduced by 25%[15], and in consequence, all its substantive activities suffered considerable constraints. The most affected programmes were: 1) Funds for regional development of ST&I; 2) Funds to promote ST&I activities; 3) Funds for technological innovation to increase the productivity of companies, and 4) Funds for infrastructure strengthening. The Scholarship Programme and the National System of Researchers were less affected by this reduction. In this year, Conacyt supported 64,994 postgraduate students (36% PhDs and 54% Masters); 498 scientific projects and 421 innovation projects, and 27,186 researchers with a membership in the National Researchers System (Conacyt, 2017a).

2.2.3.2 Higher education and research institutions (HE&RIs)

The higher education system in Mexico consists of public and private educational and research institutions. The public institutions are categorised as national and regional, depending on their source of funds. National institutions receive annual block grants from the federal budget, and regional universities receive funds from the federal and the state level. Both public and private institutions can access the competitive funds, offered by Conacyt, SEP and by the regional research authorities, for physical infrastructure and equipment to improve their educational offer. There is no systematic data available relative to the importance of each source of income of HE&RIs. In regards to the S&T national budget, Conacyt reported that a substantial proportion of this (30%) is dedicated to support domestic HE&RIs (2017a).

The most important public and private HE&RIs in Mexico were established between 1930 and 1980. These institutions included the National University of Mexico (UNAM), the National Polytechnic Institute (IPN), the Technological Institute of

[15] Conacyt first claimed that this reduction was associated with the changes in the international prices of oil. However, Mexico has had for about two decades mechanisms to insulate the federal budget from the temporary falls in oil-related revenues. Conacyt claimed that with this decision the government was seeking to foster the participation of HEIs and the private sector in funding innovation activities.

Higher Studies of Monterrey (ITESM), the Metropolitan Autonomous University (UAM), as well as various regional universities. By 1980, only 84 HE&RIs existed in this country, and most of them were located in Mexico City. This started to change in the 1990s when Mexico experienced an unprecedented expansion in higher education, which resulted in an increase in the number and variety of institutions, students, faculty, and research. Thus, in this period, the Mexican higher education system became complex and highly differentiated (Brunner et al., 2008).

According to official sources, in 2005 there were 2,807 HE&RIs and 7,031 in 2018, meaning that in a period of thirteen years, the number of universities and educational institutes grew threefold. From these, 41% were public, and 59% were private institutions (ANUIES, 2018; OECD, 2009b). An important remark here is the number of private HE&RIs is larger than public institutions, these concentrate the highest shares of enrolment and are the first larger employers of researchers (62%). According to ANUIES[16], between 2017 and 2018, public institutions captured 71% of the total enrolment at postgraduate training.

Higher education and research institutions in Mexico have two primary missions. First, to train and supply highly qualified human capital; and second, to conduct research and produce useful knowledge for the innovation system (Brunner et al., 2008; Casanova-Cardiel, 2007). Historically, they have also been essential in the diffusion of scientific knowledge and culture in society. In addition to this, most of them, particularly the oldest and largest institutions, are reorganising their internal structure in order to foster entrepreneurship activities among researchers and to establish strong linkages with external entities (Perez & Calderon, 2014). This process is widely known in the literature as the third mission of universities and their relation

[16] The National Association of Universities and Higher Education Institutions.

with knowledge users, which exemplifies the new organisation of research (Etzkowitz & Leydesdorff, 2000; Laredo, 2007; Nedeva, 2006)

2.2.3.3 Research organisations

These organisations can be characterised into three groups, where the first group comprises the research centres coordinated and funded by Conacyt, which are known as “Conacyt Research Centres”. The second group consists of mission-oriented organisations linked to national ministries, and the third group are the institutes linked to the administration and funds of domestic universities.

2.2.3.3.1 Conacyt Research Centres

This is a system of 26 research organisations clustered in three main scientific and technological areas:

1) Mathematics and natural science research, with ten institutions;
2) Social science and humanities, with eight institutions;
3) Technology development and innovation, with eight institutions,

The vast majority of these centres were established between 1980 and 1990s. In 2000, Conacyt founded its most recent centre in the city of San Luis Potosi (Ipicyt) [17], which conducts multidisciplinary research in five main research areas, notably: molecular biology, environmental sciences, applied geosciences, mathematics and advanced materials.

Conacyt distributes block grants to these centres, which can also access additional resources through national, regional, and international competitive funding schemes. They also provide technical consultancy services to industries and the government. Collectively, these centres are the second major contributors to the national production of scientific knowledge (UNAM is the first) and training of human resources at the

[17] Spanish Acronym for Institute of Scientific and Technological Research of San Luis Potosi

postgraduate level. Due to their geographical location, outside Mexico City, they have become essential in the decentralisation of S&T capacities and financial resources (Corona & Dutrénit, 2013). See Table 5

Table 5 Performance indicators for Conacyt centres 2012-2017

Outcomes	2012	2013	2014	2015	2016	2017
Postgraduate training programmes	142	149	151	158	165	171
Postgraduate students enrolled	6,361	6,422	7,448	7,368	7,908	7,526
Personnel in the NRS	1,499	1,538	1,621	1,731	1,798	1,852
Research articles	2,243	2,075	2,969	3,212	3,365	3,077
R&D funded projects	2,444	2,677	2,999	2,910	2,773	2,796

Source: Conacyt, 2017

Conacyt is the primary source of funds for these centres, which puts them in a vulnerable position when compared with higher education institutions, which have a guaranteed income from the education budget. As the table above shows, in five years, the number of funded projects and the performance of other indicators have had a modest growth (10% annual average). Additionally, most public educational and research institutions lack the legal and institutional framework for the commercialisation of their developments and distribution of the possible economic profits.

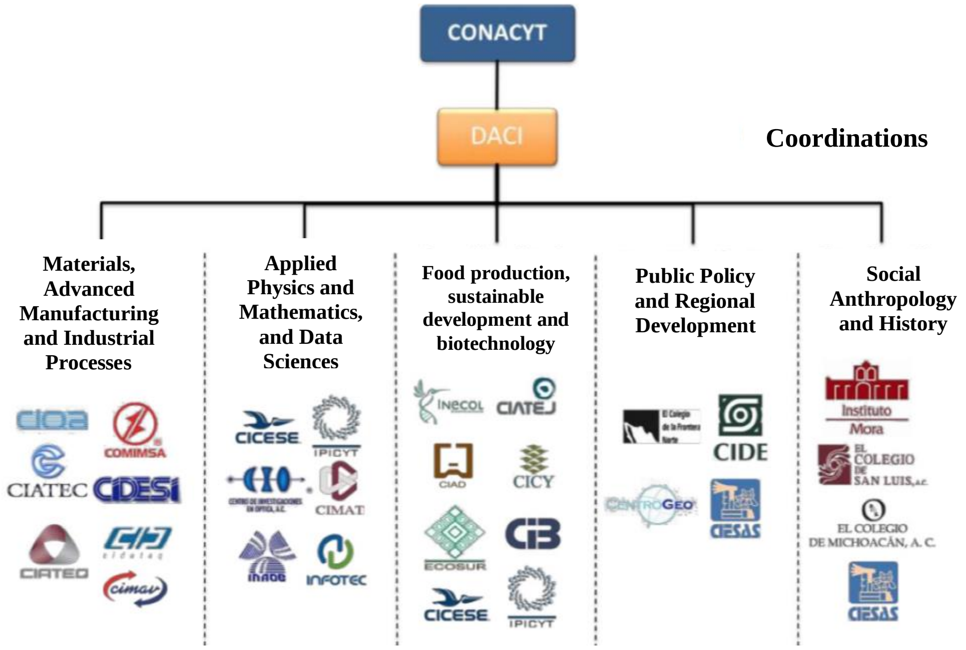
In 2016, Conacyt began a reorganisation of these centres motivated by the eminent financial constraints. As stated by the Deputy Director, this reorganisation aims:

> *"to promote a public policy where Conacyt's research centres will help to tackle urgent needs for science and technology, to establish more significant interactions among the centres, and to co-develop research projects of a greater regional impact "*(Director of Conacyt Research Centres)[18]

[18]Retrieved March 12, 2018, from: http://conacytprensa.mx/index.php/sociedad/politica-cientifica/9762-se-renueva-el-sistema-de-centros-conacyt

Conacyt and the managing authorities of each centre developed a new organisational structure that consists of five coordination areas, as illustrated in Figure 3.

Figure 3 Organisation of Conacyt's centres



Source: Conacyt[19]

Note: DACI is the Spanish acronym for Deputy Directorate of Research Centres

This new arrangement might foster collaborative research and strengthen domestic research networks, which would reduce the duplication of efforts and would optimise the existing and future resources for S&T. Additionally, these organisations are expected to engage in larger multidisciplinary projects, which might enhance the role of knowledge in the economy and society.

[19]Retrieved March 12, 2018, from: http://www.conacytprensa.mx/index.php/sociedad/politica-cientifica/15630-reorganizan-sistema-centros-publicos-investigacion-conacyt

2.2.3.3.2 Other public research centres under state ministries

These are mission-oriented organisations linked to some government ministries. They receive block grants from the related ministries and other regional, national, and international sources. These centres were created during the expansion of the public sector in Mexico (1940-1980) to provide technological solutions to other public entities in the sectors of energy, agriculture, health, and natural resources. Examples of these are the Mexican Institute of Petroleum, the Research Institute for Nuclear Research and the Electrical Research Institute, which depend on the Ministry of Energy.

These research centres conduct fundamental research, except for the Mexican Institute of Petroleum, which has a strong tradition of applied research that reflects its patenting capacity (Dutrénit et al., 2010).

2.2.3.3.3 Research institutes and research centres within domestic universities

These organisations are associated with the largest universities, such as UNAM, IPN (including Cinvestav) and UAM. In the past ten years, these created satellite locations outside Mexico City, for instance; UNAM established the National Centre for Nanotechnology in Baja California, and set up a new campus in the state of Guanajuato. Regional universities also have their research institutes and centres.

2.2.3.4 The private sector

Over the past five years, companies contributed 10% to the total R&D expenditure and performed 30% of this (Conacyt, 2015a, 2017a). However, the participation of this sector in the national S&T system is rather low despite the resources that Conacyt has mobilised into this sector in the form of direct grants, fiscal incentives, and credits to support activities of research and development.

Also, the presence of multinational companies in Mexico has not produced endogenous technological capacities in the related sectors; their investment in domestic research activities is minor (Calza & Cimoli, 2015; Lederman & Maloney, 2003). There is not available data relative to the contribution of these particular companies to S&T in Mexico. However, a recent debate in Mexico relates to the questionable performance of the companies of foreign capital, and large domestic companies, that have been receiving public research funds. An important remark here is that multinationals and large companies accumulate the vast majority of research resources, which account for 87.2% in average in the past ten years, while small and medium companies receive 12.8% (Conacyt, 2017a; Dutrénit et al., 2010). According to press conference statements made by Conacyt's director [20][21], between 2009 and 2017 this body set aside grants for over four thousand million (USD) to companies such as Ford, General Motors, Nissan, IMB, Intel, Monsanto, Bayer and Sanofi. However, these resources did not translate into tangible benefits in the form of increased private investments in R&D, productivity, salaries or new products.

This situation resonates with those studies that have looked into the undesirable effects of foreign direct investment in Mexico. Those studies have reported a negative relationship between the origin of investment capital and R&D in the country (Dutrénit, 2015; Peters, 2009). An illustration is the Survey on Technological Research and Development and the Module on Biotechnology and Nanotechnology Activities (ESIDET) [22] conducted in 2012. According to data from the 10,200 companies surveyed, SMEs perform, on average, more innovation activities than multinationals. Firms supported by foreign capital represent on average only 2% of the companies that reported some innovation-related activity, whereas domestic SMEs account for 11%. In other words, the involvement of the private sector in S&T activities is still emergent in Mexico, despite the strong presence of foreign capital.

20 Retrieved January 18, 2019, from: https://www.jornada.com.mx/ultimas/sociedad/2019/01/18/ford-gm-ibm-y-monsanto-entre-beneficiarias-del-conacyt-4267.html

21 Retrieved February 05, 2019, from: https://aristeguinoticias.com/0502/mexico/tras-recorte-presupuestal-conacyt-hara-mas-con-menos-alvarez-buylla/

22 The survey obtains information related to human and financial resources intended for activities of R&D in the productive sector. The National Institute of Statistics and Geography and Conacyt coordinate this survey. Retrieved January 20, 2019, from:http://en.www.inegi.org.mx/proyectos/encestablecimientos/especiales/esidet/2014/

2.3 SUMMARY

This chapter provided an overview of the emergence and development of the Mexican S&T system. An assessment of this system suggests that the grand challenge for Mexico can still be summarised as Dutrénit et al., described in 2010:

> *"The Mexican system has most of the agents reported in other successful countries. In the case of the actors in Mexico, their actions and interactions at different levels and different intensities contribute to characterise this system as still under development."* (2010, p. 64)

This chapter showed that S&T policy in Mexico has had a strong focus on the supply-side, and that a persistent challenge in this system is the consolidation of strong interactions between actors. In this regard, the chapter showed that the government established some changes in order to address this challenge. Some of those changes included the establishment of advisory bodies in S&T for the Federal Government, although, their influence in dealing with pressing concerns, such as the reductions of funds, the emergent participation of the private sector and the low wages for scientists, among others, is still limited. This may be because the role of these bodies is highly political; for instance, the selection of their directors requires the approval of the President. Another more recent intervention is the reorganisation of Conacyt's research centres, which S&T authorities expect that financial pressures will incentivise the coordination of efforts and resources between public actors at all levels and with private actors.

These changes seek to reorganise the system, particularly they aim to redefine the roles of the actors, initially defined in the industrialisation processes of the 1950s and 1970s, which resulted in a narrow delineation of their functions. The functions were demarcated by the domain of action that actors could affect and by their financial capacity. Their functions were clear, i.e., the government was responsible for the financial resources; universities and research institutes would supply the system with human resources, knowledge, and technologies and the private sector would appropriate these inputs and would produce growth. The premise behind this reasoning was that the research produced in domestic HE&RIs would pair the technological development (science-push). This policy approach only changed in the

2000s, but failed to change the behaviour of the actors. This was because while policymakers embraced the innovation policy paradigm and the private sector became the top performer of S&T funds (demand-pull), the government was still the primary funder, and the companies continued to depend on foreign technology. Additionally, HE&RIs did not experience significant changes in their internal organisation and orientation of their research activities.

This chapter showed that Conacyt has been crucial in the development of this system, but that the following factors hinder its capacity to steer the functioning of the system:

1) A hierarchical governance structure, where Conacyt does not have the same authority and priority as federal ministries.
2) Weak financial power, which can signal an unauthentic concern for the advancement of domestic S&T at the highest policy levels. In 2018, The Science and Technology Advisory Forum and the national commission for S&T presented a proposal to the legislators to increase the budget for Conacyt (by three billion pesos or one and half billion USD). This initiative was unsuccessful, and the budget for 2019 was the same as for 2018, signalling that the ambitions of the actors in this system do not match with the priorities of higher-level policymakers.

In light of the above, the organic origins of the Mexican research system linger in the demarcation of domains of action and distribution of resources among national actors. Addressing this challenge would require a more directed and coordinated commitment of actors.

The following chapters in this part of the thesis will provide a more in-depth assessment of the initiatives for research training.

CHAPTER 3 DOCTORAL TRAINING IN MEXICO: THE POLICIES AND ACTORS CONSTRUCTING THIS SYSTEM

3.1 INTRODUCTION

This chapter provides a diachronic and analytical review of the three main components of the doctoral training system in Mexico. The chapter begins with a description of the policy instruments and their rationale, and the contextual conditions that underpinned their intervention. This chapter will show that despite the commonly assumed interconnected nature of these policies, this system is the product of unplanned responses to external pressures; the deregulation of the higher education and research system, and more recently of coordinated efforts between education policy and S&T policy.

This chapter will identify the policy rationales, changes in policies and the domain of action of the actors involved in the construction of this system. The chapter puts forward the on-going challenges for doctoral training in Mexico, and briefly introduces the Scholarship Programme, which will be fully unpacked in the next chapter. This chapter will also examine how the S&T policy translated into three concrete programmes furthering the development of the doctoral training system and assesses the motivations and outcomes of these programmes. This will require to assess whether these programmes resulted by chance, in response to exogenous events, or as a result of a reflective process.

This chapter builds on a review of the S&T policy initiatives particular to doctoral training in Mexico. Due to the interconnected relationship between these and master's courses, and because in some cases, resources do not provide disaggregated data, the word postgraduate will refer to both masters and doctoral training. The chapter also draws on academic studies and grey literature on the Mexican S&T system and higher education.

This chapter is organised as follows. Section 3.2 provides a brief historical account of the doctoral training system in Mexico and begins to present the core components of the system. Section 3.3 offers a review of the National Research System. Section 3.4 examines the National Postgraduate Programme, which is a turning point towards a coordinated policy between two domains science and technology and education. Section 3.5 offers a brief review of the evaluation culture and practices on S&T policy in Mexico. Finally, section 3.6 discusses and concludes.

3.2 CONSTRUCTION OF THE DOCTORAL TRAINING SYSTEM IN MEXICO

Doctoral training is a relatively recent activity in Mexico. Its origins go back to the year 1937, when only elite groups of the population had access to this form of advanced training, and when higher education institutions were few and were concentrated in Mexico City. Between the 1937 and 1950, the National Autonomous University (UNAM) founded in 1910, and the National Polytechnic Institute (IPN) (1936) were the only institutions offering postgraduate education[23], in philosophy, natural sciences, political sciences and fine arts.

In this period, doctoral training did not respond to a particular policy, simply because there was no policy. The government was the primary funder of higher education and research but had no direct influence on the internal organisation of HE&RIs. There were no formally established entry and examination processes; training was based on the mentor-apprenticeship model.

It is possible to consider the existence of a policy only until the 1950s when the government furthered the growth of UNAM in 1952 and fostered the creation of new institutions across the country. During the 1950s and the 1960s, the number of students on postgraduate training was minimal[24]; only two or three degrees were awarded annually, mainly because HE&RIs had few academics. According to Arredondo et al.

[23] The National Polytechnic started its first programme on engineering at postgraduate level in 1943.
[24] During the period 1930-1960, national efforts were mostly addressing the high levels of illiteracy, by facilitating access to elementary education.

(2006), for doctoral courses, citizens were sent to foreign institutions, and these did not exceed 450 graduates per year. S&T public agencies were the funders of postgraduate education in this period, and sponsored approximately 75% of the total population enrolled. These public agencies were the National Council of Advanced Education and Scientific Research (1935); the Commission and Coordinator of the Scientific Research (1942); and the National Institute of Scientific Research (1950). In this period, the Central Bank of Mexico (Banxico) established a loan program for specialised training in economics.

3.2.1 Conacyt: the core of the doctoral training system in Mexico

The creation of Conacyt signalled the beginning of a policy for S&T in Mexico, whose central focus was to sponsor nationals to embark on postgraduate training in order to create domestic research capacities (Conacyt, 1976). The significance of Conacyt can be illustrated by two particular actions produced in the first years of operation. First, the comprehensive diagnosis exercises that culminated with the Indicative Plan for S&T (1976), which conveyed the points of concern in the emerging research system in this country. The Indicative Plan showed that the number of HE&RIs and doctoral courses were insufficient to meet the needs for research and advanced skills of this country, which was in the middle of its industrialisation process. It also emphasised that the co-dependency between doctoral training and research required systematic actions and collaboration between the relevant sectors, notably, higher education, S&T and industry. The Plan highlighted other pressing issues, such as the inadequate training level of academics - in 1976, only 3% of academics had doctoral degrees - and the lack of full-time research positions.

The second action involved the reorientation of the Scholarships Programme, which had been operating without any particular focus on national priorities and lacked selection criteria, to a more systematic and transparent instrument. Furthermore, the concentration of research capacities in a couple of universities in Mexico City led Conacyt to direct the Programme to achieve a postgraduate training system that would increase the qualifications of academics and would foster its regionalisation. Also, Conacyt stressed that the pursuit of these ambitions required to coordinate the S&T policy with the educational policies.

Ultimately, Conacyt became the primary funder of doctoral education, which confirmed its relevance in this doctoral system. Table 6 shows that Conacyt contributes 84% of the total funding to postgraduate studies through the Scholarships Programme. Other sources of funding are HE&RIs, mainly research-oriented universities and research centres, such as Cinvestav and UNAM; and the Ministry of Education. Other sources are the Fund for the Development of Human Resources (Fiderh), a federal trust fund administered by the Central Bank and that operates as a loan[25].

Table 6 Postgraduate scholarships granted by federal government, 2007-2013

Institution	%
Conacyt	83.83
Ministry of Education	11.62
Ministry of Health	3.64
Secretariat of the Navy	0.33
Communications and transport	0.19
Ministry of Energy	0.13
Ministry of Agriculture, Fisheries and Food	0.10
Ministry of Finance	0.09
Ministry of Economy	0.04
Ministry of Environment	0.03
Total	100

Source: Conacyt (2014a)

3.2.2 Characteristics of the development of the doctoral training system

The development of this system in Mexico can be categorised into three diachronic stages spanning the last six decades. The first stage (1960-1982), was a period of '*expansion without regulation*', which was characterised by the uncontrolled growth of higher education institutions, particularly of private universities (Mendoza-Rojas, 2015). The next stage (1982-1991) was one of '*crisis and rationalisation*'. Here the expenditure in S&T plummeted over 50% and the development of a national research system was not in the list of priorities for the government (Alcantara et al., 2008b;

[25] Between 2005 and 2018, Fiderh has received 15,975 applications, from which 9,459 have successfully passed the reviewing process and received postgraduate loans.

Altbach & Balán, 2007). The last and current stage can be described as one of '*consolidation of domestic postgraduate training*' and is the result of a reflective policymaking process between Conacyt and the Ministry of Education.

The pertinent characteristics of these three stages are presented in the following sections.

3.2.2.1 Initial efforts towards building a national postgraduate system

The actions of the government between 1960 and 1970 aimed to increase the number of researchers in HE&RIs, which would ensure the development of a research base in Mexico. These actions were motivated by the expectation that the private sector would demand the advanced skills and knowledge provided by the research system, which would ultimately lead to economic growth (Conacyt, 1976).

Among the most significant actions were the creation of public research centres and institutes such as Cinvestav[26] (1961) and the Institute of Petroleum[27] (1965). These organisations began to consolidate after the creation of Conacyt, which offered financial support for students to enrol in postgraduate courses and funded the research activities of these HE&RIs. Due to this, the enrolment of students into postgraduate training grew fivefold in five years from 2,180 students at the end of the 1960s to 9,846 in 1975. Another significant action was the decentralisation of S&T and of postgraduate training. Thus, between the 1970s and the 1980s, the first regional research institutes were created outside Mexico City, such as the Applied Chemistry Research Centre (1986) and the Optics Research Centre (1981). In addition to this, Conacyt provided HE&RIs block grants to establish new research training

[26] Centre for Research and Advanced Studies of the National Polytechnic Institute. Initially planned as a postgraduate department of the National Polytechnic Institute it became a national research institution with campuses across the country. It conducts research in areas such as biotechnology, social sciences, and physics.
[27] This is a public research organization created to develop technical solutions, conduct basic and applied research, and provide specialised training to the then state-owned oil company (Pemex).

programmes. As a result of these actions, by 1976, there were 462 postgraduate courses: 247 masters, 73 doctoral courses, and 142 specialities.

Despite these advances, a diagnosis report presented by Conayt in 1983 showed that the issues contained in the Indicative Plan of 1976 remained unsolved. Those issues were the small size of the research system, the lack of research positions in HE&RIs and the concentration of capacities and financial resources in Mexico City. This diagnosis also indicated other emerging issues, such as that the hard sciences courses were attracting fewer students than those in the humanities (Conacyt, 1983). The factor that can explain why things had not changed significantly in Mexico was the unregulated growth of education courses, some of which had no relation with science and technology.

In addition to this, Conacyt re-emphasised the need to coordinate the S&T policy with education and the economic and industrial policy. However, these recommendations did not produce a positive response among the high-level policymakers. This was because they prioritised the economic policy issues. The policy logic that characterises this period was one of a narrow economic agenda, focused on competitiveness, jobs and growth. Thus, policymakers disregarded the impact that S&T could have in producing endogenous research capacities. In consequence, the structural issues remained unchanged, and prevented the consolidation of a strong training system. Moreover, this response accentuated the disconnection between relevant actors and had longstanding effects on the organisation of domestic research.

Aware of the questionable progress in research and higher education in the past decade, Conacyt and the Ministry of Education (SEP) presented two coordinated initiatives, namely: *the National Indicative Plan for Science and Technology* (1976-1982), and *the National Programme for Science and Technology* (1978-1982). These documents urged academics to have adequate training because this had been a persistent weakness limiting the development of domestic research capacities. The objectives in these documents turned into three initiatives aimed to upgrade the qualifications of the national academic personnel, such as *the National Programme for Higher Education (Pronaes)* (1984-1986), *the Integral Programme for Higher the*

Development of Education (Proides) (1986-1988) and *the National Researchers System (NRS)* (1984-present). The first two channelled additional financial resources to HE&RIs, and the third provided tax-free incentives for individual researchers.

These programmes aimed to increase the enrolment in postgraduate courses, to strengthen the linkages between research courses and the nation's social needs and to allocate financial resources to HE&RIs based on student enrolments, quality of the courses and graduation rates.

In 1984, SEP implemented Pronaes in pursuit of the following objectives: 1) to improve the credentials of the academic personnel. 2) To invest in physical infrastructure for research, and 3) to allocate funds for the improvement of teaching and research activities. However, this initiative caused conflict among HE&RIs, which did not receive well the performance evaluations that SEP set as a condition to obtain the financial support in Pronaes. The HE&RIs interpreted this as a trespass on their autonomy[28] (Varela-Petito, 2011). After negotiations between SEP and HE&RIs, the agreement was that the HE&RIs themselves would carry out the evaluations without the interference of SEP. With this in mind, it is possible to say that Pronaes ignored the heterogeneity of the HE&RIs, whose missions varied, and which existed in specific regional contexts with diversified academic traditions. This did not facilitate the implementation of a one-size-fits-all policy as Pronaes.

The intentions set by SEP in Pronaes failed to result in a coordinated policy and yielded limited outcomes, and after two years of operation, Pronaes was replaced by Proides (1986-1988). This event occurred in the midst of the economic crisis caused by the bankruptcy of the public finances, which led the government to mobilise the

[28] Public universities are legally autonomous and hold academic traditions where government interventions could be seen as a threat to academic freedom. This position is commonly counterweighted by their financial dependence on public funds.

existing resources onto the pressing economic matters and to abandon the development of S&T (Canales, 2011; Cimoli, 2000). This resulted in chaotic effects for the Mexican scientific system, for instance, due to the severe reductions to the S&T budget (from 0.46% of the GDP in 1982 to 0.3% in 1986); the financial capacity of Conacyt was reduced by 40%. The funds for postgraduate education and research decreased from $ 4,340 USD million in 1971 to $1,677 USD million in 1989.

In response to the financial constraints, domestic HE&RIs formulated Proides[29]. This comprised an extensive diagnosis of the most pressing matters, and proposed that higher education should be organised into regional subsystems to encourage the participation of regional governments in the financing of this sector. Other challenges that Proides attempted to address include the depreciation of the salaries for academics, and the need to increase the public expenditure on higher education to 1% of GDP. It also highlighted the decline of the academic and research missions in HE&RIs, and the imbalance of quality in the national postgraduate courses, which resulted from the unregulated expansion of the higher education system (Sagarra et al., 2015).

In Proides both HE&RIs and the government joint efforts to further the postgraduate system, which had been evolving intermittently and without particular direction in the preceding fifteen years. In principle, Pronaes and Proides shared the same goals; the main difference between these was that the government had elaborated the Pronaes without any involvement from universities. While Proides emphasised the participation of HE&RIs in the design of higher education policy. Thus, together, these programmes set up the institutional structure for a higher education policy coordination at the regional and national level (Arredondo et al., 2006; Gómez, 2014).

[29] The Programme was led by the National Association of Universities and Higher Education Institutions (ANUIES), composed of the heads of HEIs

3.2.2.2 Tensions and structural weaknesses in reaching a unified policy to further a postgraduate training system

Prior to these initiatives, there had been no connection between the scientific development domain (Conacyt) and the higher education domain (SEP). In fact, Conacyt had not direct interference in the postgraduate system before the above mentioned initiatives. Conacyt started to be involved in shaping this system by, arguably, working together with SEP, through Pronaes and Proides, in the pursuit of the same objective, i.e. to build and consolidate the higher education system. However, the capacity of these two bodies to steer change was defined by their financial resources and mission. Thus, Conacyt was merely seen as an advisor in higher education issues, and had few financial resources in comparison to SEP[30] (see the previous chapter). Consequently, Conacyt had little decision-making power on the implementation of the two programmes. Its involvement consisted of advice and support in the design of instruments to evaluate the performance of HE&RIs.

Independent from the actions implemented by SEP, Conacyt had under its responsibility the operationalisation of the Scholarship Programme and the NRS. Conacyt also formulated the *National Programme for Technological and Scientific Development* (1984-1988), which aimed to promote the formation of highly skilled human resources through postgraduate studies. This programme contained the following strategies: 1) the consolidation of domestic postgraduate training programmes; 2) the allocation of scholarships for postgraduate students admitted to domestic programmes, and reliance on foreign postgraduate courses as a complement to the domestic postgraduate offer; and 3) the incorporation of nationals trained abroad and foreign scholars into domestic postgraduate courses (Conacyt, 1983). Despite the

[30] For instance, when compared to the budget of other public agencies, the Ministry of Education received 0.45% GDP. In the same period, the total budget for S&T was 0.3% GDP, from which 7% of this budget was allocated to Conacyt (Brunner et al., 2008).

strong component of higher education in this programme, these strategies had no connection with the national higher education policy.

Despite the uncoordinated efforts that distinguish the 1970s and 1980s, the numbers of students enrolled in domestic postgraduate studies rose from 6,000 to 35,000. Similarly, the postgraduate offer increased from 462 programmes in 1975 to 1,290 in 1984, and the number of public research centres doubled, particularly outside the metropolitan area (Conacyt, 1990). However, the misalignment between higher education policy and S&T policy reflected in the quality of the available postgraduate courses. This was because while Conacyt was supporting the advancement of research capacities, the national postgraduate system depended on the authority of SEP, and continued to face structural challenges resulting from the non-regulated expansion of higher education in previous decades.

In summary, the initiatives implemented during the preceding years had not produced a strong research training system. Studies suggest that the same difficulties highlighted in the initial S&T policy documents continued to exist, and new challenges emerged as a consequence of the disarticulation between higher education policy and research policy (Tuirán & Muñoz, 2010).

3.2.2.3 Modernisation and evaluations

Between the 1970s and the 1980s, the higher education system and the research system in Mexico developed unconnected. The tensions between HE&RIs and the Ministry of Education, and the reduced influence and financial capacity of Conacyt marked this period. The effects of the economic crisis in 1982 deepened these tensions and eroded the benefits gained in previous efforts. This can be illustrated by the fact that the objectives set by HE&RIs in Proides had no continuity in the *Educational Modernisation Programme (1989-1994)*. This programme, led by SEP, aimed to promote the regionalisation of undergraduate training and emphasised the consolidation of technological education. Its ultimate aim was to increase the availability of higher education in every region in Mexico to reduce the prevailing unequal access.

What was distinctive in this programme was that it contained several recommendations made by transnational policy and funding bodies, namely the United Nations Educational, Scientific and Cultural Organization (Unesco), the Inter-American Development Bank (IADB) and the World Bank (WB). For these bodies, primary education and technical-vocational-schools at secondary and high school level were critical in this particular period of crisis and economic globalisation, as students could more rapidly enter the workforce. Thus, as part of the financial support that these bodies provided to Mexico to alleviate the effects of the economic crisis of 1982, they "recommended that funds be channelled to basic and technological education since the highest rate of return was obtained in these sectors of education" (Gómez, 2014, p. 60). Accordingly, the government prioritised undergraduate education over postgraduate courses, and as a consequence of this higher education and S&T did not only experience budget reductions, these also dropped in priority in the policy agenda. Evidence for this is that the expenditures on S&T decreased from 0.45 to 0.27% of GDP in 1982. This left Conacyt in a difficult resource-constrained situation, which adversely affected the development of the scientific and doctoral training system.

In the 1990s, also following the recommendations of the funding bodies mentioned above, the Mexican government adopted several changes. These were: 1) Introduction of external evaluations on productivity. 2) Allocation of extra funds linked to the outcomes of these evaluations, and 3) promotion of higher technical education that offered two-year courses[31]. In response to these changes, HE&RIs, driven by the financial incentives they could accrue through increased efficiency, implemented internal mechanisms to incentivise productivity in academics. This incentive, better

[31]These programmes are known as "técnico superior universitario", and are similar to the American community colleges and French Institus Universitaires de Technologie. They are offered by technical universities and institutes located at the regional level as alternatives to the normal studies that take four to five years to complete.

known as *becas de productividad (productivity incentive scheme)* followed the implementation of the *Programme for Upgrading Higher Education Academic Staff* (1994). This programme was later replaced by the *Plan for Upgrading Academic Credentials at Higher Education Institutions* (Promep) (1996), which remains current until this day. Promep was SEP's response to the new membership criteria introduced by Conacyt in the NRS that required members to hold doctoral degrees, leaving out about 50% of its members (Kent-Serna, 2009).

Promep aimed to address two unresolved issues in the higher education and research system. Notably, those issues were that not all full-time staff had specialised training (in 1996, only 8% had doctoral degrees, and 32% had master's degrees), and the lack of full-time positions to absorb the academics working under part-time contracts.

Similar to SEP's modernisation programme, Conacyt issued the *Programme for Science and Technological Modernisation (1990-1994),* in which introduced the differentiation between science policy and technology policy. In the science policy domain, this programme was set to improve the qualifications of academics and to diversify higher education by introducing more technological specialisations. Whereas, on the technology policy domain, Conacyt, commissioned by the President, implemented several programmes to incentivise R&D in the private sector. Those programmes were: 1) the Fund for R&D and Technological Modernisation, which was later transformed into the Programme to Support Technological Modernisation in Industry; 2) the Fund for Strengthening Scientific and Technological Capacities, and 3) the Special Programme to Promote Academic-Industry links. The first two funded high-risk R&D projects with promising market potential, and the third one supported the creation of private R&D centres. Both, this programme and its successor, the *Science and Technology Programme (1995-2000)* were highly influenced by the discourse of globalisation, reduced government intervention, quality, productivity and growth that led public policy interventions in this period. Another significant feature in these programmes was that they were designed under the assumption that the private sector would demand the knowledge and advanced skills produced in domestic HE&RIs, which will prompt long-term economic growth (Castaños-Lomnitz, 2006; Dutrénit et al., 2008; Nadal, 1995).

A significant event that marked this period was that in 1992, Conacyt began to operate under the administrative structure of the Ministry of Education. Prior to this, Conacyt was part of the Ministry of Budget and Programming - now the Ministry of Finance. Although it would have been expected that bringing together SEP and Conacyt would prompt them to active collaboration, their missions and domains of action remained independent, i.e. Conacyt was there to attend S&T matters, and had no legal authority to intervene in the education sector directly. This responsibility remained centralised in the Ministry of Education and regional governments (Mejía, 2014), and Conacyt continued to be seen as the organisation dedicated to S&T matters only, as if these were not intertwined with those matters in higher education.

3.2.2.4 Complementary programmes that supported the creation of the training system

Table 7 summarises the complementary programmes that contributed to the development of the doctoral training system in Mexico. These programmes, operated by Conacyt alone or by SEP, or coordinated by these two, had less direct effects on postgraduate education, this mainly due to their short-lived implementation.

Table 7 Complementary programmes to improve the postgraduate system

Programme	Year	Domain/authority
Fund for Higher Education Modernisation (FOMES)	1990	Education
Programme to Support Mexican Science (PACIME)[32]	1992	Education/S&T
Upgrading Higher Education Academic Staff (SUPERA)	1994	Education
Plan Upgrading Teachers at Higher Education Institutions (PROMEP)	1996	Education
Repatriation and Retention Programme	2006	S&T
Postdoctoral Fellowships Programme (national and abroad)	2007	S&T

[32] Operated with federal resources (40%) and a loan from the World Bank (60%)

Programme	Year	Domain/authority
Conacyt's Fellowships Programme for early career researchers	2014	S&T

Based on Varela-Petito (2011) and Conacyt's website[33]

These programmes granted financial resources to HE&RIs to acquire infrastructure; to upgrade the credentials of academic staff; to repatriate national researchers living abroad and to attract researchers of foreign nationality. Between 2007 and 2015, Conacyt and HE&RIs repatriated 559 fellowship holders trained abroad, and retained 738 trained in domestic universities and researchers of foreign nationality trained abroad.

In short, this section highlighted the origins of the postgraduate training system in Mexico by presenting the pertinent events and policy decisions throughout 1970-1990.

Currently, the Mexican postgraduate system can be characterised by the three programmes with which Conacyt and SEP promote the improvement of domestic capacities in scientific and technological advanced training. The subsection below offers a brief description of these three programmes as an illustration of the current array of the postgraduate system.

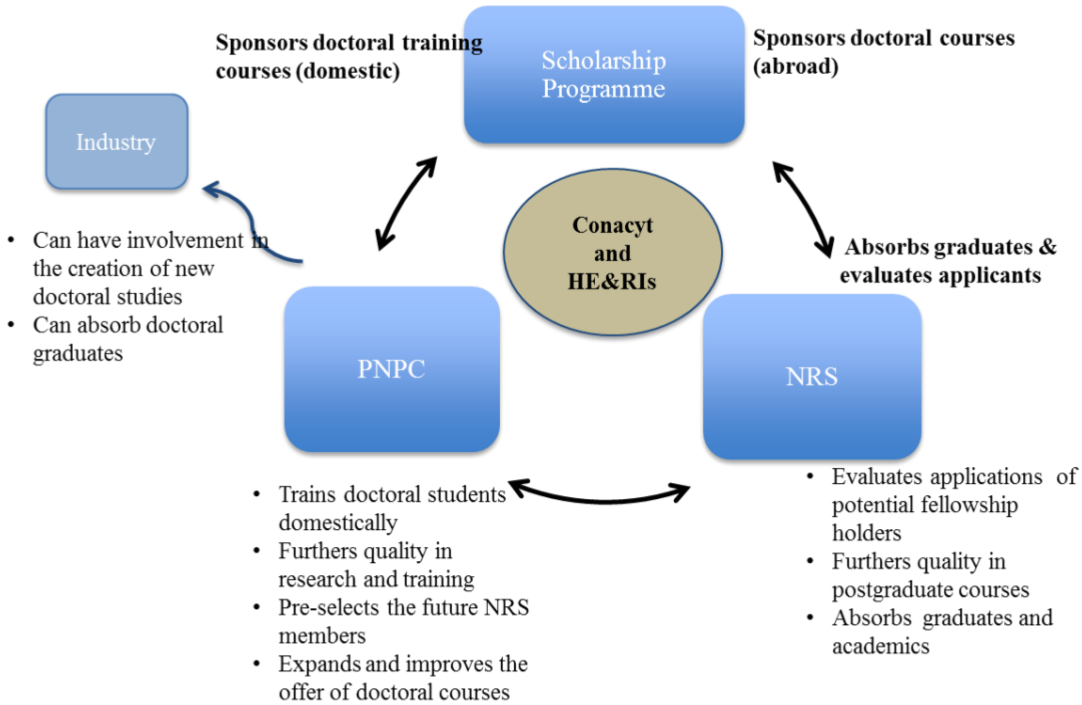
3.2.3 The three cornerstone components of the research and postgraduate training system in Mexico

As presented in the preceding sections in this chapter, the postgraduate system and research system in Mexico evolved organically. During their initial stages of existence, HE&RIs led their evolution, and after the introduction of financial resources linked to performance evaluations, both became, to a certain extent, a government-led system.

[33] https://www.conacyt.gob.mx/index.php/el-conacyt/desarrollo-cientifico/catedrasconacyt

In regards to doctoral training in S&T, this system is constituted by three programmes that emerged separately over time. These programmes are: 1) *The Scholarship Programme* (1971), *The National Researchers System* (NRS), and 3) *The Excellence Postgraduate Programmes* (PNPC) (1991). Through these programmes, Conacyt seeks to consolidate domestic training and research capacities. Figure 4 illustrates the interrelationship and role of these programmes concerning doctoral education in Mexico.

Figure 4 Doctoral training policies: actors and connections



The overall objective of these programmes is *"to increase and to consolidate a high-level human capital stock to perform research activities"* (Conacyt, 2014b, p. 22). As shown in Figure 4, Conacyt and HE&RIs are key in this array. Conacyt provides the financial resources, and HE&RIs act as performers of research and training activities. The industry sector has no direct participation in postgraduate education and S&T matters. The HE&RIs also participate in the implementation in these programmes, mainly in the review of applications of potential beneficiaries. For instance, they (researchers in HE&RIs) evaluate the applications of the potential doctoral students to be trained outside Mexico under the sponsorship of the Scholarship Programme. They also select the students that will undertake high-quality training in domestic courses. Ultimately, they evaluate the quality and productivity of the doctoral graduates that apply for membership to the National Researchers System.

The strong interrelation between these three is reflected in that the number of graduates sponsored by the Scholarship Programme and the PNPC that enter the NRS is an indication of the success of these programmes altogether – in 2018, 80% of the funded graduates were members of the NRS.

The following sections will provide a detailed description and analysis of the three programmes. It will show that two of these share a singular peculiarity; they were not the result of a planned process but rather fortuitous responses to structural issues in the research system. Next sections account of how these programmes came into place, what are the issues that they attempt to solve and assess the extent to which they shaped the doctoral system in Mexico.

3.3 THE NATIONAL RESEARCHERS SYSTEM (NRS): FROM A TEMPORARY MEASURE TO A LONGSTANDING POLICY

The review of the National Researchers System (NRS) and of the remaining two programmes addresses two dimensions, notably, the policy agenda and policy implementation. The policy agenda component looks at policy rationales, and the implementation component comprises the actions, resources, constraints and interactions among actors. This will allow for an examination of the policy thinking and the factors that enabled the functioning of the components of this research system.

3.3.1 Brief description

The National Researchers System (NRS) is a programme and a register comprising the most significant proportion of scientific personnel in Mexico. Since the year 2012, it also includes a proportion of the Mexican researchers living abroad. As a programme, it is a peer review assessment of the productivity and quality of the research outputs produced by its members, for whom it provides a tax-free monthly contribution. In January 2019, 3, 0721 members were members of this register.

3.3.2 *Origins of the NRS: fortuitousness and tensions between science and politics*

The NRS has its origin in the 1980s, notably on 26th July 1984[34], when the government implemented this as an emergency response to the effects that the economic crisis of 1982 had on the salaries of academics. Salaries had dropped by 60%, and academics started to leave the country. To alleviate this situation, the Mexican Academy of Science[35] presented to the government the proposal sustaining the NRS. The government approved the proposal the same day[36], but with a few changes. The haste of this decision was an indication of the critical state of academia in Mexico.

There were two contrasting views on the potential impact of NRS. The government saw it only as a temporary measure that would end when the country's economic situation would improve. Thus, this was not framed within a wider national policy, such as education or S&T[37]. Conversely, the academic community saw in NRS an overarching strategy for the advancement of domestic scientific research, in which doctoral training was at its core. The statements of Dr Pablo Rudomín, president of the Academy between 1981 and 1983, illustrate this:

> *"There are [some people] who will propose again that scientific research should be primarily at the service of economic activities. Or someone who would advocate for letting scientific research to finance itself, by adapting to the demands of the market (...) What should be clear is that one of the most important functions of scientific research in our country, if not the most important, is its contribution to the formation of highly trained human resources"* Pablo Rudomín (1995) in Canales (2011, p. 98)

[34] Some sources documented that the NRS had its origins in 1975 within the Academy of Science. The initial proposal was presented to the Ministry of Education and the President, but there was not a positive response from these. See Kent-Serna (2009).
[35] At that time called: Academy of Scientific Research.
[36] "and at one o'clock we had presented it (the NRS proposal) to the president; at 1:15, it was approved. (…) What had not happened for ten years occurred in less than an hour" (Vega y Leon, 2012, p. 12)
[37] In the initial proposal, academics recommended incorporating the NRS in the National Education Programme (Pronaes).

> *"(the NRS) brought the possibility of creating a research and training system, where researchers would prepare the future national researchers (…) The initial proposal envisioned, in addition to salary compensations and adequate funding for postgraduate students, infrastructure and facilities to conduct research, such as equipment and reagents, grants to facilitate the international mobility of national researchers, and to bring academics from abroad for academic stays"* Pablo Rudomín (1996) in Canales (2011, p. 98)

These quotations entail two things; first, the existing tensions in regards to what should be the mission of scientific research, and who should fund it. Secondly, that the development of science and technology was left to operate organically. These issues persisted in the policy thinking in Mexico in the following decades.

The initial proposal contemplated the Academy of Science as responsible for the implementation of the NRS. However, the government did not accept this formulation and commissioned its implementation to SEP[38]. The following factors could have influenced this decision:

1) The governance and bureaucratic structure of the educational and research system;
2) The fragmented relationship between HE&RIs and the government;
3) The perception that education, and S&T was different and separate domains with little or no connection;
4) The lack of trust of the government in the scientific community, where the main concern was that if the Academy of Science implemented the NRS, this would put at risk the government's authority and control over its functioning.

Thus, at the eyes of the government, SEP was the only reliable and financially capable institution to look after education matters.

[38] Through the Directorate General of Scientific Research and Academic Improvement

Later in that same year (1984), after SEP lobbied with high-level officials moving NRS to Conacyt, the government commissioned this to implement the NRS. The argument for this change was that the NRS was an instrument for researchers, not for education, and its implementation was within the purview of Conacyt (Canales, 2011; Gil & Contreras, 2017) . The consequences of this decision, conscious or not, were not at all beneficial for S&T. This decision re-emphasised the lack of an articulated view concerning higher education and research. Secondly, it meant that Conacyt was now responsible for financing the NRS, which had considerable impact on its finances. While for SEP this expense represented less than 0.1% of its budget, Conacyt had to put aside more than 40% of its already reduced resources (Vega y Leon, 2012).

Conacyt established the NRS as a merit-based incentive with the following features:

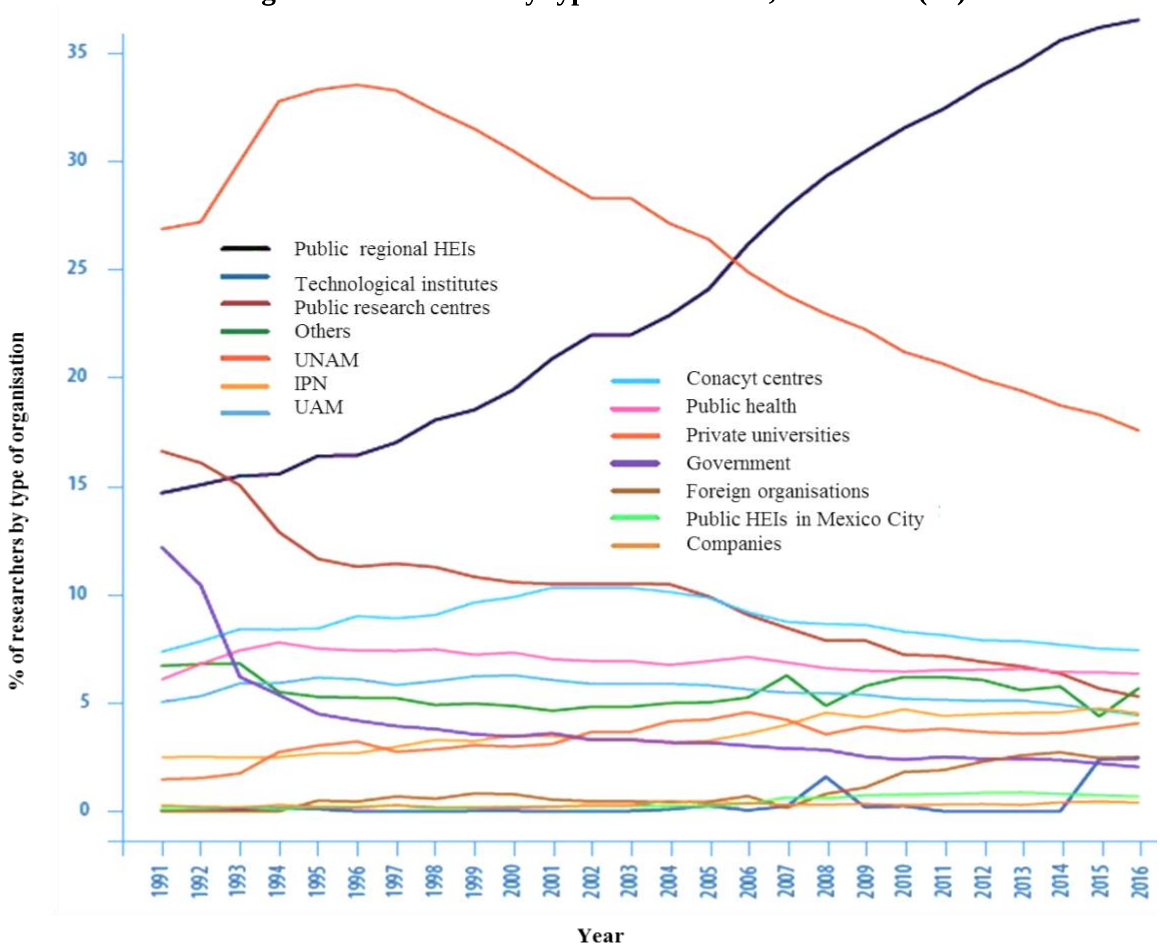
- **Tax-free salary supplement.** NRS was a financial subsidy, not a generalised increase in salary, that was exempt from taxes and not subject to trade union negotiations.
- **Transitional.** NRS was a temporary emergency measure to prevent the exodus of national academics.
- **Peer-reviewed.** Researchers evaluated the performance of full-time academics in public HE&RIs.

In its first call, the NRS received 3,118 applications of which 1,650 were successful.

3.3.3 The NRS today

Although the NRS was an emergency measure and not planned, it became one of the most important instruments for science and technology policy in Mexico. It is the second most important S&T programme, just after the Scholarship Programme. In 2018, the NRS accounted for 25% of Conacyt's annual budget. Every year, approximately 640 new researchers from all public and private research organisations become members. Figure 5 illustrates the evolution of membership in NRS by type of institution[39] during 1991-2016.

Figure 5 Researchers by type of institution, 1991-2016 (%)



Source: Rodríguez (2016)

[39] Place of work of researchers.

3.3.3.1 Objectives

The NRS promotes the quality of scientific, technological research and innovation in Mexico, "it furthers the improvement of national researchers' expertise in state-of-the-art knowledge and technologies" (CONACYT, 2019) [40].

3.3.3.2 Financial incentives and prestige

In addition to the pecuniary incentives, NRS is a *de facto* source of prestige and differentiation in the national S&T community. The financial compensations can be as much as 30% to 60% of the monthly salary of academics [41], while prestige symbolises respect in the domestic academic community. To illustrate the contribution of NRS into academic salaries, an example was constructed using the real salaries in 2018 for a large university [42] in Mexico City. This example involved a full-time researcher that was a level II member in NRS, with a monthly salary of $1,537 USD. After applying the NRS incentive, this salary turned into a final compensation of $6,220 USD. Thus, NRS can increase academic salaries in about 75%.

Being an NRS member denotes recognition and status for both researchers and HE&RIs. Academic positions, permanent or temporary, require applicants to be members. Some institutions hire newly graduated doctoral students, who must be less than 37 years old, with the condition that they will become members of NRS during the first two years of employment. If this does not happen, the employer will not renew their contracts.

[40] Retrieved March 4, 2018, from https://www.conacyt.gob.mx/index.php/el-conacyt/sistema-nacional-de-investigadores

[41] There is no consistent information on salaries for researchers in Mexico. Salaries vary according to the size, age, financial authority (federal or regional) of HEI&Rs –regional universities have the lowest levels in terms of salaries, internal subsidies and union agreements.

[42] In this university, salaries for a part-time lecturer vary around $520 and $829 USD per month. For a full-time researcher, salaries are around $1,120 and $1,537 USD.

3.3.3.3 Membership and reviews

NRS membership defines career opportunities for national researchers; if a researcher is not a member, he/she is unlikely to obtain a research position, he/she will not be eligible to apply for competitive funds, and will not be invited to advise or review in S&T projects. HE&RIs can employ no-NRS-members as part-time lecturers on zero-hours contracts and for administrative positions. CVs can illustrate the relevance of membership; in this, the category of membership is the next most crucial information, just after personal details.

Domestic doctoral students are expected to meet the criteria for membership before graduation, and apply for membership immediately as they receive their degree. Once a member, the next goal is to move upwards in the NRS hierarchy.

3.3.3.3.1 Entrance and promotion

The general criteria to become a member include:

1) To hold a doctoral degree;
2) To conduct research activities in a public or private national research institution, abroad or any other public or private institution[43];
3) To have a demonstrable record of research outputs, particularly publications in research journals.

In order to move upwards in the system, members are required to prove their contributions to knowledge[44], i.e. a strong record of internationally leading research, a proven track record of successfully supervising postgraduate students and prove of

[43]As of 1989, researchers working for the private sector (HEIs and companies) can apply for membership.
[44] Publications have different weights depending on whether published in national or international outlets. Books, reports and conference proceedings also have a different weight. Reviewing committees decide on these weights discretionally.

academic leadership. Table 8 shows, in descending order, the elements considered for promotion.

Table 8 NRS promotion criteria

Products	Main elements
Research outputs	• Articles • Specialised scholarly books • Book chapters • Citations • Patents • Technology transfer
Training new researchers	• Thesis supervision (doctoral supervisions are the most valued) • Teaching at university level (postgraduate level is more valued) • Graduated PhDs members of NRS
Leadership and institutional development	• Creation and/or consolidation of new research lines • Contributions to the development and consolidation of domestic postgraduate courses • Track record of successful funds/grants applications • Membership in editorial science and technological boards • Review of national and international journals • A registered reviewer in Conacyt's registry (RCA), i.e. can evaluate: applications for funds, scholarships, NRS, PNPC, innovation competitive funds, technology projects, etc. • International mobility and participation in national and international research projects
Public engagement and other activities	• Paid evaluations and projects for national and international bodies • Events or publications to promote public awareness of S&T • Conference and seminars • Collaborations with industries

Source: NRS guidelines, 2017[45]

Membership is divided into two hierarchical categories: 1) candidates, and 2) national researcher. This last category is subdivided into level I, II and III. The academics that

[45] https://www.conacyt.gob.mx/index.php/el-conacyt/sistema-nacional-de-investigadores/marco-legal/reglamento-sni/13493-reglamento-sni/file

have maintained their membership at level III -the highest level for 15 years and are 65 or more years old are awarded the category of *emeritus* for life.

3.3.4 Challenges

One of the most significant benefits from the NRS into the Mexican research system is the increased availability of high-quality personnel in the postgraduate courses registered in the PNCP. The success membership rate for those that graduated from courses in the PNPC is 80%. However, one of the most visible challenges that arise from the NRS is its 'inbreeding', that is *"a system devoted to the advancement of knowledge that only serves itself"* (Alcantara et al., 2008a, p. 7). This effect can be the result of the obvious interest of academics in the functioning of NRS, and of the short-term vision in S&T policy that did not foster its adaptation to the current pressures in science and technology.

Other challenges include the dependence of academics on the financial incentive. This is because the salaries for academics have not experienced significant increases; these vary according to the annual adjustments to inflation or due to union negotiations. Additionally, HE&RIs have become dependent upon the financial benefits of NRS. They can also increase their income through the number of their NRS members in the PNPC[46], and other competitive funds operated by Conacyt that value membership highly.

Another challenge relates to the concentration of incentives in senior researchers, which in combination with the financial dependence translates into scarce available positions and resources for early career researchers. Some 75% of academics in HE&RIs are 65 or older, but the NRS does not consider differentiated incentives for

[46] The quantity and level of researchers in the NRS are evaluation criteria that determine the category of 'quality' given by reviewers to the postgraduate programmes registered by HEIs in the PNPC The quality of these programmes has a direct effect on the resources that HEIs can receive from Conacyt to attend academic events, laboratory expenses and academic stays.

early career researchers, who are predominantly situated in the candidate and level I. These levels represent the largest portion of members (76.4%) in NRS.

It is possible to say that NRS has been crucial in the consolidation of the research profession in Mexico. However, it had produced other rather unwanted effects, such as financial dependence and no real improvements in academic salaries. Also, the concentration of benefits on senior academics and scarce opportunities for early career researchers.

3.4 THE EXCELLENCE POSTGRADUATE PROGRAMME (PNPC): THE BEDROCK FOR QUALITY DOCTORAL TRAINING

3.4.1 Background

In the 1990s, the consequences of the deregulated expansion of postgraduate courses became tangible. First, in the heterogeneous quality in the existing training offer, and secondly, in the low availability of courses in S&T fields, particularly at the doctoral level (Acosta, 2014; Rodríguez, 2000). In this period, doctoral courses in social sciences accounted for 45% of the total enrolment, while those in the natural and exact sciences represented 23%. These issues and the presence of international evaluations led policymakers to reflect on how far behind Mexico was in regards to the development of competitive scientific capabilities. The most significant concern was that the reduced size of the S&T community would affect the capacity of HE&RIs to train the engineers and researchers that would facilitate Mexico’s transition to an innovative economy (Conacyt, 1983; OECD, 2008b).

In response to this situation, the Ministry of Education (SEP) implemented the *Programme for Upgrading Higher Education Academic Staff* (1994), later replaced with the *Plan for Upgrading Academics at Higher Education Institutions* (Promep) (1996). Both of these programmes aimed to increase the number of qualified personnel in higher education institutions. In the same period, Conacyt implemented the Excellence Postgraduate Programme (EPP, later called PNPC).

The significance of EPP resided in that this was the result of a reflexive policy process, in contrast to the NRS that was an externally stimulated event. The EPP was a turning point from the previous policy reasoning characterised by transient responses to structural issues. Moreover, for Conacyt, EPP represented the opportunity to affect the higher education system directly; it was no longer only an advisor.

EPP was set to incentivise the development of internationally competitive postgraduate courses in domestic HE&RIs. It functioned as a competitive funding scheme and as a register that listed the courses that passed a rigorous evaluation process, designed by Conacyt, HE&RIs, national and international experts on higher education. Conacyt coordinated the evaluation process, and members of the NRS acted as reviewers of a set of standards of excellence, such as the qualifications of academics, their scientific productivity, and the rigour of the admission process, among others.

Conacyt offered additional financial support to the HE&RIs that successfully passed the evaluations. These funds were set to enhance the research infrastructure and to foster the participation of academics and students in national and international academic events. At the individual level, Conacyt granted scholarships to the students admitted in the domestic postgraduate courses through the Scholarships Programme. Before EPP, Conacyt had been granting scholarships for masters, and doctoral courses to any student enrolled in HE&RIs, without any mechanism to ensure the quality of training and the efficient use of public money. Thus, with the creation of EPP, Conacyt brought together the Scholarship Programme and NRS in a coordinated initiative that would foster the advancement of the research system.

3.4.2 Towards a coordinated postgraduate training policy: The Programme for Strengthening National Graduate Studies (PFPN)

As a result of the actions that, separately, Conacyt and SEP started in the 1990s, the number of academics increased from 12,500 to 21,600 in a decade. Also, the enrolment in doctoral courses increased from 3% to 7.1% of the total enrolment in postgraduate courses. See Table 9.

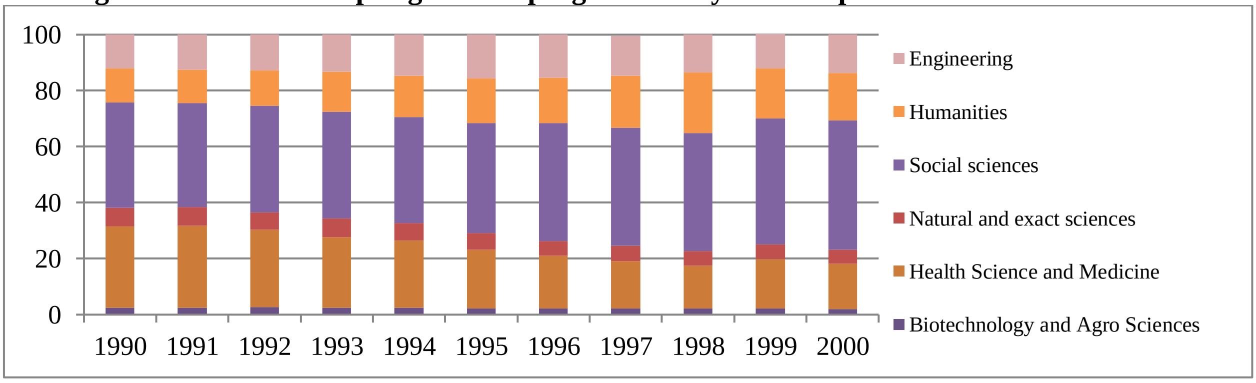
Table 9 Enrolment in graduate education by levels of study 1990-2000

Year	Enrolment total	Doctor%	Masters %	Specialisations %
1990	43,965	3.0	61.2	35.6
1995	65,615	6.8	64.5	28.5
2000	118,099	7.1	69.6	23.2

Source: Aupetit & Jaramillo de Escobar (2014); Luchilo (2010); Yevgeny & Dahlman (2008)

However, these results contrasted with the number of courses that had successfully met the quality criteria in the EPP. Only 500 of the 25,000 postgraduate courses offered in Mexico were in the register. This meant that 98% of the total postgraduate offer could not guarantee quality standards in their courses. In addition to this, the enrolment in S&T courses was very low. For instance, in 2000, social sciences courses represented 47% of enrolments, followed by humanities (17%), health sciences (16%), engineering (14%), and natural and exact sciences (5%). See Figure 6.

Figure 6 Enrolment in postgraduate programmes by area of specialisation %



Source: ANUIES (2003)[47]

Possible explanations for this were, first, that the offer of S&T courses was still small to guarantee access to the population completing undergraduate training. Secondly, this offer was still concentrated in the Metropolitan area. This situation raised

[47] http://publicaciones.anuies.mx/acervo/revsup/res124/txt6.htm

questions in the government about the efficient use of the resources employed by Conacyt to consolidate the S&T training system (Casanova-Cardiel, 2007; Rodríguez, 1999).

In addition to this, the International Monetary Fund and the World Bank stressed the urgency for Mexico to establish adequate measures to expand its scientific workforce. Their recommendations emphasised the need for consistent and coordinated actions between HE&RIs, Conacyt and SEP (Conacyt, 1990). The concern here was that the Mexican society would experience the adverse effects on their living and working conditions should it fail to address this issue (Brunner et al., 2008).

Consequently, the new challenge, in addition to those mentioned above, was to articulate efforts with the relevant actors. Correspondingly, the *National Plan for Education* (Pronae) (2001-2006) by SEP and the *Special Programme for Science and Technology* (Peciti) (2001-2006) by Conacyt shared, for the first time, as a common goal the advancement of postgraduate education. Table 10 summarises the issues and coordinated actions in Pronae and Peciti.

Table 10 Pronaes and Peciti (2001-2006): aims and planned actions

Pronae 2001-2006 & Peciti 2001-2006	
Issues	-Unbalanced quality among national postgraduate studies -Uneven qualifications among academics in HE&RIs -Concentration of postgraduate studies available in the Metropolitan area -Insufficient availability of doctoral studies -Insufficient capacity of HE&RIs to produce scientific and innovative activities
Aims	-Increase the proportion of the population with postgraduate training -Increase the availability of studies across the country, paying particular attention to the development of those offered outside the Metropolitan area (regionalisation of postgraduate studies) -Improve the quality of postgraduate studies offered by HE&RIs -Improve the infrastructure and resources for S&T in HE&RIs -Further the advancement of the national postgraduate training system in coordination with the national S&T system
Actions	-Work in coordination (Conacyt and the Ministry of Education) to: -Design instruments and mechanisms to increase quality in postgraduate training in HE&RIs -Design and implement the Programme for Strengthening National Graduate Studies (PFPN)

Source: based on Conacyt (Conacyt, 2002) and SEP (2001)

Conacyt and SEP restructured EPP, previously led by Conacyt alone, and formulated the *Programme for Strengthening National Graduate Studies* (PFPN). This was an improved version of EPP and a funding scheme linked to quality in postgraduate training. PFPN considered the improvement of doctoral education as the enabler of a solid scientific base that would train the future generations of researchers, would provide solutions to national problems and position Mexican science globally (Brunner et al., 2008).

Conacyt implemented the PFPN between 2002 and 2006, and it incorporated two instruments: the *National Postgraduate Programme* (PNP) and the *Integrated Programme to Promote Postgraduate Studies* (Pifop). PNP replaced the EPP and operated under a similar logic, i.e. to evaluate and to register domestic postgraduate courses according to the quality of their research and training activities. However, unlike EPP, the courses in this register had to prove high-performance standards through international quality publications and research collaboration. Accordingly, the best indicator of the progress would be the research outputs of the academic personnel, who were required to be members in NRS (Conacyt, 2002). The PNP categorised the courses as 1) internationally competitive, 2) high-level and 3) excellence programmes.

In parallel to PNP, Conacyt implemented Pifop; a temporal and direct funding instrument for the courses that had shown ‘potential’ to meet the established quality standards, and which had formally committed to improve their performance by 2006. Pifop’s most significant outcome was that it enabled the consolidation of postgraduate education at the regional level, and by 2005, HE&RIs in 30 of the 32 Mexican states were active participants in this programme. However, the best training courses in terms of resources and research tradition, were still concentrated in Mexico City in the largest universities.

After five years of implementation of these programmes, there were 772 courses in PFPN: 340 in PNP and 382 in Pifop. The majority of courses in PNP were in physics, mathematics and earth sciences (61), followed by health sciences (50) biology and chemistry (40). In Pifop, most courses were in the areas of engineering (118) and social sciences (72).

In summary, PNP and Pifop were essential in the transformation of doctoral education in Mexico. On the one hand, PNP addressed the international component in postgraduate education, while Pifop promoted the regionalisation of the postgraduate education offer. Furthermore, as the first policy jointly designed by Conacyt and SEP, PFPN signalled the intention to transform the domestic research system.

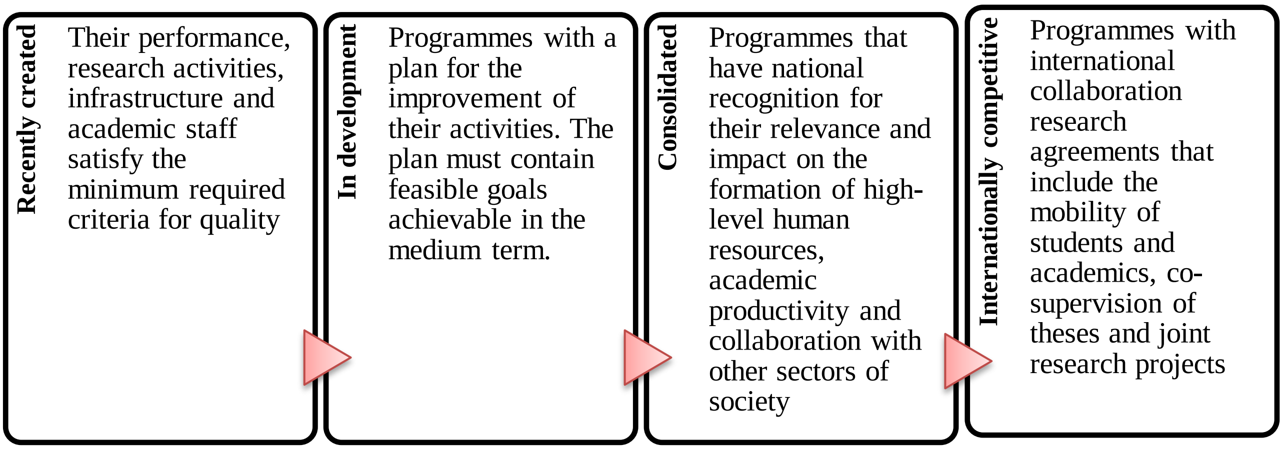
3.4.3 Consolidation of domestic postgraduate training: the National Quality Postgraduate Programme (PNPC)

In 2007 Conacyt replaced the PFPN with the *National Quality Postgraduate Programme* (PNPC), this was a planned decision that aimed to "promote the continuous improvement and assurance of quality in the national postgraduate courses, for this will further national scientific, technological and innovation capabilities" (Conacyt, 2008, p. 108).

PNPC operates at three levels; macro (HE&RIs), organisational (research groups) and individual (postgraduate students). At the macro level, it offers additional financial resources to the HE&RIs with successful evaluation outcomes. At the organisational level, academics can access grants to undertake postdoctoral studies in foreign universities, for short academic stays and sabbatical years in national and foreign HE&RIs. Conacyt allocates these resources through the instrument named "Funds for the Consolidation of Research Groups." At the individual level, the students admitted to the courses registered in the PNCP receive rigorous training and a scholarship that covers tuition fees, living stipends, and health services. They can also access funds to attend courses, undertake research visits and specialised training in other national and/or international HE&RIs.

Conacyt and SEP coordinate the assessment of the courses in PNPC, and consists of three stages: ex-ante assessment, external and ex-post evaluations. The first consists of a self-assessment, and the second two are conducted by peer-review committees composed by academics and professionals in higher education quality (Conacyt & SEP, 2016). The courses accepted in the PNPC are allocated to one of four categories: 1) emerging or newly created; 2) in development; 3) consolidated, and 4) internationally competitive. The latter being the highest distinction. These categories also represent the development stages of the postgraduate courses. See Figure 7.

Figure 7 The four categories/stages of the programmes in the PNPC



Source: based on Conacyt's website[48]

The assessment principles are: 1) credentials and the quality of academics collaborating in the courses, and measured through their membership in NRS; 2) rigorous admission processes to select the best postgraduate students; and 3) adequate teaching and research infrastructure.

3.4.4 New components of the PNPC

The reformulation of PNPC in 2007 consisted of coordinated work from Conacyt and SEP with the support of national and international experts in postgraduate education. This exercise was carried out to expand the model of quality assurance beyond research-oriented programmes (Conacyt, 2016a). Currently, PNPC comprises the three following components: 1) the assurance of quality in research and postgraduate training, 2) academia-industry linkages, and 3) the internationalisation of postgraduate

[48] https://www.conacyt.gob.mx/index.php/becas-y-posgrados/programa-nacional-de-posgrados-de-calidad

training. With these, Conacyt and SEP seek to alleviate some of the persistent issues in the postgraduate training system. For instance, the preceding initiatives focused on full-time research-programmes, leaving professional and part-time postgraduate courses unaddressed. This may explain the lack of personnel with advanced science and technological qualifications in industry, and may explain, to some extent, the strong orientation towards basic science research in HE&RIs.

Thus, in 2011, Conacyt established a new modality covering distance-learning postgraduate studies, which provides professionals with a balanced-mix of research and generic skills (Conacyt, 2012a; FCCYT, 2008). Students are expected to capitalise on their training by addressing current problems in their workplace. Also, in 2012, Conacyt introduced further modalities, such as specialisations for the health sector "Especialidades Médicas" and the collaborative postgraduate programmes with industry "Posgrados con la Industria". These programmes aim to incentivise HE&RIs to diversify their training offer and to create knowledge-transfer links between these and the productive sectors (Conacyt & SEP, 2016).

In 2011, 73% of the courses in PNPC (1,322) were research-oriented, and in 2018 , these represented 64% (from 2,296). In 2013 only 15 collaborative programmes with industry were in the registry, and by 2018 these had increased over twofold (34). In 2018 PNPC represented 21% of the total offer for postgraduate training [49] of which 1,235 (54%) are master's, 658 (29%) doctoral courses, and 403 are specialisations (18%). See Table 11

[49] There are, in Mexico 10,737 postgraduate programmes, 7,780 for master's level, 1,905 specialisations and 1,051 for doctoral training. The PNPC comprises 21% of the total offer of postgraduate studies in Mexico. 62% in doctoral studies, 21% in specialities and 16% in masters studies.

Table 11 PNPC: Research oriented and professional courses, 2018

Research oriented programmes				Professional postgraduate programmes				
	Masters	**PhD**	**Sub-total**	**Masters**	**PhD**	**Specialisation**	**Sub-total**	**Total**
Total	815	650	1465	420	8	403	831	2296
Full-time	811	647	1458	377	6	121	504	1962
Medical specialisations	0	0	0	0	0	277	277	277
Distance learning	1		1	19	1	2	22	23
Collaborative programmes with industry	3	3	6	24	1	3	28	34
Total	815	650	1465	420	8	403	831	2,296

Source: based on the PNPC's website[50]

In addition to this, PNPC embraced the internationalisation of research as a standard of quality in postgraduate education, which also serves as a reference for better practices in scientific research and seeks to increase the participation of Mexico in international scientific networks (Conacyt & SEP, 2015).

Notably, in the evolution of the doctoral training system in Mexico, internationalisation signifies the results of a sustained and directed intervention that began in the 1990s with the Excellence Programme. It also indicates that not all HE&RIs responded to the incentives and pressures signalled in this initiative, and after a decade of existence, the vast majority of doctoral courses could not guarantee the quality standard criteria (Conacyt, 2002, 2014b). In 2001, only 15.29% of the total offer of doctoral courses met the criteria stipulated in the PNPC. In 2004, only 34 courses were in the international category, but in 2018, these had increased to 245 (10% of the total PNPC). However, the availability of doctoral courses in this category

[50] http://svrtmp.main.conacyt.mx/ConsultasPNPC/padron-pnpc.php, consulted on 05 February 2019

is still small, with 89 courses in natural, exact sciences and engineering (49%), followed by social science (18%).

In summary, the PNPC is the result of policy collaboration between the education authorities and the S&T authorities, which was crucial in setting the basis for quality and excellence in the Mexican doctoral training system. Moreover, it indicates that hierarchical policy arrangements, where S&T and education are seen as two separate policy domains can limit the advancement of research capacities.
The following section describes the policy evaluation practices in the S&T domain in Mexico.

3.5 EVALUATION PRACTICES AND POLICY LEARNING OF THE DOCTORAL TRAINING SYSTEM IN MEXICO

As mentioned above, the doctoral training system in Mexico, which is a close representation of its research system, as it embodies the production of scientific knowledge and training of new researchers, has evolved through a set of uncoordinated and unplanned policy reactions.

In Mexico, the evaluation of science and technology matters started in the 1980s when, as a reaction to the debt crisis, the government commissioned Conacyt to introduce evaluations in its activities and programmes. The rationale behind this interest for evaluation of S&T was to ensure that the reduced budget resulting from the crisis would be used efficiently; i.e. to produce more with fewer resources (Dutrénit et al., 2008). Conacyt was also instructed to allocate more financial resources to scientific research activities and the formation of human resources in S&T. At that time, the core programme operated by Conacyt was the Scholarship Programme, and the relevant indicators for 'efficiency' were the capacity of Conacyt to allocate its annual budget fully and an increase in the number of beneficiaries.

The Adjunct Directorate for Planning and Evaluation is the unit responsible for monitoring each programme funded by Conacyt. The goal of the directorate is to guarantee the efficient use of Conacyt's budget; which translates into making sure that the budget is used in its entirety. The directorate uses the results matrix as a central monitoring tool, where each unit reports activities, resources and results. Each year, with the information collected through the results matrix, Conacyt publishes a report of activities that consists of an audit type accountability summary that contains a description of each programme, its annual goals and budget, and quantifiable outcomes that are presented in the form of variations in the number of beneficiaries each year.

In 1994, OECD led the first external evaluation of Mexico's research system (Castaños-Lomnitz, 2004). Ever since, OECD has played a significant role in the promotion of policy evaluation in Mexico; both as an evaluator and by providing guidelines as to what to evaluate.

Since this first evaluation, overall evaluations of the structure and functioning of Mexico's research system have been carried by the same body, other international bodies and by the Advisory Forum[51], the agency responsible for providing advice to Conacyt policymakers. See for instance: "OECD Reviews of Innovation Policy: Mexico" (OECD, 2009c); "RIO Country Report 2015: Mexico" (EC, 2016); Diagnostic of STI policy in Mexico, 2000-2006 (better known as the Green Book) (FCCYT, 2006b), "Knowledge and Innovation in Mexico: Towards a State Policy for the National Development Plan and the Special Programme 2006-2012, (FCCYT, 2006a) and "Proposals to the design of the PECITI 2012-2037. Meta-evaluation of the Special Program of Science, Technology and Innovation (PECITI 2008-2012)" (FCCYT, 2013). These evaluations inform the design of the national S&T policy Programme, notably, PECITI. A characteristic of these evaluation exercises is that these were framed under the OECD policy model that focuses on countries' capacity

[51] This Forum was established, as a result of a direct order from President Vicente Fox on June the 5th 2002, as an independent entity that would advise Conacyt and the President in STI matters. The head of the Forum is appointed by the President, and it is mostly constituted by scientists, some technologists and a few entrepreneurs (Casas et al., 2000; Corona et al., 2013).

to produce knowledge and technologies, in the demand of knowledge by local actors (Dutrénit et al., 2008; Sanz, 2007).

Since its creation, the Advisory Forum has engaged in the design and evaluation of PECITI. However, it is important to emphasise that although in principle, this agency is independent of Conacyt, its financial resources for operation and evaluation activities come entirely from Conacyt. Thus, the role of the Forum in scrutinising relevant issues in S&T is unquestionable, but it is not possible to claim particular changes in the policymaking arena as a result of its role in this system. It is necessary to analyse its influence in the national policymaking against possible conflicts of interests that may exist due to its financial dependency.

At the programme level, the Forum has also led several assessments, such as the "Historical evolution of the National System of Researchers, 20 years after its creation" (FCCYT, 2005); "Impact evaluation of the training program for scientists and technologists 1997-2006" (FCCYT, 2008), and "The National System of Researchers in numbers" (FCCYT, 2016). Conacyt has also coordinated the evaluation of its programmes, hiring consultants and academics to conduct the assessments. These evaluations are: "1971-2000, thirty years of the Scholarship-Credit Program: Evolution, results and impact" by Ortega, et al. (2001) and "Highly skilled Mexican migration: elements for a National Science and Technology Policy" by Delgado-Wise, et al. (2015)[52]

The common characteristic of the programme evaluations is that these are the majority descriptive by nature. They focus on the increases or decreases of budgetary resources and the number of beneficiaries. There are no transversal evaluations encompassing

[52] This exercise was coordinated by Conacyt and funded by this body and by UNESCO through the Management of Social Transformations (MOST) Programme, which aims to improve connections between knowledge and action.

the key programmes for the formation of advanced research skills, namely the scholarship programme, the NRS and PNPC. Moreover, there are rarely any visible changes in these programmes as a consequence of the results of evaluations (Yevgeny & Dahlman, 2008). Throughout the existence of these programmes, changes have corresponded to budget reductions.

In summary, the evaluation of culture and practice of S&T policy in Mexico can be better described as emergent – formal evaluation, beyond audit and accountability reports, is not systematic, sustained (conducted consistently through time) and rigorous.

3.6 SUMMARY

This chapter has primarily focused on the evolution of the doctoral training system in Mexico. It highlighted that this system was the result of policy inertia, characterised by transient responses to external events and linked to technological and economic development. Also, this chapter has outlined the most significant events and decisions that shaped this system, which emerged through a separate treatment of education and S&T matters. In the process of modernisation in Mexico, which marked the beginning of a research system, S&T was neglected by policymakers, and this reflected in the inadequate financial capacity of Conacyt to address the structural issues whitin the research system. The policy approach of this period signals the narrow agenda or conviction on the benefits that science could provide. Because of the inertia and uncoordinated efforts that followed, the research system, and in consequence the doctoral system, developed organically and lacked the elements to become a system that could compete globally.

The origins of doctoral training in Mexico were driven by a linear policy approach, centred on increasing the supply of skills and with an expectation that the industrial sectors would absorb them. Conacyt played a crucial role in shaping this system and has managed to remain relevant despite its lack of authority and resources.

This chapter has offered a review of the three components of this research system and outlined the context and rationales that gave rise to the implementation of these components. The review illustrates that these components, notably, NRS and PNPC, although having different origins, are deeply interconnected. NRS was a fortuitous-temporary-measure to alleviate the effects of the economic crisis of 1982 in the salaries of academics, while PNPC, and its preceding initiatives, were planned actions. PNPC became a *de facto* policy for S&T, and NRS secures high-quality research outputs and supports the academic profession in Mexico through pecuniary incentives and prestige. The institutionalisation of quality criteria translated into changes in the hiring practices in HE&RIs, which require research personnel to be members of NRS.

In summary, this chapter illustrated that S&T policy in Mexico evolved slowly, often contradicting the economic and technological ambitions with constant budgetary reductions. However, an important difference, and potential advantage, between the policies of the initial decades and the current policy is that policymakers have accumulated learning experiences and seem to be shifting towards a coordinated policy agenda. Ultimately, the chapter has provided a brief review of the policy evaluation practices in S&T programmes in Mexico.

The next chapter examines in detail the Scholarships Programme, the third constituent of the doctoral system.

CHAPTER 4 THE POSTGRADUATE SCHOLARSHIPS: CHARACTERISATION OF THE MODALITY FOR DOCTORAL TRAINING ABROAD

4.1 INTRODUCTION

This chapter examines the Scholarship Programme, the oldest and third component of the doctoral system (see section 3.2.3 in the previous chapter). The relevance of the Scholarship Programme in this thesis resides in that although it has operated for over four decades, its effects are not well understood. The Scholarship Programme is the most important source of funds for doctoral training abroad; there is not a similar strategy, and is the first S&T policy initiative in Mexico. This Programme offers direct funds to Mexican citizens to pursue doctoral courses in the best universities outside Mexico. It is expected that this international experience will yield a wide range of benefits for its beneficiaries and for the domestic research system.

This chapter aims to identify the rationale in the Scholarship Programme, the actors involved in its design and implementation, and the resources set aside for its operation. It will review in-depth this programme within its modality of doctoral training abroad. In general, this chapter will provide a basis to explain the change in the targeted actors and domestic research in Mexico due to the policy arrangements in the programme, and in particular, it will provide concrete empirical evidence about this programme and its effects on the fellowship holders and its potential employers.

This chapter is organised as follows. Section 4.2 presents a general description of the Scholarship Programme, focusing on its rationale, the context that surrounded its creation, its evolution in three stages, and offers an overall assessment of this Programme. Section 4.3 offers a review of the modality for doctoral training abroad. This section presents the functioning of this modality and the policy logic that governs its implementation. Section 4.4 summarises and concludes.

4.2 THE SCHOLARSHIP PROGRAMME

4.2.1 Background

Conacyt established the Scholarship Programme in 1971, and has justified its existence through the national policy interests that have dominated the evolution of the research system. For instance, the origins of the programme were motivated by the need to increase the research base in domestic HE&RIs and to promote the acquisition of technical skills among nationals. In the subsequent two decades, its existence was underpinned by the necessity to foster change in the national research system by improving domestic research capacities and innovation. Ultimately, in the past two decades, Conacyt has oriented the Programme towards the consolidation of the national doctoral training system, by offering to nationals the opportunity to undertake the courses that are still emerging in Mexico. Regardless of its different rationales over the years, this programme is invariably the most critical intervention in the development of scientific capacities in Mexico (Castaños-Lomnitz, 2003; Conacyt, 2001).

The Programme was set out to address the lack of skills for scientific development and innovation. To achieve this, it offers direct funds to postgraduate students willing to pursue high quality training. The programme operates through two modalities: 1) scholarships for domestic courses[53], and 2) scholarships for training abroad. This chapter focuses on this modality.

The Scholarship Programme is a central priority in Conacyt with 51.43% of the total budget for S&T. Mexico has been sending nationals abroad through this Programme expecting that these nationals would return and would transfer the benefits of international mobility into the research sector.

[53] In this modality, the programme also grants scholarships to non-nationals students.

4.2.2 *The first four decades of implementation*

Just as the constructions of the doctoral training system occurred in three stages (see chapter 3), the evolution of the Scholarship Programme can be examined through similar phases, which are: 1) expansion (1971-1981); 2) surviving the economic crisis (1982-1991), and 3) focus on domestic postgraduate courses (1991-present).

4.2.2.1 First phase: hands-off expansion

In its first years of operation, the Programme aimed to enhance the credentials of academics in HE&RIs and was directed at academic staff only. The reason for this was that most academics lacked the adequate qualifications to conduct scientific research and postgraduate training activities. See section 3.2.3.3 in the previous chapter. This means that the opportunities offered by the Programme were not fully available for the students that were every year graduating from undergraduate and masters domestic courses. In this phase, Conacyt had not yet established evaluation criteria or specific priorities, and the allocation of fellowships was entirely at its discretion.

The actors involved in this phase of the Programme were Conacyt, which provided the funding for the postgraduate fellowships, the HE&RIs interested in sending their staff to acquire further qualifications, and the academics receiving this grant. The programme sponsored a wide range of specialisations, from masters, short technical specialisations, language training, and doctoral courses to a lesser extent (Conacyt, 2001).

In 1974, Conacyt shifted the Programme to a loan-type scheme in order to incentivise fellowship holders to pursue a career in academia after graduation. Domestic HE&RIs embraced this scheme motivated by the belief that public funds needed to contribute to the development of the public sector. Henceforth, Conacyt operated this Programme influenced by the expectation that graduates would enter academia and would alleviate the research and doctoral training skills shortage. Under the new scheme, Conacyt exempted the graduated fellowship holders that returned to work in HE&RIs from repaying the loan. Those that underwent a career in the public sector, but outside academia had to repay 50% of the loan, 70% if they returned to work in the private sector, and those working for foreign companies had to pay the loan in full (Conacyt, 1976).

This decision may have been a signalled of the distance between S&T and industrial development, which unlike other industrialised nationals such as Germany and the United Kingdom, the Pogramme was exclusively designed to support S&T at public HE&RIs (Castaños-Lomnitz, 2003). However, this decision may have been influenced by the same governance arrangements that recognised S&T as the only domain of action in which Conacyt was allowed to intervene.

Between 1972 and 1980, the programme represented 51% of Conacyt's total budget (Conacyt, 1976), and had an annual growth rate of 41.6%, with 580 in 1971 to 2, 235 funded applicants. From these, 60% were for master's courses, 20% doctoral courses and 20% other types of training. The expansion of the programme also came with negative consequences associated to the lack of quality evaluation mechanisms; Conacyt ran the programme under the logic that as the resources for the programme grew, more fellowships had to be allocated, and that this would ultimately deliver positive effects.

In some cases, this meant applying less rigorous selection criteria and granting funds to any field of specialisation regardless of its connection to national S&T needs. Conacyt had no quality assurance mechanisms to guarantee that the beneficiaries would attend the best courses in the best HE&RIs, or that they would complete their training. As a consequence of this hands-off approach, the number of fellowship holders in S&T courses was small in comparison to those pursuing courses in social sciences, and in some cases, completion periods extended to seven years (Conacyt, 2005a). In addition to this, Conacyt had no legal and administrative capacity to claim and follow the payment of the loans (Canales, 2011).

On the positive side, the programme supported the expansion of higher education in Mexico by improving the skills of the academics and scientists that would teach in the new public and private HE&RIs, which consolidated the supply-oriented policy logic in the programme (Conacyt, 1983; Ortega et al., 2001).

4.2.2.2 Second phase: crisis

The programme survived the economic crisis, but its budget was reduced by 50%, and Conacyt directed the available resources to the researchers in NRS. Previous to the crisis, Conacyt granted around 4,000 scholarships each year, while in 1983, it only granted 2,710. Academic personnel were given priority for receiving the funds (Ortega et al., 2001; Valenti & Del Castillo, 2000).

The crisis marked the start of a new phase in the implementation of the programme. Conacyt, prompted by budget restrictions, introduced some changes, including:

- Performance accountability measures: fellowship holders had to inform Conacyt on the progress of their studies. If they failed to do so, Conacyt would stop paying the living stipend[54]. Also, Conacyt attempted to reduce the living stipend during official holiday periods, but it dropped this action after public demonstrations and pressure from the academic communities.
- The selection process for fellowships became formal and rigorous. This would focus on academic merits, and applicants had to prove the proficiency of the English language and of the language of the host country. This meant that Conacyt would no longer fund language courses.

The extent to which these measures were effective is not clear. This is because Conacyt was financially limited and understaffed, which affected its capacity to enact these courses of action as intended. In this regard, the assessment of the programme offered by Corona (2006a) suggests that these modifications corresponded to a widely adopted practice in public administrations for budgetary efficiency. While, Canales (2011) indicates that in reality, the programme operated with few changes. These accounts do not explain what changes were implemented and how these affected the overall functioning of the programme. It stands out from these two studies that the

[54] This measure remains current.

priority in this period was the NRS, which required most of Conacyt's resources, leaving few options for improving the Scholarship Programme. Moreover, it is possible to say that the adopted changes were basic attempts to optimise resources rather than concrete intentions to improve the impact of the programme.

4.2.2.3 Phase three: Towards the quality in domestic research training

This phase comprises the modifications undergone by the programme since 1991. In contrast to the previous two phases, here decisions show some degree of policy learning; the doctoral training system started to take a more consistent form, linked to other policies in the research system, notably, NRS and PNPC.

The national economic context was one of strong connections to international markets and of international evaluations carried out by international policy bodies, such as OECD. Mexico had adopted a culture of efficiency, and the measurement of results became a common practice in all public agencies. Accordingly, Conacyt expressed the need to produce evidence of the results of the programme in order to inform its design. Conacyt's concern was to guarantee that funds would be allocated through a transparent and consistent reviewing process, which related to the use of mechanisms to select the best candidates, who would attend the best courses as a guarantee of efficiency and the good use of public money.

In 2000, Conacyt commissioned an evaluation of the first thirty years of existence of the programme. In essence, the report "1971-2000, thirty years of the Scholarship Programme" comprises a description of the trends of the allocated grants, the courses, and preferred destinations. The most significant contribution of this report is a survey of 2,000[55] fellowship holders, which hints at several issues in the programme and its effects on the research system. Through this report, it became evident that Conacyt

[55] Estimates suggest that between 1971 and 1999, Conacyt granted 48,194 scholarships.

lacked information on the number of fellowship holders that returned and those that did not return. An important remark here is that before this report, Conacyt had no consistent data to trace the final destination of the beneficiaries, and their completion stage was also unknown (Castaños-Lomnitz, 2004).

The report estimated that the percentage of brain drain -nationals that did not return- was 10%; this result, however, was challenged by the still under-staffed research community, who suggested that the real percentage was higher than that reported. According to Arenas et al (2001), an estimated 65% of fellowship holders in the fields of S&T did not return. The United States was the preferred destination of fellowship holders to undertake training, and to stay after graduation. Their study also emphasised the empirical limitations, due to the lack of systematic data, which affected the capacity of their study to afford a comprehensive analysis on the impact of the Programme on career choices, career development, just to mention a few of the variables that could have been affected by the Programme at the individual level.

Another issue identified in the report was the small proportion of graduated fellowship holders that had successfully become members in NRS. When collating the names of members against those of the fellowship holders that had finalised their studies, it emerged that only 22% of the fellows were NRS members. Consequently, the domestic academic community and policymakers started to question the effectiveness of the Programme to produce the needed research capacities. The question that both sectors asked was: where were the remaining 78% of fellowship holders? However, Conacyt had no answer to this question. According to Castaños-Lomnitz (2004) and Canales (2011), although the Programme had been sponsoring postgraduate education for thirty years, this effort had not resulted in considerable growth in the NRS. These authors attributed this situation to the quality of the research skills in graduates, which may not have been up to the standards of the NRS[56], which prompted questions on the quality of the overseas courses selected by fellowship holders. Conversely, the lack of positions in academia, no-academic career paths, and migration could have also explained this.

This report prompted reflections about the factors hindering the programme's positive impact on domestic research. Accordingly, as part of this process of learning, the key concerns were about the cost of sending nationals abroad to study and on the imperative need to establish mechanisms to guarantee that public money would be used to train fellowship holders in the best training courses. In regards to the financial cost, Arenas et al (2001) estimated that sending a citizen to the USA for training required a minimum of USD 250,000. This was a considerable expenditure for the financial capacity of Conacyt, but the other alternative, to train nationals in domestic HE&RIs, was not a pertinent course of action because only a few domestic courses offered internationally competitive training in this period. In response to this, Conacyt started to operate the Programme in a more accountable and directed way, focusing on enhancing the quality of domestic doctoral courses.

In this phase, the modality of doctoral training abroad was justified for its potential to further the improvement of domestic courses and to offer national students the specialisations not available or in an emerging stage in Mexico. With this, Conacyt anticipated that nationals would engage in the state-of-the-art research topics, and would return to contribute to the consolidation of domestic postgraduate courses.

Other changes included that the Programme would prioritise S&T courses over social sciences courses and that in 2006, this abandoned the loan scheme and went back to functioning as direct grants in the form of scholarships.

[56] The graduated fellows that successfully entered the NRS had graduated from Stanford University, Cornell University, Berkeley, and Harvard University.

The Scholarship Programme became a pillar in the doctoral system in that it did not only spurred policy learning and coordination with the PNCP to increase the quality of domestic research training courses. It also linked its functioning to the NRS, which changed its membership criteria making doctoral training degrees compulsory, and establishing the training of doctoral students as a condition for promotion (Aupetit & Jaramillo de Escobar, 2014; Castaños-Lomnitz, 2003).

4.2.3 Outcomes

There is no similar policy for postgraduate training in Mexico; despite the technical shortcomings and budget reductions that the Programme has experienced through the years; it remains a longstanding attempt to foster domestic S&T capacities. Table 12 illustrates the changes in the distribution of scholarships between 1971 and 2018.

Table 12 Scholarships granted 1971-2018

Concept	1971-1980	1981-1989	1990-1999[57]	2000-2010	2010-2018
Total scholarships granted	23,054	21,297	48,194	119137	375,207
Average domestic Scholarships per year(e)	1,332 (58%)	1,700 (72%)	3,758 (78%)	13,031 (89%)	20,187 (89%)
Average scholarships for training abroad per year (e)	973 (42%)	666 (28%)	1,062 (22%)	1684 (11%)	2,429 (10%)
% of scholarships for masters courses	13%	40%	70%	72%	54%
% of scholarships for doctoral courses	37%	24%	25%	20%	40%

Source: Conacyt (2013, 2017a, 2018)

[57] The overall increased number of scholarships in the 1990s was a result of the decision of Conacyt to end the support for other courses such as those for learning a foreign language, mainly English, support for thesis completion, and other short-term courses.

In order to guarantee better conditions for fellowship holders, such as reduced tuition fees, and to establish collaborative research links, Conacyt started to negotiate agreements with foreign governments and HE&RIs, particularly in the USA and Europe.

4.2.4 Overall assessment

The evolution of the Programme shows that this was conceived as a capacity-building mechanism that operated only on the supply side and that followed a hands-off logic in its first three decades of existence[58]. This policy logic was based on the belief that increasing the stocks of research skills was beneficial in its own right. Thus, in addition to its resource and technical constraints, the programme was unconnected from the real needs for S&T in Mexico.

4.3 THE SCHOLARSHIP PROGRAMME AND POSTGRADUATE TRAINING ABROAD

4.3.1 Background

The Scholarship Programme is the primary funding instrument for doctoral training in foreign universities. Arenas et al. (2001) estimated that between the 1990s and the 2000s, this had sponsored 75% of the total enrolment in postgraduate education. Corona (2006a) offered a similar appraisal in his diachronic study, which estimated that the Programme throughout its existence had sponsored 74% of the total population enrolled in doctoral and masters courses in Mexico and abroad. In 2008, the Scientific and Technological Advisory Forum[59] revealed that the Programme covered 65% of the national funds for courses outside Mexico (FCCYT, 2008).

[58] Policy documents for these periods do not ignore the link between science and economic development - policy narratives are ambitious and consistently refer to the experiences of developed economies, and to the recommendations of international agencies, such as OECD and the World Bank.

[59] The Science and Technology Advisory Forum is integrated by reputed remembers of the scientific and technological community; the inter-ministerial committee for S&T (responsible for the

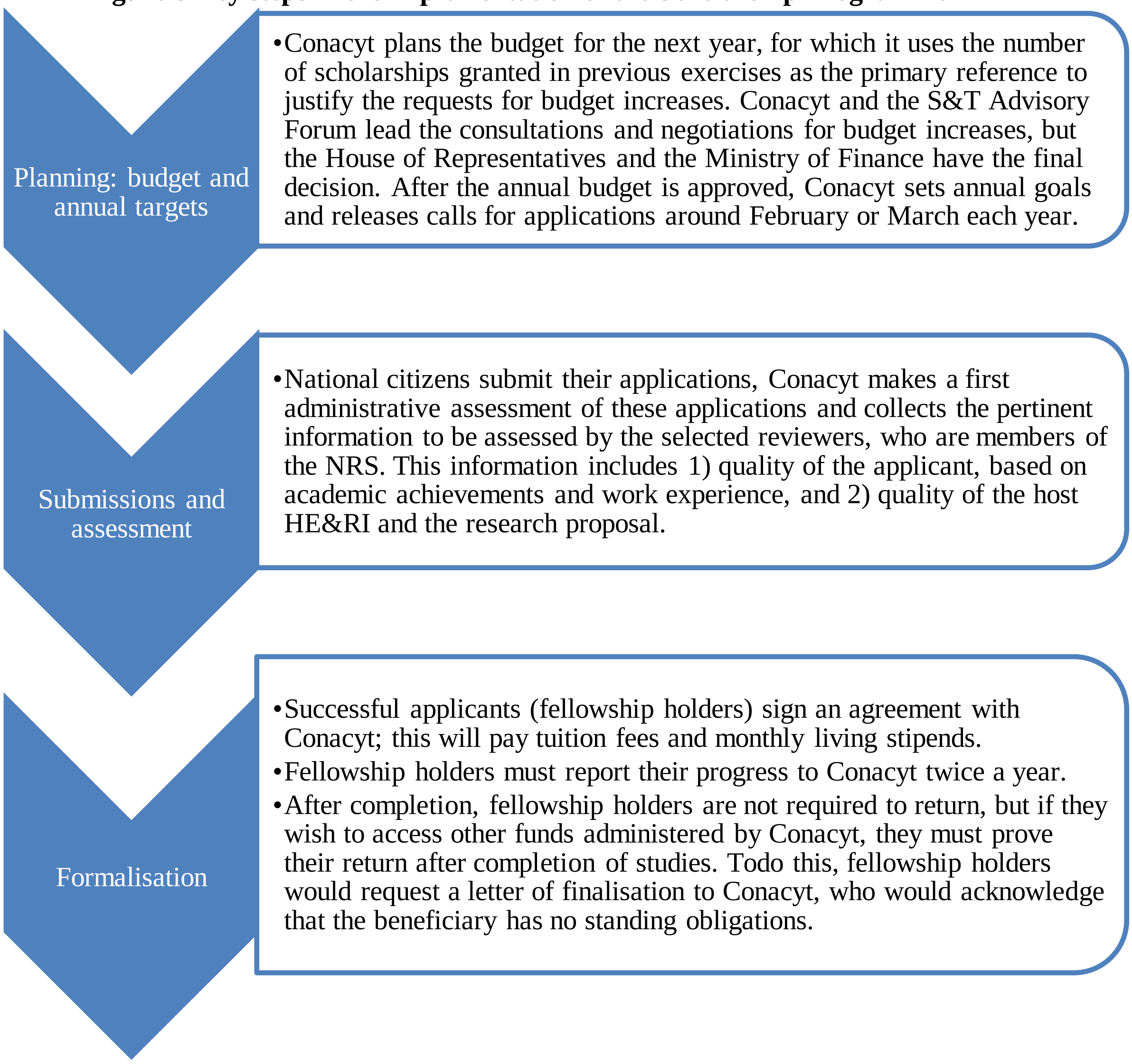
In this modality, the Programme seeks to expand the opportunities for specialised training for national doctoral students and to further the development of the emerging research fields in domestic HE&RIs. The value of the Programme lies on the potential benefits that international mobility can trigger in the national research system, and expects that collaborative environments and top research facilities would provide fellowship holders with excellent research training. Conacyt sees it as a direct channel to connect domestic research with global practices on scientific research. In line with this, the Programme is set under the expectation that fellowship holders would return and would share their expertise and knowledge with domestic peers and future generations of researchers.

4.3.2 Implementation of the Programme and results

In 2013, Conacyt transferred part of the responsibilities of the implementation of the Programme to state-level S&T authorities, prompted by an intended shift towards the decentralisation of resources and decision-making on S&T matters, and to address the particular priorities and concerns of each region. This decision also aims to foster the participation of regional governments in the financing of S&T activities, although Conacyt continues to fund the Programme entirely. Regional governments mainly conduct the review of applications submitted by potential fellowship holders, following the criteria established by Conacyt. Figure 8 outlines the pertinent elements in the implementation of the Scholarship Programme.

integration of the national budget); the General Council for Scientific Research and Technological Development, and the National Conference of S&T.

Figure 8 Key steps in the implementation of the Scholarship Programme



Relevant remarks in this process are:

- The assessment of the host university is based on the 200 HE&RIs in the Times Higher Education Ranking. Collaboration agreements are other assessment criteria, through which Conacyt can negotiate reduced tuition fees[60] with the host universities.

- Between 2013 and 2018, Conacyt received 5,943 applications, of which only 54% made it to the formalisation process. Acceptance rates between 2013 and 2016 were 55.3%, 63.3%, 43.2% and 43% respectively.
- With the progress reports, Conacyt aims to guarantee completion of the studies among fellowship holders. However, these are a formality and do not inform decision-making.
- The fellowship can cover three or four years, depending on the length of the doctoral course[61]. Table 13 presents the costs covered by the Scholarship Programme.

Table 13 Main costs covered by Conacyt

Tuition fees	Living costs (monthly)
Up to $300,000 Mexican Pesos in its equivalent in US dollars ($15,660), pounds (£11,985) or euros (€13,956) as appropriate to the currency in the destination country.	-European Union: €1,090.00 -United Kingdom: £770.00; London £880.00 -Rest of the world: $1,100.00 (USD)

- Each year Conacyt grants around two thousand new fellowships, from which the vast majority, over the past five years, were in the following fields and destinations. See Table 14.

60 These agreements guarantee that the students sponsored by Conacyt will have a lower tuition fee. In some cases, the foreign counterpart covers 50% of the tuition fee, such as the agreement with the UK government through the Chevening scheme. In other cases, the foreign counterpart sponsors the native language course, which includes the tuition fee, living stipend and health services, and academic mentorships. An illustration of this is the agreement between Conacyt and the German Academic Exchange Service (DAAD).

61 A current controversy regarding the length of support emerged when Conacyt was reluctant to extend funds for the fourth year. Anecdotal experiences suggest that until 2019, Conacyt used to support the fourth and even the fifth year without much hesitation, but this practice did not seem to produce the effects intended by Conacyt because fellowship holders would not return.

Table 14 Main fields and destinations in the Scholarship Programme

Fields	Destinations
Biology, Chemistry and Biotechnology (32%)	The United Kingdom (26%)
	The United States (21%)
Social Sciences and Humanities (25%)	Spain (11.5%)
Engineering (15%)	Germany (10%)
Physics and Mathematics (15%)	France (8.1%)
Health and Medicine (12%)	The Netherlands (7%)
	Canada (6.8%)

The extent to which fellowship holders would return is a pressing issue for Conacyt. This is not only a matter of quantifiable results but more importantly, is a matter of affording comprehensive examinations on the effects produced in the national research system. This issue has been stressed in several studies; for instance, Castaños-Lomnitz (2004) showed that over 65% of fellowship holders remained abroad. Also, a recent report by Delgado-Wise et al. (2015), showed that the return rate between 2000 and 2014 was 54.7%. An also relevant remark in these reports was that about 30% of those who return were planning to leave permanently (13.6%) or temporarily (16.1%), which raised an issue that is not addressed by the programme, i.e. it does not consider incentives to attract fellowship holders after graduation or to capitalise on diaspora effects.

Conacyt monitors[62] the efficiency of the programme following accountability and budgetary logic, where increases in the numbers of scholarships are widely seen as a good use of public money. Conacyt also has commissioned external evaluations such as Bracho et al. (2012) FCCYT (2008), and Delgado-Wise et al. (2015). These reports also tend to follow the same evaluation logic of quantification of results, but do not dig further into effects of the programme, except Delgado-Wise et al., who briefly

62 There is a specialised department for this monitoring.

examined the following impacts: unemployment, unbalanced gender distribution of funds and brain drain.

4.4 SUMMARY

This chapter has provided a review of the Scholarship Programme, which has been the most relevant source of funds for doctoral training in Mexico since 1971. This programme comprises two modalities: domestic fellowships and fellowships for courses in foreign universities. For the sake of having a clear-detailed description, the chapter has focused on the second modality.

The Programme relies on foreign doctoral training to build research capacities in fellowship holders and domestic research institutions, and expects that these fellowship holders would return after graduation and would transfer their knowledge and skills to their national peers.

A brief assessment in this chapter suggests that the policy logic in the Programme contrasts with particular examples of Asia, which underwent the process of industrialisation in the same period as Mexico, such as Korea and China. These countries responded purposely and fast to the challenges in global research and linked the advancement of their research and technology systems to industrial and economic development (Bang-Soon, 1992; L. Kim & Nelson, 2000). They resourced from international mobility to improve their research skills and faced the emigration of mobile researchers, which they addressed by incentivising these researchers to start knowledge-based business projects or by funding ambitious long-term research and setting-up mechanisms to foster diaspora effects (Fangmeng, 2016; L. Kim & Nelson, 2000).

It is possible to say that the policy approaches in the Asian cases share some traits with those of developed economies, as they implement schemes to attract foreign talent (Kang et al., 2018), and design policies for the resourcing of expatriates (Ciumasu, 2010; Saxenian, 2001; Zweig et al., 2008). Conversely, Mexico approached international mobility also as a source of change, but fragmented notions about the relationship between scientific research and economic development hindered the capitalisation of this into the research system.

In short, the Scholarship Programme is set on ambitious expectations and is presented as a systemic policy instrument, but this is run as a conventional linear instrument based on the accumulative approach. This is because while it aims to provide advanced research skills, it fails to connect to the particular national S&T challenges and is not part of a larger plan for change. Moreover, the levels of migration reported in previous studies can be an indication of its struggles to balance the interests of fellowship holders, who seek prestigious global careers, the resources and conditions to produce relevant research, with the expectations of return in the programme. In this regard, the programme can present a wide set of opportunities for its beneficiaries, who will interpret these according to their personal and professional expectations, but these opportunities may have little or no relation to the overall policy objective.

An in-depth assessment of the opportunities and effects produced by the Programme in its beneficiaries is provided in the empirical chapter of this thesis, which will examine how fellows respond to the opportunities signalled in the programme.

CHAPTER 5 NANOSCIENCE AND NANOTECHNOLOGY: CURRENT TRENDS AND THE STATUS OF THIS SECTOR IN MEXICO

5.1 INTRODUCTION

In order to conduct an in-depth study it was necessary to identify a suitable case, which should focus on a research area that is relevant for both researchers and governments. More importantly, this should be an area that would be relevant to many of the issues discussed in the preceding chapters in this thesis, notably, the use of public policy to steer change in a research system. Thus, the selected area should have the potential to generate benefits in domestic research, and possible social and economic benefits.

As this study focuses on the Mexican research system, an attempt was made to choose an area with comparable characteristics to other developing countries. Also, to test the theoretical assumptions about the power of policies to produce change, it was considered a case where important progress is being made. This would better demonstrate the working of policies in the process of the international mobility of researchers, and serve to assess the pertinent effects.

This chapter aims to present a detailed argument for the selection of nanotechnology. Thus, the rest of this chapter is organised as follows. Section 5.2 briefly explores the overall status of nanotechnology, as presented in the current literature. The chapter begins with an overall description of what this entails for research and policy, and its position as a core technology for development. Section 5.3 offers a review of nanotechnology in Mexico, which will contextualise the relevant aspects of this sector concerning the S&T national policy agenda and will identify the involved actors, and the standing of Mexico in this area. Ultimately, section 5.4 summarises.

5.2 SOME GENERAL UNDERSTANDINGS ON NANOTECHNOLOGY

There is no clear-cut distinction between nanoscience and nanotechnology. Both concepts are used to refer to the study of physical phenomena in the size range of 1-100 nanometers, and the development of techniques and structures, and the incorporation of these into applications (Kostoff et al., 2007). This study distinguishes between nanoscience and nanotechnology by adopting the following definitions proposed by The Royal Society & The Royal Academy of Engineering (2004), who afford a sensible distinction between these two.

> *"Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale."*
>
> *"Nanotechnologies are the design, characterisation, production and application of structures, devices and systems by controlling shape and size at the nanometre scale."*(2004, p. 2)

Nanoscience and nanotechnology are not merely about size; it is also about the physical, chemical, biological and optical properties that emerge naturally at the nanoscale, and about the tools and the competences to understand and to manipulate their effects. Nanotechnology incorporates a wide range of practices and disciplines that overlap on the spectrum of natural sciences. From chemistry, physics, and engineering, nanotechnology spans over other fields such as medicine, materials science, mathematics, computer sciences, and electronics, among others.

Nanotechnology seems to present the promise of change and progress; arguably, it is key for the transformation of manufacturing techniques and for the advancement of new materials, which would yield a new organisation of the production processes, which would reflect in a possible new division of labour (Dewick et al., 2006). Accordingly, this would require new demands and uses of skills and knowledge for the advancement of economies and societies (Kostoff et al., 2007; OECD, 2010b; Stephan et al., 2007). This promise is evident by the double-digit growth rates of the market - materials, tools, and devices based on nanotechnologies - in the past five years; that is 18.2% annual growth rate. Forecasts[63] suggest that the global market for these technologies should reach USD 90.5 Billion by 2021. The usage of the commercialised applications ranges from synthetic biology, electronics, medicine, environmental remediation, agriculture and food production, to beauty products industrial manufacturing and other consumer products.

Due to its potential to significantly expand industries and stimulate growth, nanotechnology is an emerging field that receives a great deal of attention in developed and developing economies and is a top priority for the innovation leaders (OECD, 2009a). Between 2000 and 2014, over sixty countries, such as Switzerland, Germany, and the UK, have followed the United States' efforts to establish nanotechnology initiatives. According to the UNESCO Science Report (2015), the leading producers of scientific knowledge in this multidisciplinary field are Switzerland, the Republic of Korea, Germany, France, and the USA. This order is rearranged when it comes to the development of applications; the USA takes the lead, followed by Japan, the Republic of Korea, Germany, Switzerland, and France. Also, emerging countries such as China, Brazil, Russia and less developed economies, such as Nepal and Pakistan, have shown interests in the potential benefits of nanotechnology.

Policy interventions in this sector involve funds for research, education, and large amounts of R&D spending. A common, if not their most common concern, for governments is the lack of researchers and engineers with specialisation in nanoscale related issues (OECD, 2011b; Stephan et al., 2007). Nanotechnology requires sophisticated facilities and expert skills and knowledge to push forward the advancement of this field and its applications. In this regard, Stephan et al. (2007)

[63] Retrieved on 16 June 2018, from: https://www.globenewswire.com/news-release/2017/01/17/906164/0/en/Nanotechnology-Sees-Big-Growth-in-Products-and-Applications-Reports-BCC-Research.html

asserted that the market for skills in nanotechnology is growing in both the research and the industrial realms, but that the supply of such skills seems somewhat to evolve slowly. In order to address this issue, policymakers devise the necessary instruments to incentivise domestic students to enrol in training courses in this area, as well as to resource from the foreign workforce. An instance of governments' interests in accumulating skills regardless of their origin was reported in Ouellette, (2015) and Walsh, (2015), who indicated that researchers dedicated to nanotechnology in the United States are overwhelmingly foreign-born.

Scholarly works from STI studies posit that for developing countries, nanotechnology can be a window of opportunity to advance their research and innovation capacities (Bozeman et al., 2007; Maclurcan, 2005a; Niosi & Reid, 2007; Shapira et al., 2011). These works assert that the nanotechnologies will revolutionise industries and society by fostering the convergence between technologies, and could lead to an increased demand for research skills. The opportunity for developing countries resides in that some, such as China, Brazil and India, have accumulated significant stocks of knowledge and technical skills in knowledge-based technologies. These can be visible in their advancements in educational matters, investments in S&T particular to nanotechnology, increased scientific publications, and in the presence of industrial sectors that could see in this an opportunity for productivity and innovation (Niosi et al., 2013; Niosi & Reid, 2007). Also, developing countries could invest in nanotechnology, led by an aspirational goal for development, political power, strategic interest and prestige (Clunan et al., 2014).

One of the priorities in developing countries aiming to capitalise on these opportunities is to increase their research capacities by investing in the training of their researchers, for they embody the required specialised skills for knowledge-based sectors (Gokhberg et al., 2016; Hung & Chu, 2006; Lee, Miozzo, & Laredo, 2010b). While these opportunities represent a possible path for development, they also represent a challenge. This is because while engaged in building research capacities, these countries must operate faster and more purposively to create a considerable scientific and technological base (Bozeman et al., 2007; Dewick et al., 2004).

The following section outlines the context and status of nanotechnology in Mexico.

5.3 THE CURRENT STATE OF NANOTECHNOLOGY IN MEXICO

There is little research on the development of nanotechnology in Latin-American countries. Most studies consist of evaluation exercises on the central strategies implemented in Argentina and Brazil (Kay & Shapira, 2009; Ramani, 2014). In the case of Mexico, studies show a mixed picture, some deemed the slow development of this sector to the lack of directed government intervention[64] (Delgado-Ramos, 2014; Záyago-Lau & Foladori, 2010), while others assert that Mexico has an actual national initiative for nanotechnology (Ramani, 2014; Salamanca-Buentello et al., 2005). However, although policy documents mention this as a national priority, there is not a full-fledged policy for this sector, meaning there are not set aside resources for this area specifically.

However, the absence of a central policy has not hindered the development of nanotechnology in Mexico. The national scientific community has been actively sensitising policymakers on the relevance of this sector, and in 2002 prominent researchers from public and private HE&RIs discussed the need for a national policy to foster nanotechnology. They presented a proposal that included a review of the policy initiatives in other countries, the trends of expenditures in R&D in this area and the economic value of its potential applications, to Conacyt, the S&T Advisory Forum and the Science and Technology Commission the Chamber of Deputies. Beyond the acknowledgement of nanotechnology as an S&T priority, and the adoption of a narrative concerning its value for science and the growth, and some investments in laboratories, nothing else happened. The promoters of this initiative claimed that the

64 However, this situation is not exclusive to nanotechnology, for example, some studies show that despite having directed policies to promote the development of biotechnology, this had not shown significant improvements (Gil & Contreras, 2017).

financial resources were the main factor behind the hesitant response of policymakers. Also, the tension in regards to who is supposed to further technological development seemed to be another factor. This is because although Conacyt is the institution dedicated to S&T matters, its budget is limited, and the Ministry of Economy is the entity responsible and with the resources for looking at the technological needs in the industry.

In 2005, the government started to mobilise resources for the development of nanotechnology. These efforts lasted until 2010 and became visible in the creation of research centres and the renovation of existing laboratories[65]. These investments seemed to have followed the United Nations proclamation[66] of nanotechnology, which claimed that this was a platform for technological catching up and put forward a direct recommendation to developing countries to embrace this as a source of economic and social progress (UN, 2005), rather than a directed long-term policy. Consequently, these efforts started to deteriorate due to changes of governments and political interests. According to Robles and de Gortari (2014), biotechnology received greater emphasis, but this had no connection to the development of nanotechnology.

Domestic HE&RIs have been advancing scientific research in nanotechnology, which could be interpreted as a sign of aspiration in researchers for change and visibility in the global scientific community. In 2009, the leading public research institutions established a national research network, whose primary aim is to connect the current research to the necessities of the private sector. During the first years of operation, this initiative received around USD 700,000 from Conacyt, and due to the persistence of

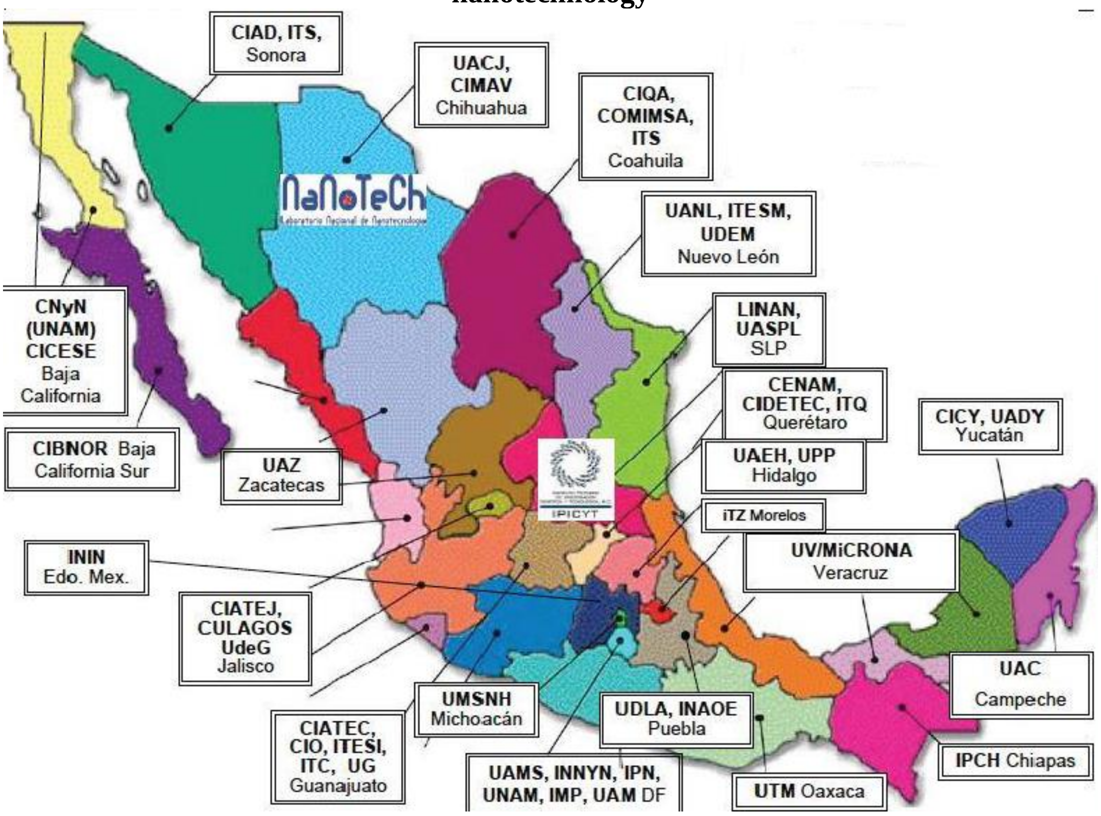
[65] In 2006, the following laboratories were created: the National Nanotechnology Laboratory, the Research Laboratory in Nanoscience and Nanotechnology and the Bi-national (USA-Mexico) Sustainability Laboratory.

[66] In a report released in 2005, the UN Task Force on Science, Technology and Innovation addressed the potential of nanotechnology for sustainable development. This report emphasised the potential impact of nanotechnology in alleviating issues such as hunger,

the academic community, two national laboratories were created with the financial support of Conacyt. These laboratories are the National Laboratory for Research in Nanosciences and Nanotechnology, located in the Potosi Institute for Scientific and Technological Investigation (IPICyT), and the National Laboratory of Nanotechnology, located in the Centre for the Investigation of Advanced Materials (CIMAV).

There are 159 laboratories and 56 institutions conducting research in nanotechnology (Záyago-Lau & Foladori, 2010). The map in Figure 9 illustrates the distribution of these across Mexico.

Figure 9 Domestic higher education and research institutions conducting research in nanotechnology



Source: Frederick et al.(2013)

A report commissioned by the Ministry of Economy in 2008, and additional scholarly studies by Záyago-Lau & Foladori (2010) and a compilation of reports from research organisations coordinated by Zanella, et al. (2016a, 2016b), suggest that there are around 449 researchers conducting research on topics related to nanoscience and nanotechnology. This research capital resides, in its majority, in public research centres and in the research institutes coordinated by Conacyt (29%). The National Autonomous University of Mexico (UNAM) follows with 18%, National Polytechnic Institute (IPN) 8%, the Mexican Institute of Petroleum (IMP) accounts for 15% of the total number of researchers. The remaining are spread across twenty higher education institutions such as the Autonomous Metropolitan University, the Autonomous University of Nuevo Leon, the Autonomous University of San Luis Potosi, and other state universities (SE, 2008).

Mexico leads the production of scientific and technological knowledge in nanotechnology in the Latin American region, just after Brazil (Zayago et al., 2014). Public HE&RIs produce 98% of the total count of published work, which is primarily focused on basic or theoretical research, and is geographically localised in the centre and northern region in this country (Záyago et al., 2014). UNAM produces one quarter, followed by Conacyt research centres (16%) and IPN (15%). Over 20% of these publications are co-authored with European researchers and 16% with scholars in the USA (Frederick et al., 2013). International collaboration is another crucial component in which HE&RIs participate in the development of nanotechnology. Mexico has specific collaboration agreements in this area with Argentina, the European Union, Brazil, United Kingdom, and the United States of America (Materiales Avanzados, 2008). Recently, collaboration links with Chinese HE&RIs are also increasing (Appelbaum et al., 2016; SE, 2008).

Regarding the development of applications, Mexico ranks eighth among OECD countries in terms of the number of companies producing and using nanotechnology (Záyago et al., 2015). The industrial sector is defined by 188 companies that produce final products (51%), primary nano-materials (15%) and nano-intermediates (30 %) and nano-related instruments (4%). The majority of these companies are of domestic capital (68%) and tend to conduct manufacturing activities and have a strong dependency on external imports of primary materials (Appelbaum et al., 2016). These companies come from the sectors of transport, energy and environment, ICT’s and electronics, health and biotechnology, and traditional sectors (CIMAV, 2017).

The industrial capacities in this sector follow the same pattern as the research capacities in that these are localised in the centre and northern regions, both are areas with strong industrial tradition in siderurgy, ICT's, aerospace, pharmaceutics and chemicals. In 2008, an initiative partially funded by the Inter-American Development Bank consisted of the creation of the Research and Technological Innovation Park (PIIT) in Monterrey, which hosts the nano-cluster[67]. This initiative brought together research institutions and private companies to create and commercialise solutions and tools. The park comprises, in its majority, multinational companies, such as Cemex (Mexico), Peñoles (Mexico), Sigma (Mexico), Motorola (USA), AMD (USA), Bosch (Germany), Cydsa (Mexico), Vitro (Mexico), Owens Corning (USA), and Pepsico (USA), and domestic research organisations such as ITESM, CINVESTAV-IPN, CIQA and CIDESI. Also, universities such as the Texas State University, Arizona State University and Texas University.

HE&RIs also lead in patent activities, according to Appelbaum et al. (2014) and Záyago et al. (2016), between 1993 and 2014, there were 217 patents granted to inventors resided in Mexico, from which 83% were for HE&RIs, followed by large companies and individual inventors. The potential applications of these patents could be used in the manufacture of chemicals and new materials, pharmaceuticals, cosmetics and electronics (Zayago et al., 2014).

5.3.1 Reported challenges in the nanotechnology sector in Mexico

This section relies on several reports and assessments of nanotechnology in Latin-American countries and Mexico particularly, such as the following works: Foladori et al. (2015); Zayago et al. (2015, 2014; 2014); Kay & Shapira (2009); Bernal & Juanico (2011); Robles & de Gortari (2014) and Maclurcan (2005b, 2005a) among others.

[67] See Zayago (2008) for a comprehensive reflection on the cluster and its potential for development in Mexico.

The issues identified in these works are:

- The lack of a long-term policy. Conacyt is the primary provider of funds through competitive instruments, such as “the institutional funds” (fondos institucionales), sectoral funds and mixed funds. The institutional funds are the main source of funding for research. This instrument is aimed at fundamental research projects but is not exclusive to nanotechnology.
- The lack of coordination between actors. This challenge is strongly related to the general conditions of the national S&T system in Mexico; its governance; organisation of resources and the tensions between what Mexican science needs and what can be done within the current financial and institutional conditions. Despite efforts for participatory policy design and articulation between the relevant policy actors, the responsibility for S&T policy pertains to Conacyt alone. Also, this is related to the low participation of the private sector in S&T decision making and spending.
- The lack of regulation and guidelines. This concerns the need to introduce general regulations for manipulation, manufacture, intellectual property, and health and safety. There are no official national standards in all these issues in Mexico. In 2007, the federal government created the National Standardization Technical Committee on Nanotechnologies (NSTCN) to lead the creation of standards and regulatory components for nanotechnology, and to participate actively in the work of the international ISO TC 229 committee. In addition to this, academics from the largest HE&RIs established “Sinanotox”, an initiative to design and validate standard protocols for risk assessments, which comprised 450 members in 2019 from academia, the private sector and the NSTCN.
- The lack of necessary skills. This includes the need to increase and improve S&T skills. There are 44 doctoral programmes, 43 masters, and 12 undergraduate training courses specific to nanotechnology. These courses have emerged as a result of the individual efforts from HE&RIs, not as part of a central initiative from S&T authorities or education authorities.
- Another challenge, linked to the challenge above, is the international mobility of the scientific workforce (academics and doctoral students), which, on the

one hand, depends on international mobility for the improvement of research skills and to expand international networks, but, on the other, more often than not this turns into migration.

5.3.2 Justification for focusing on nanoscience and nanotechnology

The review of the national context for S&T in Mexico and the research questions in this study raised several issues concerning the functioning and effects of S&T policies in this research system. In this regard, it was necessary to ask whether nanotechnology affords an adequate focus of analysis to examine possible responses. This research selected the nanotechnology sector to produce an in-depth exploration of the Scholarship Programme. The justification of this empirical choice lies on the appropriateness of this field to examine its potential effects at the micro-level (fellowship holders) and at the meso-level (HE&RIs and companies).

The following points aim to substantiate this decision:

- Nanoscience and nanotechnology have not received a specific policy focus in Mexico, but it is widely recognised as an emerging research field, which progress depends on the research human capital (skills and knowledge) related to this.
- Nanotechnology is a dynamic field that requires increased research capacities. Nanoscience and nanotechnology have led the progress of scientific research significantly in all the related disciplines, and it is an emerging and fast-moving research area. The Mexican government has been sending doctoral students to pursue research training in the most prestigious HE&RIs in order to accumulate the necessary research capacities. The international mobility of these students is expected to keep the national system up to date in the relevant skills and knowledge; students would learn the latest techniques and knowledge in this specialised research area.
- As a fast-moving emerging field, nanotechnology relies on sophisticated and expensive techniques and equipment. Domestic HE&RIs have accumulated considerable experience and infrastructure in this area, and its related disciplines, notably, chemistry, physics, and biology, but the high costs

involved in the production of relevant research can lead researchers to draw on international facilities.

- Ultimately, this is a field that embodies progress and prestige for researchers, who are driven to learn how to produce high-quality research and to be part of the global scientific community.

In addition to these, other contextual elements that influenced this empirical decision are that despite the lack of a central policy for the development of this sector in Mexico, this shows significant potential for change at the research system. This is visible in the presence of scientific research outputs and increased participation of industrials in the market (Foladori et al., 2015). Mexico is the second producer of publications and patents in nanotechnology in Latin American and an emerging market with significant potential (Foladori, Figueroa, et al., 2015; TCI-Network, 2017; Zayago et al., 2013). Also, it has accumulated research capacities in physics, chemistry and biology; all of these required fields linked to nanotechnology.

However, how the Programme affects this emerging field is an under-researched topic. Most studies on the Scholarship Programme concentrate on brain drain effects (Arenas et al., 2001; Castaños-Lomnitz, 2003; Jiménez et al., 2010; Tigau, 2013). Broader studies on science, technology and innovation in Mexico focus on issues of governance and resources (Alcantara et al., 2008b; Corona et al., 2014; Dutrénit et al., 2010; Peña Ahumanda & Archundia Navarro, 2006).

Important remarks here are that looking at the effects of the Scholarship Programme across the entire range of disciplines it covers would introduce a further level of variability. However, by focusing on the fairly narrow field of nanotechnology, and the disciplines associated with it, it was hoped that this variability could be reduced. Also, the interpretations of the direct beneficiaries (fellowship holders) and the effects of their experience would fall within a more restricted set than if the study had considered the Programme across all the sponsored disciplines. Similarly, it narrows the effects of the Programme on its indirect beneficiaries such as those in the public sector (universities and research centres) and the private sector.

Moreover, the significance of looking at nanotechnology in this study is twofold: 1) international mobility improves domestic research, but this seems to be threatened by the consequences of brain drain. 2) S&T policies may produce unexpected responses from researchers, who are driven by academic and professional factors. Thus, it is worth exploring the change produced by the Scholarship Programme and its possible effects across its national beneficiaries in the nanotechnology sector.

In light of the above, the field of nanotechnology appeared to offer a more focused analytical lens to investigate the effects of the programme.

5.4 SUMMARY

Nanoscience and nanotechnology are widely acknowledged among policymakers and researchers for their scientific and economic potential benefits. For developing countries, this is claimed to provide a window of opportunities to enhance their research capacities and growth. This chapter has presented a review of nanotechnology in Mexico and offered a justification for the selection of this field as the focus of study.

The core of the evolution of nanotechnology in Mexico is in the research capacities of its HE&Is and Conacyt is the primary funder. At the industrial level, the existing capacities can be the catalyst to mobilise the scientific capacities into applied solutions. In this regard, improving the disarticulation between actors could promote synergies, more and better use of resources.

A final reflection on this chapter is that literature on the development of nanotechnology in Mexico emphasises the lack of national policy as the central issue. Assertions in this regard seemed to be driven by the assumption that should Mexico had established a long-term programme, things would be better. This logic is not entirely misplaced in that it follows the innovation-development dominant reasoning. However, there are other things to consider when assessing change in knowledge-driven sectors. For instance, Germany adopted a direct policy approach for nanotechnology until 2006, but even before that, it had been a great contributor to its progress and has one of the largest markets in this sector (Clunan et al., 2014). Germany is a case with no close similarity to Mexico, but it helps to illustrate that scientific knowledge and involved actors evolve, to some extent, independent of policies. Moreover, most, if not all, studies on nanotechnologies in Mexico stress the limitations and challenges in this system, but the role that policies play in its development and the international mobility of researchers is specifically less known.

PART II LITERATURE REVIEW

CHAPTER 6 THE INTERNATIONAL MOBILITY OF RESEARCHERS: DOMINANT RESEARCH AND POLICY APPROACHES

6.1 INTRODUCTION

As presented in the chapters in section I, particularly in chapter 3 and chapter 4, one significant feature in the research system in Mexico is its connection or reliance on the training of its researchers in foreign universities. The Scholarship Programme facilitates trans-national mobility among domestic doctoral students, who would learn the latest skills and research debates, and who would return to Mexico to transfer these among their domestic peers.

As the Programme promotes face-to-face training in overseas and leading research environments, the analysis required considering the ongoing debates in the literature about international mobility and migration. Thus, this chapter reviews the core concepts and notions relating to the international mobility of researchers, and positions this research in the broader context of science and technology policy. The chapter highlights the significance of doctoral training concerning the transnational nature of scientific knowledge. This chapter covers the two dominant notions on international mobility, i.e. brain gain *versus* brain drain and diaspora, and their impacts on developing countries.

This chapter is organised as follows. Section 6.2 section gives a short overview of the foundational concepts that underpin the existence of policy instruments to incentivise international mobility. Section 6.3 reviews the theoretical frameworks that dominate the debate around this process and its effects for the sender and receiving countries. It also outlines the common policy responses to the brain drain issue in developed and developing countries. This section will draw the main implications of the presented frameworks for this study. Section 6.4 offers a review of the factors and related processes in the increasing mobility of researchers. This section will highlight the drivers in researchers to undergo international mobility, which seem to be governed by non-pecuniary incentives such as recognition, career opportunities, and global research practices. Section 6.5 summarises.

6.2 LITERATURE REVIEW ON THE INTERNATIONAL MOBILITY OF RESEARCHERS

In this work doctoral training comprises two central processes; one is the acquisition of research skills, and the second is the international experience. Thus, this section builds on two central bodies of literature, one of which includes the contributions from human capital theory and S&T and innovation studies on the value of research skills and scientific knowledge. Due to the multidisciplinary nature of the scholarship on the international mobility of researchers, this chapter also reviews contributions from development studies, economics, migration studies, higher education, the sociology of science and science policy.

This work will use the terms “mobile people” and “mobile researchers” to refer to the researchers undergoing doctoral training, to someone at postdoctoral level and to the experienced researchers that have undergone any cross border mobility. This study is concerned with the researchers that undertake mobility in pursuit of doctoral training, which can be defined as longer-term mobility (Coey, 2018; Rostan & Höhle, 2014).

6.2.1 The value of knowledge and skills

The pioneering contributions from endogenous growth theory and later from science, technology studies and innovation studies provided the first pointers towards the relationship between knowledge and economic development (Fagerberg & Srholec, 2008; Freeman, 1995; Nelson & Nelson, 2002; Nelson & Phelps, 1966; Sutz, 2011). The central argument in these studies is that knowledge and skills, conceptualised as human capital at the national level, are a source of innovation and growth (Furman et al., 2002; Lenihan et al., 2019). These two elements, in combination with the adequate allocation of financial resources, are regarded as crucial in the transformation for all economies and have formed the notion that the stocks of capital embodied in people would result in strong national capacities.

The theoretical foundations of endogenous growth theory and innovation studies reside in human capital theory, pioneered and formalised by Schultz (1963; 1961), Becker (1962), and Mincer (1981). Human capital theory asserts that highly educated and skilled citizens will perform better and more complex tasks that would foster economic growth. The central assumption in this theory is that investments in education will increase productivity in individuals, future earnings and profits at the national level. In other words, human capital is a condition (production factor) and a consequence of economic growth. It is fair to say that human capital theory set the intersection between education and economic progress, as it rests upon the belief that investments in education will foster development, and development will encourage investments in education.

However, although highly influential, human capital theory fails to appreciate the significance of heterogeneity in individuals and national contexts in the formation and accumulation of knowledge and skills (human capital). In this regard, one of the valuable contributions of science, technology and innovation (STI) studies is their framing of human capital as a policy problem at the institutional and system level. In the view of STI, the organisation of knowledge, this is its production and utilisation, would further particular enhancements according to the pre-existing conditions of societies. For instance, STI scholars have explained that different historical and institutional arrangements across countries have led to differences in national endowments of human capital (David & Lopez, 2001; Toner, 2011; Vinding, 2006).

STI inherited some of its theoretical foundations from human capital theory, and as a consequence, some scholars in STI studies rests on the notion that the human capital of individuals is a decisive factor to explain scientific leaderships and innovation potential (Gokhberg et al., 2016; Veugelers, 2014). In STI studies, human capital activities do not only involve the diffusion and embodiment of sophisticated skills, but it also involves the generation of new knowledge. It is this process of generation and use of knowledge where human capital becomes a source of technical change, innovation and economic development. Consequently, the number of people with specialised skills and knowledge are a distinctive feature of development and progress in developed economies (Auriol et al., 2013b; Lucas, 1990; Romer, 2000; Thune, 2010), and for developing countries, these are crucial in the process of technological learning and catching-up (Lundvall et al., 2009).

From the policymaking viewpoint, human capital entails the connotation that the investments directed at improving the competences in citizens will generate future personal and widespread returns in the economy in the form of better salaries, increased productivity, better employment opportunities and improved quality of life (Aghion et al., 2008; Becker, 1993; Heitor et al., 2014a; Llerena & Mireille, 2005; OECD, 1996). STI studies added a science-driven approach, embraced the notion of human capital and contributed with concepts such as capabilities, interactions, and networks. The STI literature assumes change or progress when human capital is enacted and produces high-value activities in *ad hoc* conditions and resources (Bozeman & Corley, 2004; Bozeman et al., 2001; Davenport, 2004). Accordingly, governmental interventions are expected to facilitate the setting where the human capital in researchers and engineers would be transformed into innovative products (Fagerberg & Srholec, 2008).

6.2.1.1 The relevance of doctoral skills

Within the different skills that are relevant for the advancement of national research, doctoral research skills are widely recognised as drivers of technological change and to sustained long-term growth. These are of crucial importance for building capacities to investigate relevant scientific phenomena and to create wealth (Auriol, 2007; Lundvall, 2011). Thus, the benefits that these skills can produce are the most valuable capital across countries, and the new factor for competition in the knowledge economy (OECD, 2008d).

According to the STI studies literature, doctoral training enables graduates to contribute to the progress of knowledge in their disciplines and prepares them to become independent researchers. Doctoral students acquire a specialised understanding of research problems and of the methods to produce new answers to those problems (Bazeley, 1999a; Stephan et al., 2004). More recent studies indicate that doctoral training should also foster entrepreneurial skills in researchers (Boden & Nedeva, 2010; Gokhberg et al., 2016; Lee, et al., 2010a). Moreover, doctoral students establish networks with colleagues sharing similar and complementary expertise and interests[68]. Ultimately, through doctoral training, higher education institutions make a direct impact on society (Antonelli & Fassio, 2015; Mangematin, 2000; Mangematin & Robin, 2003; Power & Malmberg, 2008).

Both endogenous growth theory and STI studies have spread the common belief that policies should increase the national stock of research skills. The central assumption behind the reasoning in these bodies of literature is that the more advanced research and innovation skills in an economy, the better possibilities for its industrial structure to assimilate and develop technologies (Aghion et al., 2009; Stephan et al., 2004). Such reasoning is also present in policymaking practices, where the capacity of national policy interventions to produce research skills has become a benchmark for competitiveness, and a standard indicator for their actual and potential development. This capacity is usually measured through the number of people conducting research activities; people holding doctoral degrees and people enrolled in a doctoral programme (OECD, 2012a, 2015b; Toner, 2011).

Accordingly, the rationale for policy intervention under the innovation framework is the promotion of a specialised scientific workforce, which would ultimately produce benefits in economic terms. It is this reasoning, in combination with a potential shortage of researchers what triggers policy responses to address the issues regarding advanced research training, notably doctoral training (Lee, et al., 2010; OECD, 2012f).

The significance of this assumption for the present study is that doctoral training is costly, and requires government intervention to sponsor and to improve the training of the future generations of researchers. The use of public money in advanced research training is justified by the link between the preparation of individuals and the

[68] These connections can be with academic peers, professional and/or industrial actors.

positioning of economies. In this regard, scholars suggest that the most significant output of public funds in S&T is the formation of doctoral students. They also indicate that the impact of policy interventions in this process is one of the most difficult to assess (Bozeman et al., 2001; Bozeman & Gaughan, 2007; Corolleur et al., 2004; Laredo, 2007).

6.2.2 The international mobility of highly skilled people

International scientific mobility is a process that involves, among other things, the physical movement of research talent from one country to another, and it has become a common feature in the research profession and a priority for S&T policy (Czaika & Orazbayev, 2018; Marginson & Van der Wende, 2007a). Another element in this process is its impact on mobile researchers, who tend to produce better research outputs and who tend to collaborate in global research networks more actively (Børing et al., 2015; Reale et al., 2018; Scellato et al., 2015).

The international mobility of researchers is a multifaceted phenomenon, and its literature is diverse. Typically, the literature refers to this phenomenon under the following terms: international talent; elite migrants; migration flows; mobile talent; and global researchers, among others (Findlay et al., 2012; Robyn Iredale, 2001; Salt & Singleton, 1995). International mobility can include short-term exchanges, research visits, international training schools, sabbaticals, doctoral studies or postdoctoral research and language improvement courses, and other international activities (Appelt et al., 2015; OECD, 2008d; Teichler, 2015).

The literature generally analyses the international mobility of researchers and higher education students as two separate phenomena. It treats students by their international status in university enrolment, and tends to cover, mainly, students at undergraduate programmes (Baláž & Williams, 2004; Findlay, 2011; González et al., 2011; King & Ruiz-Gelices, 2003). On the other hand, the literature on the mobility of researchers includes both their educational and professional status (Ackers, 2005a; Casey et al., 2001; Walsh, 2015). It looks at doctoral students, early career and senior researchers (Auriol et al., 2013b; Docquier & Rapoport, 2009; Laudel, 2005; Laudel & Bielick, 2019), and often uses the terms of mobility and migration as synonyms.

The use of these terms interchangeably is due to the lack of clear-cut conceptual delineations of each concept, which has raised the heed to make some distinction between permanent (migration) and temporary (mobility) movements (Iredale & Appleyard, 2001; Iredale, 2001). This task, however, faces a limitation, that is the lack of substantial evidence on where to draw a line on the length of time that should be considered as short-term or longer-term mobility, which challenges the validity of any artificial boundary. This difficulty is often attributed to the lack of reliable data to map the physical movements of researchers through their career.

In this regard, this study adopts the definition provided by Ackers, who sees international mobility as continuously changing rather than an ultimate state. According to her definition, mobility is a process "constantly open to re-negotiation and review as lives evolve and circumstances change" (Ackers, 2005b, p. 11). In this thesis, international mobility is an open-ended process, but, for analytical purposes, it retains the distinction between mobility and migration when concerning the intentions of mobile researchers to return or to remain abroad.

6.2.2.1 Doctoral training within international mobility

According to Mangematin & Robin, in the context of internationalisation of research, doctoral students "represent one of the laboratory's products, for they embody the skills and know-how acquired during their professional experience as trainee researchers" (2003, p. 3). Also, through international mobility, they accelarate the knowledge production process and the globalisation of useful knowledge (Freeman, 2010), and procure broader competences (OECD, 2012f).

Economies increasingly rely on doctoral students (OECD, 2015d; Toner, 2011). They are part of the broader population of researchers and are expected to push the frontiers of knowledge and technology (Bozeman & Mangematin, 2004; Gokhberg et al., 2016) and to contribute to the next generation of innovations (Gaughan & Robin, 2004). Their potential contributions to knowledge and to the economy depend on the quality of the capital they acquired during training (Auriol et al., 2010; Mangematin, 2000).

International mobility is widely seen as a standard feature in scientific research training (OECD, 2010a), and in the words of Ackers, “almost as a rite of passage” (Ackers, 2008, p. 418). This is visible in the increasing number of students moving abroad to pursue their studies that has become prominent over recent decades. According to the OECD, foreign-born enrolled in academic research programmes outside their home country have increased more than fourfold in the last five decades. Doctoral students represent 59% of internationally mobile students, and those in science, technology, engineering, and mathematics (STEM) disciplines are among the most mobile across member countries (OECD, 2015c, 2016a). In-flows of these students concentrate on the more innovative and economically developed nations, such as the United States, the United Kingdom, and Germany, while developing countries act as the primary senders, specifically China, India, Mexico and the Philippines (Boeri et al., 2012; OECD, 2016b; Van Damme, 2016).

This differentiation between sender countries and recipient countries dominates the debate about brain drain issues, which centres on the capacity of nations to capitalise the skills and talent of mobile people. This debate has entered the policymaking domain, and it is visible in reactive mechanisms used by governments to attract and to retain research talent. The next section further develops this debate and its implications.

6.3 THE DOMINANT APPROACH AND THE ALTERNATIVE APPROACH IN THE STUDY OF INTERNATIONAL MOBILITY

This section comprises the foundational theoretical framework in the study of migration of highly educated people and scientific mobility. It presents the founding propositions on this phenomenon and the dominant conceptual outlook that despite its limitations to explain its multifaceted effects remains the accepted model. Most recent views and emergent frameworks are also presented. These originate mainly from science and technology studies, sociology and higher education studies. Ultimately, the section characterises the current policy responses in developed and developing countries in close relation to the human capital framework and stresses that this has translated into policy reasoning giving rise to a race for accumulating, or not losing the best and brightest.

6.3.1 Theoretical considerations of brain drain: origins, consolidation of the brain approach and emergence of connective approaches

6.3.1.1 The eve of the brain drain debate

The term brain drain was initially used by economists to refer to the significant outflows of British scientists and engineers to the USA between 1950 and 1960. It implied that the emigration of a nation's highly skilled and intellectual workforce reduced the country's standard of living and economic power (Robertson, 2006; Scott, 1970). Nowadays, in simple terms, brain drain is synonymous with the outbound movement of human capital.

This initial debate on highly-skilled migration was concerned with the social aspects of education and the effects of emigration on social welfare. Two opposing views emerged about how the exodus of the national talent would affect the citizens that remain in the country, and who were assumed to be less educated than those that left. Those two views form the "nationalist" and "internationalist" arguments.

The overall conceptual framework that characterised the initial debate about the economics of brain drain was a broad and evaluative one, focused on welfare creation, distribution effects of the brain drain and negative consequences for sender countries (Keely, 1986). In this debate, human capital theory was not the dominant framework, although there were some initial conceptions, such as the association between education and productivity and welfare. A critical review of the brain drain literature presented by Cañibano & Woolley (2012) identifies the underlying elements that structured this debate in relation to human capital. According to their review, the analytical reflections of the scholars behind the nationalist and internationalist views were: 1) individuals are heterogeneous, interconnected and interdependent, face uncertainty, and are embedded in temporality. 2) The productivity and value of human capital vary depending on the social and economic context of its use; and 3) factors of production are complementary.

Those in nationalistic approach had a distinctly pessimistic view of the effects the emigration of the highly skilled. It assumes investments in public education imposes a collective burden that required the educated citizens to repay the cost of their training. Thus, those that left the home country fail to do so, eroding public finances and holding a debt to society (brain drain) (Boulding, 1968; Johnson, 1965; Patinkin, 1968). The possibility that through emigration, the home country's welfare would suffer significantly prompted responses aimed at trying to prevent the outflows of these highly educated people. A drastic consideration came from Bhagwati (1974) and Bhagwati & Hamada (1974) who suggested a "Brain Drain Tax" as a measure of compensation for the citizens that continued to reside in the home country.

In contrast, those supporting the internationalist approach brought a more positive outlook and pointed that not all were losses for the home countries. For instance, they claimed that the remittances that migrants sent to their families back home would compensate for the possible losses (Johnson, 1968). For the internationalist viewpoint, the potential losses that a sender country would suffer are not as significant as suggested by the basic brain drain model. The leading proponents of this assertion are Grubel and Scott (1966), who disregarded the claims about the harmful effects of brain drain for developing countries, and suggested that researchers' contribution to knowledge is the most positive effect of international mobility. In their view, both the origin country and the host country could benefit from the knowledge produced by the researchers that left. Their proposition implied that migrating was the best decision researchers had made because staying would have hindered their possibilities for contributing to knowledge and the overall society. Along with this argument, other scholars have claimed that emigration can prompt education-seeking behaviours in the nationals that stayed, which could compensate for the nationals that migrated (Beine et al., 2001, 2008; Mountford, 1997; Solimano, 2008; Stark, 2004).

The internationalist argument was that migration could not be understood under simplistic interpretations about losses and gains for the sender country (nationalist view). Instead, they proposed that there was a wide variety of losses and gains for all the countries involved. More importantly, arguments in this line stressed that the accumulation of highly skilled people was not on its own a determinant for development, but the capacity of a society to learn and the configuration of their knowledge structure that would entail socio-economic benefits (Boulding, 1968). For the internationalist viewpoint, brain drain was not about losing people, but about how it could prompt connections and complementarities in the production of knowledge between the nationals that migrated and those that stayed.

6.3.1.2 The neoclassical economics of brain drain: The dominance of the human capital framework

The work of Cañibano & Woolley (2012) showed that the vast majority of the literature on brain drain followed mainstream economics thinking, namely, human capital theory. It also showed that the intellectual diversity and broadness of the brain drain debate that characterised its beginnings came to a halt, i.e. it shift into the debate about human capital. The reasons for this were not discussed but could be explained by the intellectual dominance of neoclassical economics and its strong influence in policymaking.

In the 1970s, the study of skilled and scientific migration embraced the human capital approach that regarded individuals as embodiments of any nation's wealth. The mechanisms to increase and realise such wealth were those associated with investments – private and public – in schooling, on-the-job- training, mobility and migration that enable individuals to acquire and improve their knowledge and skills during their lifetime (Becker, 1993; Schultz, 1961; Scott, 1970). The underlying reasoning behind was that investments in education would maximise the value, via increased returns, of the human capital in individuals. In other words, studies relying on this framework assumed that returns grow as the stocks of human capital increased.

Under the human capital approach, both individuals and governments are willing to invest in education, as the increases in human capital are associated with economies of scale and positive externalities. Three main assumptions in this framework need to be stressed:

1) the more schooling a person had, the more productive this person would be, and better earnings would receive;

2) the more people with similar skills in the productive system, the more wealth could be produced;
3) the greater stocks of citizens receiving education, the higher stocks of human capital for the nation, and the more knowledge and skills accumulated in society.

As the human capital in individuals represents a proportion of a nation's wealth – in which governments invested to produce more wealth – a question that scholars aimed to answer was: how does the migration of the highly educated affect the national economy and society? Assuming that human capital is contained in individuals and that these would seek the maximisation of their investments in education and training (Schultz, 1971, p. 48), the following implications should be considered:

- highly skilled individuals will look for locations where they can make better use and receive higher returns to their accumulated capital;
- when skilled individuals move to another country, as they take with them the potential benefits they would have produce for them and their country, they reduce the aggregated social product;
- 3) skilled emigrants erode public investments in education as they fail to repay these through their contributions to the productive system and the tax system.

In summary, human capital is embodied in individuals and this increases via education. It is accumulative, i.e. increases of human capital in individuals is both beneficial for them and society.

6.3.1.2.1 The brain drain discussion on losses and gains

In regards to the possible effects that can derive from the emigration of the highly educated, according to scholars in the human capital debate on brain drain, developing countries are the exporters of skills and knowledge. In these countries, labour markets are incomplete or inadequate to employ and make optimal use of the national skilled labour force. These sender countries would suffer the negative effects of the emigration of their skilled citizens, which would reflect in their reduced capacity to produce wealth (Giannoccolo, 2006). This human capital approach is mainly found in the nationalistic approach, thus in this debate, developed countries are increasing their human capital stocks at the expense of the investments of developing countries. Thus, the outflows of human capital from a country via emigration to another are seen as losses (brain drain). Whereas, the destination countries are accumulating the potential benefits when receiving the foreign-born human capital (brain gain).

The nationalist outlook brought in a pessimistic scenario where the sender countries would face among several challenges the following: 1) distortions of salary levels for the highly skilled and the unskilled, which would encourage unemployment and overexpansion of educational facilities (Bhagwati & Hamada, 1974). 2) Suboptimal use of human capital, such as the highly educated, would be planning to migrate or unemployed, which would inhibit the diffusion of skills in the national productive sector. This phenomenon is known in this stream of literature as "brain waste", and refers to the situation in which highly educated individuals perform productive activities that do not require them to exploit their skills and experience accumulated in their lifetime (Bhagwati, 1979). Thus, in addition to having lost their most talented, developing countries will incur in higher levels of public expenditure to address these adjustments (Cañibano & Woolley, 2012).

Some opposing views to the nationalistic brain drain approach involved a smaller body of literature that have focuses on the possible adverse effects that can emerge from the entrance of foreign-born researchers in host countries. These works emphasised that foreign-born highly-skilled people benefit from higher returns than equally skilled domestic citizens (Kemnitz, 2001). Also, these foreign-born researchers would reduce the opportunities for highly-skilled nationals (Borjas, 2005, 2006, 2009). Similar studies have contradicted these assertions by showing that even if there was a sizable amount of highly-skilled non-nationals competing with nationals; the foreign-born population would enhance productivity and compensate for the adverse effects induced by immigration on educational incentives for the domestic population (Azarnert, 2010). Thus, international talent is conducive to economic and social benefits.

In the light of the above, it is possible to say that the brain drain debate seems to reduce the international mobility of researchers to losses and gains, in which only the accumulation of human capital would increase productivity, salaries, welfare and wealth (Nelson & Phelps, 1966). However, this interpretation is unbalanced because the potential negative effects of brain drain seemed to occur in undeveloped countries, whereas developed countries would be those accruing the benefits. Such representation can be considered simplistic as scientific mobility does not only respond to market incentives, and it is not static as the human capital model assumes. More importantly, its effects cannot only be explained by measurements of outflows of researchers from one geographical location to another, or by measuring the outputs generated by the migrant researchers.

The critical assessment of Cañibano & Woolley (2012) on the seminal and current literature about international mobility, highlights Boulding's (1968) assertions as one that offered a broader and flexible perspective in the study of scientific mobility. However, his argument was not the most influential in comparison with the human capital model. Boulding's argument offered a more balanced view in that he assumed knowledge as a structure and global public good with symmetrical access to it. A limitation of this argument is that it ignores the sense of ownership dominating the knowledge production setting, and the potential hindrances that developing countries may encounter in accessing, de-codifying and using this knowledge.

Interestingly, this view on highly skilled migration is re-emerging as an alternative outlook. As the significance of geographical boundaries diminishes in the scientific profession an alternative approach, notably "circulationist" "diasporas", "connectionist" or "connective" approach (Gaillard & Gaillard, 1998; Johnson & Regets, 1998) has emerged. This approach is mostly present in works from the sociology of science, science and technology and innovation studies and higher education studies. The propositions of this are presented in the following sub-section.

6.3.1.3 The connectionist approach to the brain drain debate

Some developing countries have successfully capitalised on non-returnees in their productive sectors, and their experiences have challenged the idea that mobility would most likely end in brain drain for the sender countries. The most notable cases for these accounts are China and India, whose policies capitalise on ties with nationals abroad to collaborate in ambitious technological projects at home (Fangmeng, 2016; OECD, 2012b; Saxenian, 2005). Building on the evidence from these and similar cases, a recent body of literature has embraced the study of brain drain within a dimension that puts forward its positive feedback effects.

The works in this school of thought present an alternative approach that aims to afford a possible solution to the negative effects of brain drain and embodies concepts such as brain circulation, knowledge flows, and diaspora. This approach offers an alternative outlook on highly skilled migration that draws on the foundations of evolutionary economics, which see the relationship between knowledge and economy as a structure and process in constant change (Loasby, 2001, 2012). According to this approach, the benefits of knowledge do not come from this being a static stock, but a networked structure of complementary skills, infrastructure and technical equipment and codified knowledge (Cañibano & Potts, 2018).

Studies drawing on this approach come from different disciplines, ranging from the sociology of science, socio-economics of knowledge, science and technology and innovation studies, science policy and higher education studies, among others. These outline an optimistic view on migration in that they assert that return is not a condition for the home countries to access the benefits of sending nationals abroad. Instead of considering migration as unidirectional and driven by a rationale of maximisation of human capital returns, this viewpoint describes this phenomenon as circulatory and polycentric, and one that changes over time. It puts great value on the flows of knowledge and technology under the argument that national researchers living abroad are a source of potential solutions to tackle the social and economic problems in the home countries (Gibson & McKenzie, 2014).

This approach emerged as an alternative to the conceptual limitations of the human capital brain drain approach, which failed to alleviate the negative impacts in the sender countries (Meyer & Brown, 1999; Meyer, 2006). The underlying idea in this approach is that home countries can access the capital in domestic researchers through networks that connect these among themselves, and with peers at home. Initially, this was a policy initiative implemented by the Colombian government to support knowledge networks. This later became a line of thought in the study of the international mobility of researchers that sees scientific knowledge as a structure rather than as an aggregate.

According to the proponents of the connective approach, the human capital approach view on brain drain presents an unrealistic view of the migration of the highly skilled. This is because citizens who embodying valuable skills are not homogenous, do not respond exclusively to market signals and do not exist and make decisions in isolation (Meyer et al., 1997). The majority of scholars in this alternative approach draw on STI studies to investigate how mobile or migrant researchers interact within a national research system and how do they collaborate in global and local networks (Andújar et al., 2015; Saxenian, 2005). The most significant proposition of the scholars in this connective approach is that they present researchers as individuals that have accumulated substantial expertise and skills in their field, but who do not work in isolation. Due to the nature of scientific research, researchers "are deeply rooted in their networks, with their own skills being historically and physically contextualised" (Meyer, 2001, p. 96).

The connectionist approach stresses the need for broader explanatory frameworks, as the effects of brain drain need to be understood by the underlying mechanisms that shape the production and diffusion of scientific research. This approach looks at international mobility as systemic and transnational, where there are no winners or losers but collaborative exchanges (Davenport, 2004; Gibson & McKenzie, 2014; Kuznetzov, 2006b; Seguin et al., 2006). This approach is an attempt to present mobile people in real-time, as individuals that interpret the signals in their particular contexts, and who devise coping strategies to face the uncertainty about their future moves, and who evolve and modify the configurations of knowledge (Cañibano & Potts, 2018; Fernández-Zubieta et al., 2015).

The connective approach has also attracted criticisms, which is important to understand in order to conceptualise the international mobility of researchers. Main critiques include its shift to networks as empirical units of analysis rather than individual researchers without an explanation that substantiates why it is theoretically significant to look at networks rather than individuals. In this regard, the foundational assumptions of this approach have been heavily criticised because its empirical reliance on networks neglects the agency and context of individuals. In other words, the functioning of networks is contingent upon responsive individuals, the quality and frequency of exchanges, and whether the community of nationals abroad is sufficiently large and well developed (Gaillard & Gaillard, 2003b; 2001).

Other criticisms come from scholars that assert that, as a newly introduced concept, the connective approach is underdeveloped and not substantiated by a consistent strong theoretical body (Kenney et al., 2013). For instance, the most criticised limitations include that studies within this approach suggest that migration may not be permanent, i.e. nationals may return later, bringing with them the human capital accumulated abroad (Dustmann et al., 2011), and that even in the case of non-return, this can still result in positive network externalities (Boeri et al., 2012). However, these studies have not yet provided conceptual or empirical insights that will allow operationalising these assertions.

It is fair to say that the connective approach offers exciting possibilities for the study of international mobility of researchers and the design of corresponding policy responses. However, a trait of the connective approach is that there are no empirical studies to substantiate its claims, such as that suggest that there are optimal levels of brain drain (Gibson & McKenzie, 2011b). Additionally, there is little evidence concerning the configuration of these networks and their long-term effects (Cañibano & Woolley, 2012). It may be that the connective approach is appealing because it represents a sort of convenient solution to curb the adverse effects of brain drain, but its impact on the sender countries' research remains to be proven.

6.3.2 Policy responses to brain drain

The economic relevance of advanced research skills and international mobility makes these combined topics a matter of policy interest and brings an additional layer of complexity to the policy process. This is because while the benefits are desirable for all the involved and broader actors, there is a high financial cost in training researchers is costly for national governments (Blume-Kohout & Adhikari, 2016; Gaughan &

Robin, 2004; OECD, 2011a; Toner, 2011), and the international component is an extra cost. Moreover, countries face a potential risk, i.e. mobile researchers might not return (Beine et al., 2014; Tejeda, 2013; Tejeda & Bolay, 2010).

As presented in previous sections in this chapter, the issue of the effects of brain drain has long been the subject of economics literature. This is because according to human capital and endogenous theories of growth, the skills and knowledge embodied in individuals are the bases of economic growth and development (Romer, 2000).

This section will show that the existing literature, both from the traditional and the connective approach, addresses two main topics. The first topic centres on what entails a global competition for talent (Florida, 1991; OECD, 2008b). The second focuses on the global and fluid nature of the production of knowledge, for instance, the significance of the internationalisation of research training (Altbach & Knight, 2007; Serger & Wise, 2010). In the policymaking realm policy responses most commonly indicate reasoning that is driven by the fear of losing the highly trained, notably, driven by the accumulative approach.

6.3.2.1 The dominant policy approach in developed countries

Policy instruments vary across countries, but their rationales tend to share some similarities, i.e. policies aim to foster the mobility of researchers but also aim to control the flows of talent (Bauder, 2015; Welch & Zhen, 2008). Concerned about the negative effects of a shortage of talented researchers, developed economies invest in improving the skills of their nationals, and incentivise the inward mobility of foreign researchers and postgraduate students to prevent reductions in the national stock of knowledge and skills (Atkinson, 2005; Davenport, 2004; Mahroum, 2005; Saxenian, 2005).

Developed economies have a diverse range of incentives enabling their nationals to undergo international mobility, and their rationales stem from the need to stimulate excellence in research and to advance the ideology of collaborative research (Nedeva, 2013). Some examples of public instruments are the European Erasmus and Marie Curie programmes, the Lise Meitner programme in Austria and the Canada Research

Chairs Programme (King & Ruiz-Gelices, 2003; Narzenna, 2014; Shachar, 2006; Watson, 2010).

The leading research economies are central attractors and creators of talent. They stand out for their research systems that offer international students state-of-the-art training facilities, and encouraging environments for novel ideas. Similarly, the ensuing response of international students manifests in the rapid growth of enrolment in universities in developed countries. For instance, in 2011, the United States awarded 73,000 tertiary education degrees to international students, of which 29% were enrolled in advanced research programmes. In Switzerland, international students account for over half of the doctoral students, and they make up over 64% in Germany, 40% in New Zealand and in the United Kingdom. Likewise, they constitute more than 42% in France (Cañibano et al., 2017; OECD, 2014c).

The flows of research talent have transformed research systems in developed countries (host countries). This is because those that moved to developed countries in pursuit of their research training will most likely remain abroad after completion of their courses (Stephan et al., 2015; Van Bouwel et al., 2011a). For instance, Boeri et al. (2012) found that international students in doctoral courses in the USA, Canada and Australia stay after completion of their training and start an academic career in these countries.

In developed economies, international mobility is associated with circulation and collaboration, increased flows of new ideas, creativity and diversity, all of which are considered as crucial for the excellence in cutting-edge research (Børing et al., 2015; OECD, 2008d; Scellato et al., 2015). This rationalisation builds on the innovation-growth approach that portrays mobility in terms of the benefits offered by researchers within the labour force. The following quote from an OECD report illustrates the expectations set on the potential benefits of international mobility:

> *"The positive effects for the main host countries are the stimulation of innovation capacity, an increase in the stock of available human capital and the international dissemination of knowledge….(Additionally) Skilled migrants are a source of entrepreneurship in high growth areas,*

> *and of opportunities for exporting national technologies"* (OECD, 2002a, p. 03 and 86)

The literature suggests that developed countries offer better incentives for researchers – local and international – (Facchini & Lodigiani, 2014; Lowell, 2001), and have set better structures to prevent possible adverse effects if their nationals do not return through the use of diasporas (Kuznetzov, 2006a; OECD, 2012d, 2012c). A report published by the European Union indicates that the shared policy principle across country members is to strengthen the mobility of nationals and increase the attractiveness of the European research system for the national and international highly talented (Truco, 2018). This recommendation was echoed by the OECD, who stressed the importance of facilitating the entrance of young mobile researchers, notably doctoral and post-doctoral students, also academic leaders (OECD, 2018).

Some policy responses in the leading scientific countries have included measures to further the mobility of scientific elites across regions (Hunter et al., 2009; Laudel, 2005; Trippl, 2013). These measures aim to promote the transfer of knowledge between countries (Heitor et al., 2014b) and regional integration (Ackers & Gill, 2008a; Gaillard & Gaillard, 2001). Other policy measures comprise migration schemes, namely, visa and residence regimes that facilitate the entrance and long-term settlement of foreign-born prospect star scientists and entrepreneurs (Lee & Nathan, 2010; Mechtenberg & Strausz, 2008).

In summary, for developed economies, international mobility is a source of diversity and specialised skills and knowledge. Accordingly, their policies, driven by the accumulative assumptions in economic theory, have a strong tendency towards the attraction and retention of human capital.

6.3.2.2 The dominant policy approach in developing countries

Although the literature indicates that some developed economies have experienced losses in their stocks of researchers at some point in history (Stolz & Baten, 2012), the negative effects of international mobility are seen as being more harmful for developing countries.

Developing countries see mobility as a source for improved scientific and technological knowledge and global collaboration networks (Kapur & Mchale, 2005; OECD, 2008e). The fastest-growing economies in the Asia-Pacific region have the highest out-flows of nationals, followed by developing economies in Latin America and Africa (Docquier & Rapoport, 2007; OECD, 2008d). These countries mobilise resources to incentivise nationals to interact face-to-face with leading scholars in dynamic research environments. Developing countries invest in overseas training because, more often than not, their research systems lack the necessary capacities to meet the worldwide demands to produce researchers in relevant research problems (OECD, 2004). Thus, investments are expected to improve the capacity of national universities and researchers to produce better high-quality scientific outputs (UNESCO, 2013; Zweig, 2006).

However, these countries seemed to be in constant risk of losing their talented people to developed countries. This apparent risk is stronger for Latin America, Africa and some European countries such as Portugal and Italy. Asian countries tend to be more optimistic and indicate successful innovation-oriented policy interventions, in other words; these countries tend to have directed strategies to utilise the experiences learnt abroad to solve technological problems and foster the competitiveness of national industries in international markets (Filatotchev et al., 2011; Shen et al., 2016). Improving the national higher education system is a parallel rationale for mobility in these countries (Altbach, 2009).

Policy initiatives in developing countries often aim to foster the science and technology fields and operate through individual grants, which may require the beneficiaries to return to the home country. Examples of these initiatives are the King Abdullah Scholarship Program and the Brazil Scientific Mobility Program (formerly known as Science without Borders), the Chinese Government Scholarship, Becas Chile, the Scholarships Programme of Conacyt in Mexico and the Scholarship for Turkish Students to Study Abroad.

Some countries, such as Brazil and Turkey, have implemented financial incentives to attract the return of nationals living abroad. Some of these incentives, such as King

Abdullah and Turkish programmes include early-career research grants, housing and guaranteed job positions. In other cases, return is mandatory, but is not linked to secured job prospects. For instance, Chile and Brazil have introduced administrative measures to secure the return of nationals, which is thought to increase the efficiency of the instruments in place. These countries allocated mobility grants on a certified basis, i.e. beneficiaries must certify that they will return and will remain in the country for a period equivalent to their time receiving funds. If grantees decide to remain abroad or leave after the stipulated period, they have to reimburse the total amount of funds they received. In other cases, instruments have become more flexible, such as those of China and Korea that allow citizens to decide whether they want to return (Fangmeng, 2016; Filatotchev et al., 2011; Yoon, 1992).

The policy approach in these two countries shares similar traits with those of developed economies in that they not only send their nationals abroad but also manage schemes to attract and retain foreign talent (Kang et al., 2018), and capitalise on the capital of expatriates through diaspora networks (Ciumasu, 2010; Saxenian, 2001; Zweig et al., 2008). Thus, it is possible to say that developing countries not only depend on developed countries for progress, but they also have to compete for their own talented individuals.

The diaspora approach has been influential in prompting a growing number of countries to consider their qualified diaspora as a source of development. Instances of this are South Africa and Turkey, which maintain regular contact with the networks of nationals overseas (OECD, 2012b). In the Asian region, governments sponsor short-stay visits for the nationals living abroad to enable domestic talent to learn and to discuss with them solutions to local problems (Zweig, 2006). The principal aim behind these initiatives is to build networks to communicate business opportunities, in order to promote the transfer of knowledge, and access to the extended networks of nationals abroad (Fangmeng, 2016; Saxenian, 2003; Tejeda, 2013). Thus, policymakers are keen on finding the right policy balance between incentivising nationals to undergo international mobility and connecting with those that stay abroad.

Policy patterns across countries indicate that those leading the production of science are also leaders in attracting international talent. This pattern has triggered policy responses in the sender countries to retain or attract back their talented researchers. The underlying reasoning in both policy responses from receiving and sender countries is the expectation that improvements in national research will improve the national economy. In summary, the study of brain drain is mainly dominated by the human capital approach. In this approach, developing countries seemed to be without any prospect to replace the skilled emigrants. Such a situation is believed to intensify the shortage of skills in these countries, deepening educational and social problems, and which will expand the divide between developed and developing research systems, creating inequalities at the international level (Davenport, 2004; Mahroum, 2005; Van der Wende, 2015).

There are no straight forward solutions to the brain drain problem. For instance, even if national researchers return to the sender country, they will bring improved skills, knowledge and networks, but, most likely, their financial returns (wages) would be low (Thorn & Holm-Nielsen, 2006), which will illustrate that, in some cases, additional training may not have a positive impact on earnings (Özden & Schiff, 2006). At the research system level, this means that researchers may not be able to produce activities of high value, and their impact on the national research system will be limited. In consequence, the depreciation of human capital could promote the emigration of the returnees and can discourage younger nationals from acquiring further education (Robertson, 2006), which could deepen, even more, the scarcity of advanced research skills.

The contrasting arguments to the assertions in the human capital approach provided by the connective approach offer a more positive outlook to the negative effects of brain drain. The work of Cañibano & Woolley (2012) has highlighted that such arguments are not entirely new; these reiterate the propositions from Boulding (1968), Grubel and Scott (1966), who claimed that brain drain is not necessarily permanent and migrant researchers can introduce new ideas and cultures into domestic research. More recent proponents on this school of thought suggest that the emigration of nationals could incentivise education-seeking behaviour in young populations, which would ultimately result in increased human capital and economic growth (Beine et al., 2001, 2008; Commander et al., 2004; Ganguli, 2014)

The accumulative or allocative human capital brain drain-brain gain view is rooted in the assumption that the nations that could accumulate higher stocks of human capital would increase their potential to become powerhouses for knowledge and growth (Cañibano & Woolley, 2012). Conversely, countries lacking the resources to attract and accumulate research talent would experience detrimental effects at a large scale. This dominant framework has permeated into the policymaking realm, which seeks to control the flows of mobile researchers, driven by the fear of losing the race for scientific talent. Thus, more often than not, policy instruments for attraction and retention, in both developed and developing countries derive from the notion of obtaining benefits from public investments in human capital formation (Kerr et al., 2016; Tuccio, 2019; Wahba, 2015). The alternative approach proposes that international mobility could yield distributed benefits even if they do not return to the home country. Such an assertion has prompted policy reactions guided by its promise to prevent the negative effects of brain drain.

6.3.3 Implications for this study

As shown in the sections above, the literature still presents a mixed picture of how the international mobility of researchers affects the sender countries. It also shows that theoretical and policy approaches are deeply rooted in the expectation that researchers would respond to market incentives and that their embodied skills would spur the development of nations.

International mobility is essential for the improvement of research capacities at the individual and national level. Due to the individual nature of human capital, international mobility is not only a concern for S&T policies but also educational policies and labour policies in both developed and developing countries (Davenport, 2004). The policy responses trying to shape international mobility are grounded in the economic value of the specialised skills and knowledge of researchers, utilisation of which is expected to yield wider benefits for employers and society (Auriol, 2010; Auriol et al., 2013a; Bazeley, 1999b).

It is possible to say that policies embody the intentions, and financial capacity of governments to influence the decisions of what locations afford the more attractive conditions to perform research. In other words, policies configure the distributions of knowledge. As shown in this review, policies are a pervasive component in the internationalisation of research and are an indicator of scientific leadership and economic progress. Scholarly works from both the traditional and the alternative view, assume that policies are successful when countries can train, attract and retain, or connect with their talent abroad, which is ultimately another mechanism to accumulate knowledge.

The brain drain framework assumes the uni-directionality of flows of individuals and benefits. The beneficial effects would occur where mobile researchers stay, while the challenges are found in the location from where they left. This is because knowledge and skills are embodied in researchers; thus, their human capital travels with them. Consequently, policies are set to produce localised increases in human capital to produce change through the accumulation of skills and knowledge. The nations that are unable to achieve this task would suffer when the human capital migrates.

Moreover, brain drain entails the perception of ownership of knowledge and skills, and the perception and fear of losing these to other countries (Davenport, 2004). It is not surprising that policies pursue national interests and are funded through national resources, and that these are evaluated at the national level, most commonly through macroeconomic data and R&D indicators. The notion of brain drain has largely dominated the study of the mobility of researchers and related policies. Its primary focus is the geographical distribution and accumulation of research capacities. However, it overlooks the fact that mobility is a natural consequence of the globalisation of scientific research, and this may not respond, strictly, to financial incentives. The norms followed by the research communities are also a key factor behind the interests to undergo mobility. Moreover, this view ignores the fact that mobile researchers can be relevant for bridging access to knowledge and resources for their home country.

In summary, the traditional brain drain view seems to establish a distance between research skills and the complex dynamics of science. This is because it treats human capital as localised and isolated. In reality, this is networked, contextual, relational and complementary (Bozeman et al., 2001; Cañibano et al., 2017). In other words, researchers take with them their skills when they move locations, but these are not transferred automatically to the research system. Due to mobility, the role of mobile researchers in the research systems is redefined, as they do not produce outstanding research in isolation. In the same line, the potential economic benefits that can be derived from their scientific activities can only occur if the necessary conditions are in place.

Researchers are a particular group of individuals who may not respond to market signals alone. They can also be driven by intrinsic motivations, ideologies, and values that seek to push the frontiers of knowledge and reap the reputational benefits of being part of the global scientific community. Thus, this study posits that looking at policies associated with international mobility only in terms of losses and gains will be an oversimplification of the behaviour of the scientific profession, which is composed of collective influences across and beyond borders (Ackers, 2005a; Cañibano & Woolley, 2012).

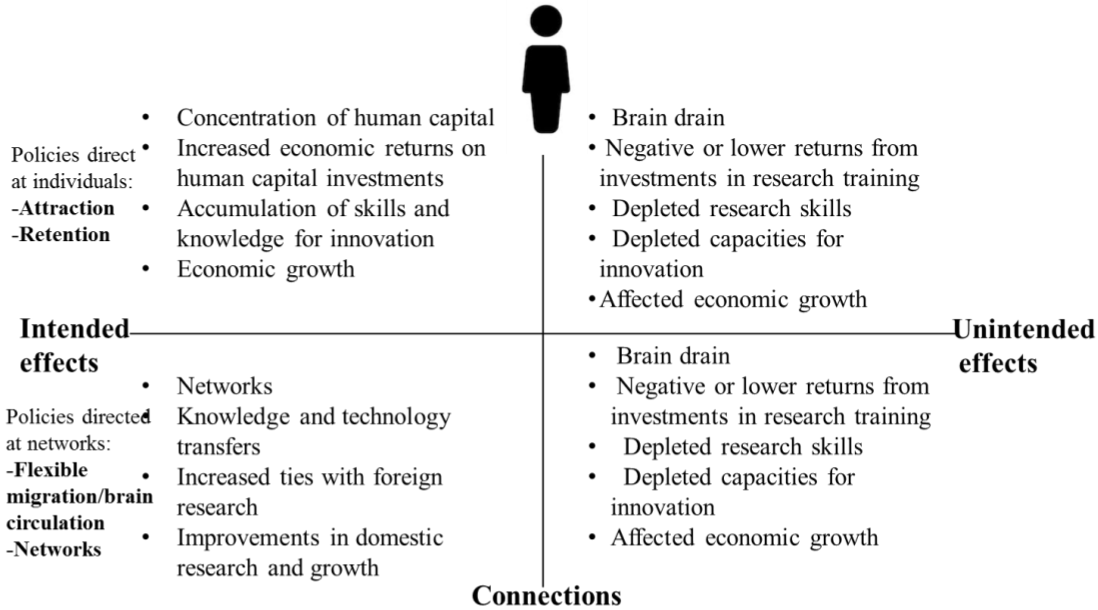
Additionally, such oversimplification will ignore that policies exist in a specific context, influenced by different forces such as political pressures, budget constraints, and which are also subjected to the interpretations of its beneficiaries. Thus, policies exist in a specific space and can produce effects that the traditional brain drain framework does not recognise. With this in mind, and drawing on Cañibano & Woolley (2012), this thesis posits that scientific mobility is a continuous and interdependent process that changes over time, and which can be affected by multiple factors in economic and social structures.

The alternative framework possesses its challenges when trying to explain the role of policies in shaping scientific mobility, for instance, “it may overstate the opportunities for positive effects on developing countries” (Gibson & McKenzie, 2014, p. 1494). Moreover, it assumes reciprocity and affinity between mobile researchers and researchers in their home country, and that their collaborations would compensate for the effects of brain drain. However, this approach does little to explain the effects that these collaborations produce, and the power of policies to lead to influence their emergence. The connectionist approach does not distinguish whether benefits are a consequence of international mobility alone or other factors. For instance, it does not explain who leads the flows of knowledge in the diaspora networks, the effects of diasporas in research activities, and the implications of these collaborations for researchers; e.g. in their career paths, management of workloads, career progress. It is worth noting that the possible negative effects of diaspora networks are less discussed in the literature, but these can be assumed to be the very same effects of brain drain, uneven accumulation of knowledge.

The value of this view to the study of S&T policies lies in its network approach, which considers knowledge transfers as an element to understand how policies shape international mobility.

Figure 10 summarises the research and policy approaches presented in the sections above. It comprises the main domains of intervention set by policy instruments; that is the individual researchers on the one hand and connections or networks on the other.

Figure 10 Summary of the two dominant views



6.3.3.1 A policy analysis of the international mobility of researchers

This thesis undertakes the study of an S&T policy instrument that facilitates international mobility following a balanced and reflective use of the established frameworks. This research does not assume positive or negative effects as a result of the international mobility of researchers. Instead, it explores the influence of policy in this process by looking at how policy works, that is understanding the policy objectives, resources, established institutions and interactions around it and the actors involved in its implementation. The reason for this is that this study assumes that research is a global activity, with its own internal dynamics that calls for empirical evidence to substantiate what effects or changes policies produce in it and how.

The strong focus of the current literature on losses and gains, centred on the accumulation of skills, technological change and economic growth cannot explain the variety of effects that unfold from the international mobility of researchers in the sender countries. This study aims to fill this gap by investigating an international mobility policy instrument in a developing country by exploring the characteristics and responses of its beneficiaries.

6.4 MOTIVATIONS FOR INTERNATIONAL SCIENTIFIC MOBILITY AND ITS EFFECTS ON RESEARCHERS

Policy instruments, even those underpinned by the alternative connectionist approach, seek to accumulate the research capacities in mobile researchers. Policies aim to build these capacities by investing in researchers and expect that interventions would produce individual benefits and expanded networks, which would place national research in the larger scientific community (Gaughan & Bozeman, 2018).

Policy makers assume that researchers would respond to their incentives, and this would trigger the intended change or would foster certain behaviours. Thus, reviewing the motivations that lead researchers to move abroad is a starting point towards understanding how policies aim to shape this process. This will make it possible to see that multiple factors shape the mobility of researchers.

The economic literature has traditionally presented researchers as individuals driven by extrinsic rewards. For instance, Boeri et al. (2012) assert that this type of mobility can be explained by the financial incentives of foreign labour markets and better opportunities for study and work, which are also associated with future financial returns, notably better salaries. These incentives, known as pull-factors, attract mobile researchers to destinations outside their home countries. National conditions negatively affecting the research system and, in consequence, affecting individual researchers work as push-factors that incentivise migration (Bloch et al., 2015; OECD, 2008d).

The central assertion of this literature is that researchers, like any other individuals in other professions, react to market signals; thus, economic incentives define the flows of migration from developing to developed countries. However, it ignores the fact that the ambitions of researchers are not necessarily strictly economic. As shown in Table 15, mobility drivers comprise more than pecuniary dimensions.

Table 15 Drivers of international mobility of researchers

Type of motivation	Factors
Economic	• Better salaries • Labour market conditions • Quality of life • Welfare • Higher return for skills • Shortage of skilled labour • Cost of migration • Labour market regulations
Professional	• Career development • Labour market conditions (facilities and demand for talent) • Research and development spending • Access to research resources • Financial support for studies or training abroad • To acquire knowledge and first rate education in the best centres of the world • The pursuit a successful career abroad (stage of career) • Interactions with peers of international recognition/collaboration • Reputational the host organisation
Epistemic	• To acquire knowledge and first rate education in the best centres of the world • Scientific cultures

Type of motivation	Factors
	• Interactions with peers of international recognition/collaboration • Existing professional connections abroad
Personal	• Enabling migration policies • Existing personal connections abroad • Sociocultural and policy regimes • Family related factors (two-body problem, schooling and childcare) • Cultural and linguistic compatibility • Geographic proximity • Cost of migration

Based on: Ackers (2005a, 2008); Appelt, et al. (2015); Auriol (2007); Avramov (2015); Bhawati & Hamada (1974); Beine et al. (2014; 2001); Børing et al. (2015); Cañibano et al. (2017); Czaika & Orazbayev (2018); Doquier & Rapoport (2012); Hatton & Williamson (2002); Gibson & McKenzie (2014); Guth & Gill (2008); Halme et al. (2012); Humphries et al. (2013); Jöns (2007); Kaczmarczyk (2010); Lee & Kim (2010); Musselin (2004b, 2013); Saxenian (2001); Schubert and Sooryamoorthy (2009); Solimano (2005, 2008); OECD (2008e); Van Bouwel (2010); Van Bouwel et al. (2011b)

This table was constructed as the result of the review of scientific mobility literature. Four main types of motivations were identified, namely, economic, professional, epistemic and personal.

6.4.1 Economic motivations

Among economic factors, the existing literature asserts that salaries and financial incentives pull researchers to more developed economies.

Most of the literature on economic motivations builds on the assertion that the international labour market will attract (pull) researchers to the workplaces that offer the best financial incentives (Giannoccolo, 2006; Scellato et al., 2015). Economic motivations also relate to general legislations that regulate mobility to and from a country. Immigration rules facilitate or inhibit the entry of the highly educated, as visa and residence permits are opportunities for long-term settlement in the country, which reflects stability and the sense of belonging for the immigrants. For instance, stringent immigration restrictions may be the grounds for deciding to not move. Thus, overall, the economic motivations behind scientific mobility reflect concerns for a good and stable way of life.

6.4.2 Professional motivations

Professional motivations are complex and difficult to disentangle from other possible drivers, such as better salaries and reputation. Thus, these motivations are assumed to be accompanied by the other three types of motivations. In the academic profession, international mobility is closely connected to career development, as this is expected to open opportunities for better positions in the home country after return, and increases the possibilities for finding a job abroad. The career-related factors affecting the decision to move abroad concern the availability of career opportunities in the host country, such as national expenditures on science and technology and the access for foreigners to these resources.

Other professional-related factors relate to the reputational aspects associated with international experience. These factors are, for instance, the reputation of the host organisation or the reputation of the country as an attractive destination for highly skilled people (Ackers, 2008). These factors stem from the mobile researchers' research agenda, and their perspectives of social status in their local and global research community. Career-related motivations reflect researchers' interests for opportunities to produce relevant research results with the resources and the infrastructure of the host organisation and country. In addition to this, working in an encouraging and reputable place will enable mobile researchers to establish prestigious professional networks.

6.4.3 Epistemic motivations

While economic and career-growth-related factors have been largely discussed in the literature, epistemic motivations have been left unexplored. These motivations concern the affinity of research interest, methodologies and interpretations of research problems among researchers. The difficulty of realising and identifying these in mobile researchers is not a trivial task, and this may explain why these are less discussed.

Epistemic motivations seem to be strongly linked to the sense of belonging in a scientific community. This is associated with the acceptance of peers, and encompasses a diverse range of elements that define the identity of researchers and their potential influence and contributions in their fields (Jöns, 2015). Moreover, according to Lam (2018), international mobility nurtures researchers' specific roles in their community according to their situational demands, which steadily shapes their sense of identity. Such identities become crucial in the configuration of knowledge production structures (Cañibano et al., 2017).

When it comes to an understanding of the epistemic motivations driving scientific mobility, the literature commonly assumes that there is some epistemic affinity between the researchers willing to move outside their home country and the host group (Jöns, 2007), although, researchers can also face an "epistemic drift" as a result of their decision to move to engage in a particular research group. This epistemic drift entails a reorientation of research agendas, methods, philosophies, in other words, re-adaptations of the research practices and culture. It is reasonable to assume that mobile researchers in the earlier stages of their careers will be more exposed to epistemological drifts, and these will affect their career path and place in their community.

Epistemological drifts are not necessarily negative, as mobility favours exchanges of research practices, diversity and prevents adoption of a narrower view of the research field (Bäker, 2015a), and may, particularly at the early stage, advance and promote the career and collaboration networks of the mobile researchers (Casey et al., 2001; Jöns, 2007; Laudel & Bielick, 2019). Seeing researchers as "epistemic agents" that are intrinsically driven to develop new ideas (Braun, 2012), international mobility helps researchers identify, in other geographical locations, peers with similar interests and new possible sources of ideas (Gibson & McKenzie, 2014).

The position and role of researchers in their epistemic communities will affect their career development opportunities. This is because being part of a community taps into the research agenda, community networks, research focus, internal hierarchies, organisation of resources, flows of knowledge and research resources, among others (Crawford et al., 1993; Heffernan & Jöns, 2013).

6.4.4 *Personal motivations*

There are some significant overlaps between the factors for scientific mobility, for instance, the labour market conditions in the destination country appear in both economic and professional motivations. However, personal motivations reveal individual circumstances unrelated to any other type of motivation. As shown in Table 15, personal factors stem from the socio-cultural biographical context (Jöns, 2007). Language and cultural regimes are significant (Laudel & Bielick, 2019), as these reflect affinity, acceptance and facility of adaptation in the host society.

Enabling policy regimes are also important, as these seem to invite researchers to explore new horizons outside their home country (Gibson & McKenzie, 2011a). This is because entry and residence instruments reflect opportunities for long-term and stable settlement in the country. In this regard, Beine et al. (2014) showed that proximity, personal networks in the destination country and quality of education in the host country could influence researchers and students to migrate. Also, opportunistic decisions can lead researchers to migrate, as geographical proximity and family relations in the host country can make their entrance and adaptation smoother. Both entrance and adaptation costs are important when pondering the cost involved in leaving or staying (Ackers, 2005a; Fiore et al., 2015).

The factors driving the decisions to migrate vary and are interwoven. Economic and financial factors are relevant, as shown in the table above, but these alone do not explain why researchers are willing to move abroad. Market mechanisms, as such wages and adjustments in the labour market, dominate the debate on the economic aspects of international mobility. Works from the sociology of science, socio-economic analysis and science and technology studies have brought a more balanced view of the forces driving this phenomenon, and present it as dependent on a variety of professional, epistemic and personal factors. For instance, Casey et al. (2001) posit that the international mobility of researchers is not like any other type of mobility; researchers move due to a wide range of possible factors, ranging from seeking an encouraging research environment, existing networks, previous training, career opportunities and future cognitive ambitions, or due to luck.

Interestingly, some scholars have stressed that these factors are not homogenous across research fields. For instance, studies have found that researchers in physics are not expected to move from the same reasons as those in biology or the social sciences. See Laudel & Bielick (2019); Cantwell (2011); Ackers (2008), Cañibano et al., (2008). Similarly, Gaughan & Robin, (2004); Musselin (2004a) and Jöns (2007, 2015) assert that scientific mobility is also contingent upon spatial configurations of scientific knowledge, career-related organisational and national arrangements.

These works do not disregard the economic component in this phenomenon, but do not consider it as a determinant. Instead, they suggest that motivations to move relate to a variety of factors, such as professional growth and personal preferences (Ackers, 2005a; Dietz et al., 2000; Iredale, 2001; Jacob & Meek, 2013). More importantly, these contributions point to the particular dynamics of scientific research. These see scientific communities as magnets for international researchers, and mobile researchers as vehicles of change in research cultures – both for their home and host countries (Cañibano et al., 2017). In short, researchers are driven by a variety of factors ranging from purely intrinsic scientific goals to economic, personal, and career development goals. Also, in some circumstances, mobility can be reputational, a contractual or a funding requirement.

6.4.5 Effects of international mobility on researchers

Studies looking at the effects of international mobility at the individual level tend to focus on productivity and quality increases on the research activities and outputs of researchers. According to these studies, researchers with international experience produce more and better research than their domestic counterparts (Dubois, Pierre et al., 2014; Franzoni et al., 2014; Gibson & McKenzie, 2014; Halevi et al., 2016; Scellato & Stephan, 2012). Other measurements include the impact of mobility in citations, patents, co-authorship, better job prospects and access to national funds (Andújar et al., 2015; Fernández-Zubieta et al., 2015; Geuna, 2015; Lawson et al., 2015; Müller et al., 2018). At the organisational level, the benefits of international mobility are commonly assumed as aggregations of the individual benefits accrued by mobile researchers.

Table 16 summarises the effects reported in the reviewed literature.

Table 16 Effects of scientific mobility

Outcomes	Source
Better performance/ publications productivity (early career researchers) **Similarities in impact through citations between returnees and non-returnees**	Robinson, et al. (2016) Franzoni, et al. (2015) Geuna (2015)
Better performance/publications productivity	Gibson & McKenzie (2014) Cruz-Castro & Sanz-Menendez (2010) Fernández-Zubieta et al. (2015) OECD (2015b) Fangmeng & Tian (2016) Veugelers & Bouwel (2015) Geuna (2015) Asknes et al. (2013)
Higher citation impact	Asknes et al.(2013) OECD (2015b) Fangmeng & Tian (2016)
Better performance/publications, grants and patents	Filatotchev (2011) Ha et al. (2014) Lu & Zhang (2015)
Co-authorship, collaboration and networks	Moed et al. (2013) Bennion & Locke (2010) Rostan & Hole (2014) Stephan et al. (2014) Scellato et al. (2014) Gibson & McKenzie (2014) Veugelers & Bouwel (2015)
Increased success in competitive funding applications	Locke & Bennion (2010)
Academic career progress	Dubois, et al. (2014) Watson (2010) Laudel (2005) Veugelers & Bouwel (2015) King & Ruiz-Gelices, (2003) Bauder (2015) Børing, et al. (2015) Muller, et al. (2018)

Access to international networks is also widely mentioned in the literature (Ackers & Gill, 2008; Leung, 2013; Scellato et al., 2015; Scellato & Stephan, 2012). A number of works tended to hint other less visible outcomes, such as that mobile researchers are equipped with a broader set of skills and may receive more institutional support to start their career than local researchers (Bennion & Locke, 2010; Johnson & Regets, 1998; Regets, 2007). According to Bozeman et al., (2001), networks and the complementary assets of researchers can be conceptualised as social capital. Social capital has an intimate interplay with human capital and physical technologies, which is central to understanding the dynamics of change in individual researchers, their communities and science.

Most works looked at effects in terms of benefits in knowledge productivity and career development opportunities. A more nuanced approach comes from Halevi et al. (2016), who assert that there are unquestionable individual benefits in international mobility, but that there is also a process of adjustment and adaptation, which can delay productivity and recognition from the new peers.

Another caveat come from Marinelli et al. (2013), who suggest that international mobility does not guarantee career progress through permanent and stable positions. Similarly, Müller et al. (2018) found that researchers with foreign training achieved greater career success than their peers trained domestically, but this was the result of self-selection effects and not a consequence of international doctoral training. In other words, the "perceived" superiority in training may give mobile researchers access to better career opportunities. In addition, Cañibano et al. (2008) found that for researchers in the fields of physics and philosophy, there was insufficient evidence to substantiate an association between international mobility and research productivity.

6.4.6 Implications for this study

Two implications for this research emerge from this review. The first is that most literature focuses on either early career researchers, namely doctoral students and postdocs or established researchers, but these groups have rarely been brought together into an examination. Comparing these two cohorts will explain how motivations vary according to the career stage of researchers.

Assuming that doctoral and postdoctoral researchers are the most mobile is not far from the truth as they expect that mobility would increase their career prospects, and would affect their potential career development. In the same line, an assumption in this research is that for established researchers, or those in their path towards a stable career, the reasons for migrating might be driven more for epistemic and professional reasons than economic. In this regard, Stephan et al. (2014) indicated that, in general, researchers undertake mobility for three central reasons: 1) the level of resources in the home country for a research career; 2) higher value on training outside the country in the home's labour market, and 3) personal situations and preferences. However, literature still fails to investigate in detail what factors underpin mobility among doctoral students and researchers already with some type of established career.

Second, most literature is rooted in the reasoning that draws on the idea that mobility can spur productivity, the optimal use of skills and knowledge that is reciprocated by maximised returns, and which is interpreted as direct advantages for high-status qualifications and access to better jobs (Børing et al., 2015; OECD, 2008c). Also, it assumes that international mobility would strengthen the research system when this affords the incentives to attract researchers and utilise their competences. Guided by this assertion, policymakers and scholars interpret international mobility as intrinsically beneficial for all the involved actors. However, there is little evidence on what are the actual effects that are transferred into the research systems.

With this in mind, this study posits that the international mobility of researchers is shaped by a complex mixture of different considerations, which are likely to vary over time (i.e. after having spent some time abroad), and its effects can be distributed over different dimensions across a national research system.

6.5 SUMMARY

The literature review in this chapter has presented the theoretical building blocks of this study. It began by highlighting the relevance of advanced research skills and the value of international mobility in the research profession. It also presented the dominant approaches in the study of international mobility, which are also dominant in policy rationales.

Predominantly, the literature sees the international mobility of researchers using the brain drain/brain gain approach, which builds on the economic view that the accumulation of human capital would deliver growth and international competitiveness. Accordingly, policies embody reactive responses to the fear of losing such valuable assets and the negative implications thereof. The alternative approach to this draws on the idea of knowledge as a structure rather than as stock. This emerging view asserts that sender countries could benefit from brain drain in that networks would connect and organise the nationals living abroad with domestic peers. The knowledge and technology transfers organised around these networks are expected to ameliorate the possible potential effects of migration and can contribute to growth in the home country. This assertion embodies the reasoning of the alternative "connectionist" approach, but empirical and conceptual consensuses are its main limitations.

A common characteristic in the reviewed literature is that arguments are biased towards resources availability in the destination and sending countries. This means that the capacity of nations to capitalise on investments in research training is contingent upon the resources to attract, retain, and connect researchers. Thus, researchers and policymakers tend to address international mobility as competition for talent.

PART III THEORY AND METHODS

CHAPTER 7 ANALYTICAL APPROACHES FOR POLICY ANALYSIS

7.1 INTRODUCTION

As the previous chapter shows, governments design and implement policies to promote international mobility among researchers and to attract and retain this talent. Policies are the principal tools through which governments attempt to control the flows of research talent and configure the distribution of knowledge. The arguments in the reviewed literature have helped frame the research questions in this study (see Chapter 1) in terms of how international mobility policy works. In order to bring some responses, this chapter will explore possible frameworks to analyse an S&T policy instrument, notably, the Scholarship Programme.

The motivation and scope of this study required an analytical framework conducive to investigating policies under a realistic outlook. This research moves away from the traditional programme theory evaluation practice, that rests on linear models of impact and causality (see Milzow et al. (2018) and White (2010)). Instead of attempting to trace one-way causality, this study brings forward the notion that policies are pivotal, but not the only, factor influencing change. This idea is not new; Pawson & Tilley (1997) emphasised that realistic evaluations should explore particular mechanisms that enable change to occur. Consequently, this research embraces a critical examination of the interplay between the Programme and its beneficiaries. This study begins by understanding the assumptions underlying public intervention in international scientific mobility (see Chapter 6). Ultimately, the analysis of effects is done guided by the assumption that the characteristics of beneficiaries, interest and interpretations to policies are also causal pathways of impact.

Thus, this chapter will seek for an appropriate framework, one that can afford analysis of the possible dimensions that influence change. A suitable framework will enable an examination of complex interdependencies, which will involve an attempt to pinpoint the configuration of features that explain how the programme works. It will also involve the characterisation of effects as the result of multifaceted mechanisms operating in a particular context (Pawson & Tilley, 1997). Ultimately, the chapter justifies the selection of a comprehensive analytical framework to elucidate the peculiarities of the Programme and how it relates to specific changes in its beneficiaries and the phenomenon under study. Through the selected framework, this research advocates a theory-led and in-depth view in the study of S&T policies, particularly in those promoting scientific mobility.

This chapter is organised as follows. Section 7.2 presents the background of policy analysis, also known as policy evaluation in the literature. Section 7.3 describes the measures and approaches with which academic works look at international mobility. Section 7.4 offers a review of two analytical frameworks to analyse policies and change in research systems. These frameworks are assessed in terms of their capacity to be used in the analysis of complex policies. This section also presents a justification for the selection of the research fields and research spaces framework. Section 7.5 operationalises the concepts presented in the preceding section, as well as the adopted definition of effects; the mechanisms to attribute these effects to policy, and the empirical scope of analysis of this thesis. Section 7.6 summarises.

7.2 POLICY EVALUATION APPROACHES IN S&T

Science and Technology (S&T) policies are widely acknowledged for their potential to increase scientific, social and economic progress. Motivated by this potential, policymakers devise the instruments that could help a nation to build and to enhance the necessary capacities to produce high-value research outputs. S&T is commonly seen as a state-led undertaking (Veugelers & Schweiger, 2015), where policies transfer the intentions of the government and its resources to individuals and organisations.

Policies are expected to change or adapt the behaviour desired in the targeted actors, typically aiming to produce valuable research products that will ultimately increase the possibilities of creating innovation and wealth. The rationale for public intervention in S&T is cast in accumulative terms concerning increases in research talent and the repositioning of economies – seen though economic growth – to face international competitiveness and competition. This pro-growth bias is rooted in the assumption that policies will produce the intended change and will deliver benefits for the users of S&T and the broader society. This bias can also be substantiated by the pressures for performance and comparability between countries (Henriques & Larédo, 2013; Lepori et al., 2014).

S&T policy instruments are intended to address the failures that prevent research systems from achieving a desirable competitive status (Arnold, 2004; Nelson, 2008). A distinctive attribute in these policies is their focus on the process of knowledge production, which can include strategies to further the production of excellent research, promote the utilisation of knowledge, and enhance the organisational setting that supports all these processes.

In line with the increasing interests of governments in shaping S&T and reductions of public resources, evaluations of policy measures have started to connect the process of policymaking with exercises assessing the effectiveness and efficiency of policy-led changes. This is thought to support, with an objective and reliable basis, the decisions of what instruments are the most adequate to the situation at hand (Amanatidou et al., 2014). Moreover, evaluations have become a source of legitimacy for the use of public resources in scientific research issues (Lascoumes & Le Gales, 2007; Sanz-Menéndez, 1997).

The concern among policymakers for selecting the best policy instruments is not only the result of an intrinsic interest in doing things better, but it is also a result of budget reductions for public research and a widespread culture of accountability and performance (Nedeva et al., 2014). In this context, public resources are expected to be allocated transparently and used efficiently and effectively, and policies are expected to deliver positive results.

The interest of policymakers in policy evaluation has been accompanied by the interest of academics, whose concerns relate to learning how policies work, how they affect the production of research and in devising appropriate methods for its study (Benner & Sandström, 2000; Bozeman & Gaughan, 2007). Academics often emphasise that S&T policies are hard to assess comprehensively due to their inherently complex nature (Borrás & Laatsit, 2019; Molas-Gallart & Davies, 2006), and that conceptual frameworks are not yet well developed to achieve such a task (Nedeva, 2010).

There is a strong tradition in S&T policy evaluation practice to focus on the extent to which policies solve the targeted issue. This traditional approach can be characterised by the use of existing evidence to prompt the translation of inputs and measured outcomes into quantifiable indicators of success. In other words, most S&T policy evaluation works are programme-theory assessments (Borrás & Laatsit, 2019a; Molas-Gallart & Davies, 2006), that is, they link the justification for a policy instrument to the objectives of that instrument, its inputs, process, outputs and outcomes. The analytical groundings in these evaluations rest on the – sometimes as complementary or sometimes as central – use of the logic model to test and refine the assumed connections between a programme and its projected impacts. See, for instance, Donaldson & Gooler (2003), Hewitt-Dundas & Roper (2011) and Milzow et al. (2018). Under the programme theory framework, policies are categorised as successful or unsuccessful, based on traces of causality that are understood to indicate whether the programme achieved its aims (Sharaput, 2012).

For the most, policy evaluations try to measure the impact of policies on the quality of the knowledge produced by beneficiaries. These measurements are then linked to the potential effects that those improvements can have on the economy and society (Smits et al., 2010). The pro-growth bias in policymaking has permeated the study of policies. This traditional framework faces some challenges, for instance, there is an ongoing debate about the extent to which it is possible to conceptualise, identify and attribute changes in S&T to policies (Bozeman & Sarewitz, 2011; Nedeva et al., 2014).

Another limitation in this framework is that it does not provide a realistic picture of how policies work, i.e., it falls short of an exploration of the broader spectrum of scenarios that can occur around the implementation of a policy instrument (Boden et al., 2006; Reale & Seeber, 2013). In this regard, some scholars have asserted that traditional views about policies – as instruments that solve failures – limit the possible empirical choices and the scope of intervention for policies. Furthermore, traditional evaluations tend to neglect the presence of other hidden effects (Milzow et al., 2018; Molas-Gallart & Davies, 2006).

In line with the relevance and challenges involved in the analysis of policies, the following section examines two frameworks for the study of an instrument that fosters international mobility. The following material also substantiates the choice of the selected framework.

7.3 ASSESSMENT OF INTERNATIONAL MOBILITY OF RESEARCHERS

The anticipation of economic benefits underpins the mobilisation of public resources into S&T policies, including international mobility initiatives. This reasoning – that can be found between the patterns of S&T policies and the understandings that associate S&T and wealth – can explain the high expectations and pressures on policies to enhance outputs and benefits. It can also explain the growing international focus on these policies and their capacity to deliver the expected outcomes.

The difficulties in studying international mobility were the most mentioned issue in the reviewed literature. Methodological issues include the lack of data and inconsistency in cross-country data (Børing et al., 2015; OECD, 2004). Exhaustive efforts to measure the magnitude to this phenomenon are presented by Boeri et al. (2012); Docquier &Marfouk (2004); Mahroum (2000); Marginson & Van der Wende (2007) and OECD (OECD, 2008e, 2010a). These works draw on national census data sets and survey data, such as the NSF's Survey of Doctorate Recipients to calculate the outflows of highly skilled people for a large set of OECD countries. Similar studies are presented by Docquier & Rapoport (2009; 2012) and Veugelers & Van Bouwel (2015).

Other efforts are those of the MORE2 project that aimed to "provide internationally comparable data, indicators and analysis in order to support further evidence-based policy development on the research profession at European and national level." (IDEA Consult, 2013, p. 6). The MORE2 project consisted of two surveys conducted in 2012. One survey was directed at researchers in European HE&RIs and another was directed at European researchers living outside Europe. Works drawing on the data produced by these surveys encompassed the following topics are: the employment choices of mobile researchers (Janger & Nowotny, 2016), flows and global trends of mobility

((Guthrie, 2017) and Terzi, 2015)), the patterns and drivers of return mobility of European researchers Cañibano et al., (2017), and one more on the value of surveys as tools to gather and standardise data on international mobility (Teichler, 2015).

One key feature noted in these survey-based studies is the increased intensity of international mobility among researchers after the 1990s. Most of these works focused on improving quantitative indicators to build a standard measurement of researcher mobility and aim to build homogeneous criteria for international comparisons. For studies based on a survey among some OECD countries see Auriol et al. (2010, 2013a, 2013b). Other contributions to the general literature drawing on targeted surveys include Scellato et al. (2012); Franzoni et al. (2012); Gibson and McKenzie (2014) and Trippl (2013). Mostly, survey-based studies tend to focus on inflows and outflows of researchers, countries of origin and destination. A notable contribution came from the MORE2 surveys, in addition to indicators on the magnitude and patterns of mobility flows, was information on the factors conditioning geographical trajectories. Along with the work of Auriol (op. cit) , the MORE2 project aimed to provide valuable information to construct the career paths for mobile researchers, particularly early-career researchers.

Further sets of literature have employed CV information (Bozeman & Corley, 2004; Cañibano et al., 2008; Dietz et al., 2000; Jonkers & Tijssen, 2008) a combination of these sources (Hunter et al., 2009) and bibliometric and patent data (Baruffaldi & Landoni, 2012; Jonkers & Cruz-Castro, 2013; Moed & Halevi, 2014; Trajtenberg, 2005).

In addition to the empirical challenges above, unclear definitions of central concepts are also problematic. The most commonly mentioned are the lack of consensus on the definition of highly skilled workers, the length of the stay, the type of training acquired abroad, and the value of the work performed by the mobile researcher (Laudel, 2005; OECD, 2002b; Solimano, 2008). In summary, significant efforts have been made to design consistent and comprehensive empirical tools that will allow the exploration of the international mobility of researchers, its causes and its effects. However, many of these endeavours remain focused on quantitative and homogenous indicators (See, for instance, Mahroum, 2000; Qin, 2015; Scellato et al., 2015).

Literature from higher education studies, the sociology of knowledge and migration studies have looked at the relevant social dimensions of this phenomenon. Dimensions have included the study of the effects of mobility on the career progress of researchers and adoption of new cultural and academic identities. See Coey (2018), Kim, (2017), King & Ruiz-Gelices (2003), Lam (2014, 2018).

7.3.1 Adopting a policy analysis approach to identify the effects of international mobility for developing countries

Geographical mobility between countries is increasingly being encouraged at the policy level. A clear picture emerged in the literature review in Chapter 6 of the way in which the conceptualisation of international mobility reflects on policy reasoning and formulation. This is seen as a state-led process, in which governments expect researchers to follow the research money and re-locate to destinations that would deliver these financial incentives. Primarily, government-led instruments consist of funding schemes for scientific training, research grants, visa schemes, degree recognition, employment opportunities after studies and tax benefits, among others (Appelt, et al., 2015; Guthrie et al., 2017; Lowell & Findlay, 2001; Mahroum, 2005; OECD, 2014a).

The literature characterises policies as critical for shaping the international flows of researchers. It highlights the widespread belief that public interventions can determine whether economies will benefit from mobile talent (Kuznetsov, 2013; OECD, 2012e; Wang et al., 2015). Traditional evaluation approaches adopt definitions for the success of instruments according to whether the sender country can accrue the benefits of such investments as opposed to suffering negative effects from brain drain. In other words, the evaluation for international mobility instruments remains fixated on the dimension of competition for talent.

Most analytical policy studies examine the causal dimensions, for instance, to show the impact of mobility on collaboration patterns, productivity enhancement or job securement. See Gonzalez et al. (2011), who examined the Erasmus mobility programme; the work of Andújar et al. (2015) on the Spanish Ramón y Cajal programme; and Arenas et al. (2001) and Castaños-Lonmitz (2003), who examined Conacyt's Scholarship Programme. These works focused on the presence or absence of increasing outputs consistent with changes in the allocation of resources.

Despite existing efforts to understand the workings of policies, there is insufficient evidence as to how policies can influence changes in a process that occurs between national and international research contexts.

This thesis posits that policy instruments reflect political and social values, historical precedents and intentions for a desired future state or change in actors' behaviours. In other words, policies can, to a certain extent, shape international mobility, "its magnitude and direction" (Appelt et al., 2015, p. 14). However, due to the multifaceted nature of scientific mobility, on the one hand, and the intricate workings of policy instruments, on the other hand, the interplay between these two can produce a wide range of effects. These can, for instance, change the perceptions about the value of international mobility of researchers. Accordingly, research around these issues should explore the mechanisms that enabled effects to occur and the contribution of policy to these.

By adopting a policy analysis perspective, this study aims to understand how the combination between the implementation of a policy programme and the individual actions of mobile researchers creates a broader setting for change.

7.4 REVIEW OF ANALYTICAL FRAMEWORKS TO STUDY POLICIES FOR INTERNATIONAL SCIENTIFIC MOBILITY

From the literature review in Chapter 6 emerged that human capital theory pervades the scholarly debate on international mobility. The underpinning assumptions in the human capital analytical framework, notably, brain drain, can be summarised as follows: 1) policies should increase knowledge stocks; 2) actors are driven by financial gains and will respond to market signals; 3) increases in S&T investments would turn into increased benefits for individuals, and into productivity and growth at higher levels of social aggregation; 4) optimal levels of human capital stocks and mobility flows. See Cañibano & Potts (2018); Cañibano & Woolley (2012); Dietz & Bozeman (2005).

Chapter 6 has outlined the limitations of the brain drain framework. The main limitation this framework holds for the present study is that it looks at policies in terms of returns, i.e. it centres around discrete outcomes that will point towards a sort of recuperation of the investments in researchers.

This section presents two frameworks that explore the relationship between S&T policies, dynamics of international scientific mobility and change. The reviewed frameworks are those concerning the National Innovation Systems and Research Fields and Policy Spaces. Other frameworks were also considered, such as the Triple Helix and the Mode 2 knowledge production. The Triple Helix focuses on the organisational aspects of knowledge production, and see this as the result of collaborations between firms, science, and government (Benner & Sandström, 2000; Etzkowitz, 2008; Leydesdorff & Meyer, 2006). More importantly, this is not a theoretical framework, but a normative political agenda lacking a solid micro foundation (Shinn, 2002; Viale & Pozziali, 2010), whereas, the Mode 2 approach places knowledge in the context of its utilisation (Gibbons, 2000), and involves looking at the structures that link the institutional and organisational foundations behind its production. These two frameworks are complementary elements of scientific research and innovation paradigms (Carayannis & Campbell, 2006; Leydesdorff, 1995). There is an overlap between the analytical foundations in them and the NIS (below). These three are non-linear models inspired by the benefits of knowledge in the economy and society.

7.4.1 National Innovation Systems (NIS) framework

The NIS analytical framework is rooted in the evolutionary perspective of economics and was proposed as an alternative to the linear model of knowledge production[69]. The main limitation of the linear framework rests in its lack of capacity to explain the complex functioning of the production of knowledge (Lundvall et al., 2009). The NIS is dominant in the study of S&T policies and innovation policies. It is also the traditional policy approach in OECD countries (Diercks, 2018; Henriques & Larédo, 2013). A concise summary of what the NIS framework offers is presented below:

> *"(in innovation systems) distinct institutions jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such, it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies"* (Metcalfe, 1995, p. 38)

The three main characteristics of the NIS are as follows: 1) it centres on understanding the interactions among related actors; 2) it assumes that improvements in technological and innovative performance would prompt economic development; 3) it considers the economic role of knowledge and skills; 4) it considers the increasing use of system-level policies (see Chaminade et al.(2009), Lundvall (1992), Nelson & Nelson (2002), OECD (1997, 2000)). In the NIS framework, the function and impact of actors depends on their core activities and resources, and on the resources directed at strengthening the already established interactions and promotion of new interactions. Furthermore, according to Lundvall (2005) and Lundvall et al. (2009), the configuration of research systems depend on the promotion of R&D, access to codified knowledge and direct interactions with technologies.

[69] The linear model remained dominant in scholarly work and as a basis for policy intervention for most of the 20th century. See Borras & Edquist (Castaños-Lomnitz, 2004).

The private sector and national structure of knowledge, characterised by the organisation of research activities, constitute the core of the system. These also are the targets of policy intervention. The organisation of research comprises the engagement of public and private actors in R&D to enhance research outputs. The institutions influencing the system constitute the wider setting. These can include the national education system, labour markets, financial markets, intellectual property rights, competition in product markets and welfare systems.

The NIS explains policies through the coordination between actors. This coordination is visible in networks and flows of resources, and in the institutions that provide the environment in which knowledge and skills are developed, diffused and used (Fagerberg & Srholec, 2008). In consequence, changes in knowledge and researchers are evaluated when transformed into tangible outcomes, such as patents, higher-quality products, universities spin-offs and entrepreneurship (Borrás & Edquist, 2019; Edler et al., 2016).

In the NIS, policies are framed as a "cornerstone" of public action for competence building and are intended to address the systemic failures that hinder the transformation of knowledge and skills into widespread benefits. With regards to research talent, policies are treated as an additional resource for improved training of scientific and technical skills (human capital), which are 'major actors' for change and growth (Borrás & Edquist, 2015, p. 220). Studies looking at the mobility of highly educated people using the NIS framework, primarily seek to elucidate which national policies are helping countries to increase the production and use of knowledge. Research training and international mobility are examined by focusing on the extent to which the entire educational and research system can produce the type of knowledge, skills and expertise that innovative actors need (Borrás & Edquist, 2013, 2015; Toner, 2011). Others, such as Hart (2007) have looked at how international mobility policies give place to new re-combinations of local and foreign ideas, and how this may affect the capacity of the system to further progress.

In summary, the national innovation system approach affords valuable insight into the relationship between policies and effects on domestic research. As observed by

Lundvall (2007a, 2007b), the NIS framework is a relevant academic and practical tool to understand the dynamics underpinning the production, diffusion and use of new, economically useful knowledge

7.4.1.1 Assessment of the national innovation systems (NIS) framework

The innovation system framework enables a multi-actor analysis, where actors, resources, and interactions between these two can explain how international mobility is conducive to changes in the system. The NIS is a flexible tool for the study of S&T policies, but such flexibility has received some criticism.

The most common criticism directed at the NIS is that the concept of 'system' is rather vague, and can lead to misinterpretations and inconsistent operationalisation. Other criticisms have highlighted the lack of consensus on where to draw the line around innovation systems, as mentioned by Edquist "there is simply no demarcation between the system and its surroundings" (1997, p. 27). This is also a consequence of the ambiguity in the underlying concepts of this framework. It has been argued that this lack of clarity is a barrier to making this framework more 'theory-like' through rigorous conceptualisations. Other shortcomings include the overemphasis on the economic value of knowledge, which can lead to a narrow view of the process of knowledge production (Bajmócy & Gébert, 2014; Quitzow, 2012). Additionally, a strong bias on the national organisational arrangements inside firms does not allow for a good understanding of the process of knowledge transformation at the network level (Edquist, 2005).

The explanatory capacity of this framework is considered to be prescriptive. This is because research has tended to focus on general and comparative assessments of national systems, looking at policies in terms of their capacity to address systemic imperfections. Some scholars assert that this tendency has prompted a rather 'normative' notion about how policies and the system should operate to fulfil its economic objectives (Carlsson et al., 2002; Mahroum, 2012; Smits et al., 2010). In other words, the innovation system approach assumes an optimum state, which can be obtained through public intervention. However, the NIS ignores other possible determinants that can affect the configuration and performance of the system, and which are important but not always identified.

Additionally, more recent critiques have stressed that the predominant tendency for research to focus only on interactions and the transformation of knowledge into products "fails to provide a conceptual underpinning on how to identify, assess and ultimately guide innovation towards certain desired directions" (Lindner et al., 2015, p. 2).

The NIS is a science-driven-innovation-growth framework, in which research training policies are a conduit of the transformation of research into economic gain. Researchers are a source of new knowledge and potential entrepreneurs, and policies should determine the levels and quality of research skills in the system (Jones & Grimshaw, 2012). However, the NIS gives little attention to the peculiarities of human capital development (Lundvall et al., 2002), and ignores that researchers do not necessarily perform activities that will translate into possible and visible innovations.

In this framework, international mobility policies are studied under the brain drain/brain gain approach. Even those studies adopting the connectionist approach limit their works to the study of possible losses and gains. However, it is unclear how to connect how external incentives influence researchers' behaviour in a framework strongly biased to innovation performance on firms. This framework is used to identify mobility patterns building on the notion of competition for talent between countries.

The NIS framework has been used to study developing countries (see Cimoli (2000); Dutrénit & Sutz (2014); Padilla & Gaudin (2014) and Hagendijk (2010)). However, this may be seen as "re-exporting" concepts that were developed to represent the particular context of rich economies, and which may not reflect the reality of developing countries. According to Altenburg et al. (1998) and Lundvall et al. (2009), the NIS framework has not overcome the following shortcomings when applied in examining developing countries: 1) policies not directed to innovation activities are not sufficiently taken into consideration; 2) other policies and their distributional effects are rarely explored; 3) the role of the government is overestimated, and other influential factors are underrepresented. Additionally, the established indicators that describe research efforts and technological trajectories may not fully capture the reality of the systems in less developed systems (Metcalfe & Ramlogan, 2008; Nelson & Rosenberg, 1993; Niosi, 2010). Moreover, policy and research arrangements are rooted in histories specific to national research systems, and possibly to different ideologies to those in developed economies.

The central argument in these critiques is that research works drawing on the NIS framework is focused on evaluating why developing systems do not perform as they should, instead of examining how these negotiate and procure change. However, scholars do not discourage the use of that framework; they recommend that its adaptation in developing countries should consider possible underdeveloped knowledge bases and the lack of reliable data in regards to innovative activities inside firms.

In light of this assessment, the NIS framework is a useful tool to identify the relevant drivers of change in a national system. It affords a significant insight into the interactions and institutions that promote the use of knowledge and skills for its transformation into valuable and innovative outputs. However, it does not provide sufficient conceptual and empirical foundations for the analysis of policies in environments where industries are less engaged in scientific research activities. It also neglects that change in developing countries can occur within and outside the prescriptive NIS agenda and standard indicators. In other words, it does not allow explanations about how policies produce change. The lack of agreement on where to draw the line around the innovation system, and the lack of clarity when applied in developing countries makes this framework not suitable for the present research study.

For the case of Mexico, this approach has proved to be useful and challenging. It helped to identify the weakness of the system, such as the concentration of S&T capacities in universities and the lack of collaboration between these institutions and industry (Calza & Cimoli, 2015; Casas et al., 2000; Dutrénit et al., 2010). Also, this approach has helped to delineate possible solutions to systemic issues, but still fails to appreciate the peculiarities of Mexico and other developing countries (Hagendijk, 2010).

7.4.2 Research fields and research spaces (RF&RS)

Scholarly works from S&T policy and policy evaluation, particularly those of Reale et al. (2014), Nedeva (2013) and Nedeva et al. (2012), have advanced the social dynamics of science and policies. A common characteristic of these is that they do not regard the value of knowledge as only economic; their focus is to unpack the varied assumptions of the value of science in society and the forces shaping scientific activities.

The original work of Nedeva (2013) offers a comprehensive framework that has been developed based on systematic analysis of the multifaceted interaction between scientific research and policies. This framework, coined "research fields and research spaces (RF&RS)", is defined as:

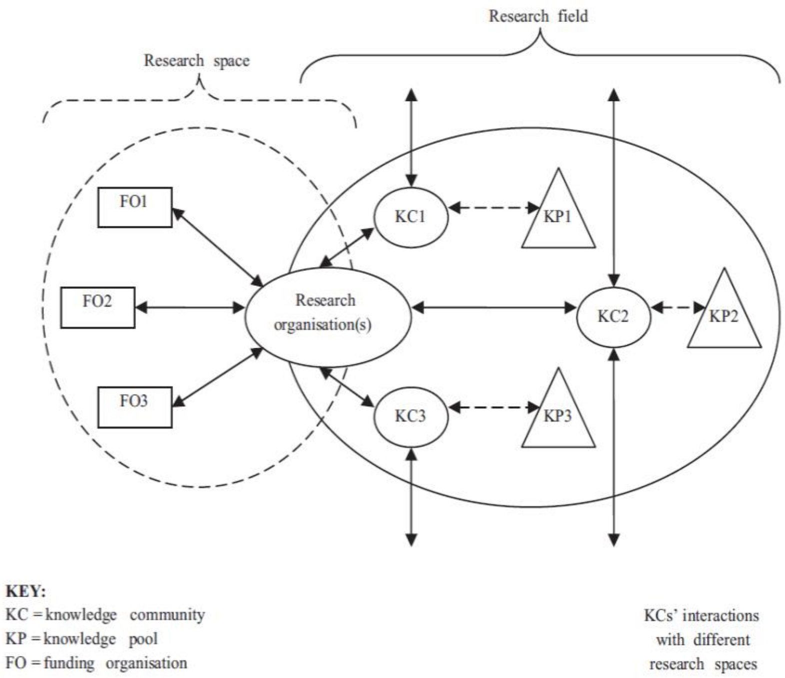
> *research spaces are funding and policy environments within which the rules of knowledge production, knowledge legitimacy and knowledge use are negotiated"* (Nedeva, 2013, p. 221)
>
> *research fields can be seen as empirically outlined by three interlinked elements, namely converging "knowledge communities", consistent "bodies of knowledge" and "research organisations". Knowledge communities are groups of researchers (academics) who share similar or commensurate epistemic assumptions, methodologies and have developed consistent systems of reputational control* (Nedeva, 2010)

The conceptualisation of the RF&Rs framework rests on the belief that understanding the dynamics of science is imperative on understanding science itself. Thus, this framework comprises notions about science, its social configuration and relationships with external pressures for change. The RF&RS framework "focuses on conceptual developments that are relational, and that aim to incorporate in the understanding of science influences (actors and relationships) a certain degree exogenous to it" (Mucha & Leszczynska, 2010, p. xviii).

The framework is organised in two central dimensions. The first dimension comprises the exchanges of resources for knowledge; i.e., funding arrangements (who provides funds, who establishes research and infrastructure priorities, how much, why, and for what). This dimension rests in the national context of research systems; it represents the relationships between funders and research communities. The second dimension in the RF&RS framework comprises the rules and values that govern research activities, practices and researchers.

Figure 11 illustrates the composition of this framework.

Figure 11 Relationship between research fields and research spaces



Source: Nedeva (2013)

In the RF&RS model policy instruments are localised in a particular regional or national research space, while research fields (and the actors in them) are inherently global. In other words, science exists in a multi-space environment that is shaped by its inherent workings and dynamics and by local and exogenous pressures. The RF&RS advances the analysis of the global nature of scientific research and recognises the potential tensions that can occur between localised policy efforts and the global and multi-space researchers. It also acknowledges national contextual differences in the organisation of research but does not overemphasise the role of any actor. In short, the RF&RS framework aims to explain how researchers, individually and communally, organise their activities and interact with policies. Ultimately, the aim of the RF&RS framework is to explain how such interactions affect the very nature of knowledge (Nedeva, 2010)

7.4.2.1 Assessment of the research fields and research spaces (RF&RS) framework

The frameworks dominating S&T studies and policy studies tend to assume that actors would behave in a specific manner, and suggest that knowledge production paradigms change while not going into the workings of these (Mode 1, Mode 2). While others focus singularly on the relationships between national actors, regarding a high value on the role of companies (NIS); the relationships between research organisations, the state and industry, and ignoring people (Triple Helix).

The RF&RS framework centres its attention in the organisation of the research system and relationships that emerge around policy forces and notions governing the dynamics of scientific knowledge. Significant interactions occur between the funders, users, and producers of knowledge. These interactions can be responses to policies and other pressures for change and are particular to specific contextual conditions. These interactions take place in a 'noisy' space, where each actor may react according to their interpretation of the signals from policies and the environment (Nedeva et al., 2012).

With this in mind, it is fair to say that the NF&RS is a comprehensive framework that allows for a realistic assessment of policies and change. The exploratory (theory-led) underpinnings of this framework advocate for a rather critical discussion of policy-steered change, moving away from prescriptive outlooks that tend to overlook and offer insufficient understanding as to how change occurs in science.

A particular limitation of this framework is that it was introduced recently, and has only been used in a few cases, which means that its robustness remains to be tested. Similarly to the NIS framework, this was developed for developed countries, notably for the European context, which may limit its explanatory capacity when applied in developing countries.

7.4.3 Selection of an appropriate national policy framework

Some general assumptions in this thesis (see Section 7.5.3) are that mobile researchers are exposed to external incentives, practices, and values. Thus, their interests are not bound to national demarcations. Also, this study assumes that the characteristics and expectations of mobile researchers can alter the signals sent by policies, and influence the change produced. Ultimately, this study posits that in order to better understand the effects of international mobility, it is necessary to see this through a prism that goes beyond the brain drain approach. It is essential to explore this phenomenon as a process that can, to a certain extent, be influenced by policy interventions.

The primary motivation for choosing a systemic approach for this study was, first, that S&T policies are system-oriented tools that aim to affect the conditions for research on a national level. Second, this research assumes that policy outcomes are shaped by a diversity of factors, and thus relies on a broad systemic approach to identify the elements that influence the structures and behaviours that policies seek to affect.

Some contributions to policy studies in the fields of S&T and innovation have urged a move away from the idea of rationality or linearity (Flanagan et al., 2011; Laranja et al., 2008). Recent contributions recognise that the policymaking process involves a complex interplay between endogenous and exogenous factors, such as institutions, socioeconomic conditions, ideas and choices of actors (Dietz & Rogers, 2012; Langfeldt et al., 2019). With this in mind, having an appropriate framework for the analysis of a national policy that operates between the national and international context was crucial.

According to the NIS framework, the major challenge developing countries face is selecting the policies, technologies, and appropriate institutions that will foster the development of the national innovation system. In this regard, the NIS approach does not fit the needs of this study for the following reasons: 1) Mexico lacks a comprehensive R&D-driven strategy; 2) companies do not engage significantly in innovation activities; 3) there are no comprehensive efforts to capitalise research skills into innovations; 4) there is no coordination between S&T policy, innovation initiatives and industrial policies; 5) there is a disconnection between actors - knowledge producers, users and policymakers (see chapter 2 and 3).

The points above led this work to consider NF&RS as the most appropriate framework. The international component is essential in this study, and it required an insightful lens that could bring together the overlapping dynamics of the national and the global in S&T policy studies. The reasons for selecting this framework are:

1) It uses elements of policy implementation, such as policy rationales, allocation of funds, origins of funds, and a broad set of actors.
2) It is flexible and offers critical elements about how national policies can explain change in the research system, and about how to identify such change.
3) It is systemic; it focuses on the roles, actions, and responses of actors in a policy space.
4) It is exploratory, rather than prescriptive; it allows for a nuanced and multi-dimensional study.

Ultimately, RF&RS assumes that change occurs because actors have changed. The core characteristics of involved actors, practices, their position in the system, and reactions to the opportunities provided by the funding structures, are crucial for capturing the process underpinning policy-led change and effects. The exploratory nature of this framework makes it possible to better understand the inner workings of the interactions between policies, actors and change.

7.5 STUDYING CHANGE USING RF&RS FRAMEWORK FOR POLICY ANALYSIS

For the targeted population, policies represent an incentive or pressure for change. However, policies do not necessarily produce the intended effects, and some of the effects produced are not in their entirety the result of such implementation. Examining the impact of complex policy instruments should entail looking into both the effects produced and the factors that may have affected their emergence.

In regards to the study of international scientific mobility, Ackers (2005a) asserts that the nature and effects of this phenomenon require more holistic approaches, such as a comprehensive framework that will allow an understanding of the dynamics of scientific mobility in combination with policy generated reactions on mobile researchers.

In line with this, this study posits that policy instruments are an important – but not the only – force that shapes the international mobility of researchers. Policy instruments embody a range of opportunities or limitations for researchers, who would interpret and react to them depending on their specific positioning in the research system and circumstances. Also, this study asserts that a better understanding of how policies work can allow for designing instruments more *ad hoc* to the current configurations of knowledge production. In this regard, this study finds in Nedeva (2013) an approach where policies focus primarily on enabling the spaces where knowledge is to be produced and balancing the tensions between who produces it and how, and who funds its production. All these dimensions tend to be perceived in the S&T policymaking arena as ownership. In Nedeva's work, policies are embedded in social systems as an extra dimension to the complex process of the organisation and production of knowledge, where individual and community characteristics also delineate the expectations and responses to policies.

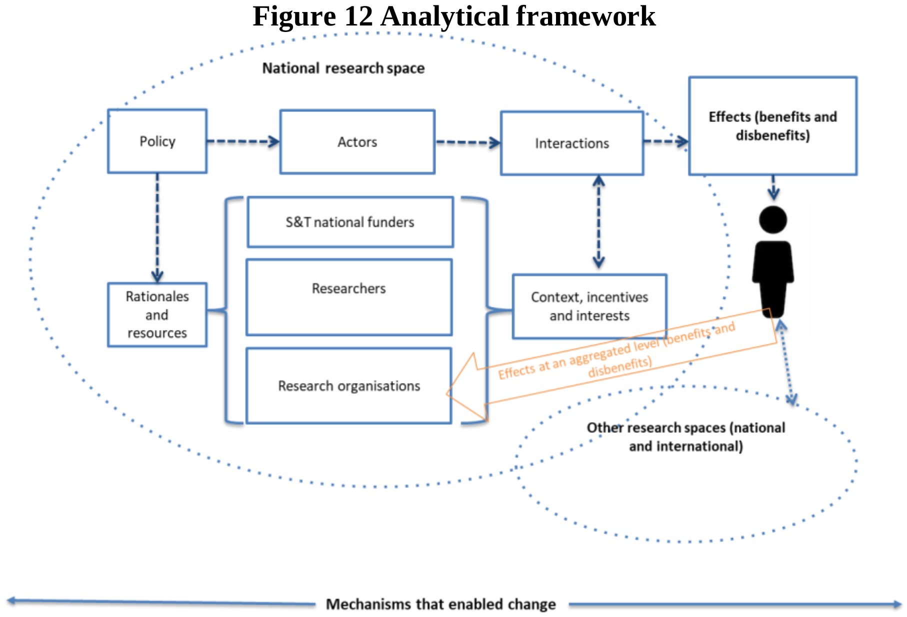
A key research question in this thesis concerns the effects that a policy instrument produces. However, the objective of this study is not to provide a one-off assessment of the Scholarship Programme's success or failure. Accordingly, the NF&RS framework has been adopted to map the rationales in policy and opportunities it in for its beneficiaries and to identify how they develop the opportunities provided by the policy. This will require the effects or changes following the implementation of the policy to be identified since, according to the realist policy evaluation school of thought, it is through the workings of the research system – comprising the implementation of a policy instrument (programme), contextual factors and relationships (Pawson & Tilley, 1997) – that conditions and actors are affected.

Consequently, this study combines the framework presented above with the analytical policy assessment proposed in Reale & Seeber (2013), who have also proposed that policy analysis should focus on 'actual' policy implementation. As a realist evaluation this study distances itself from the idealised policy logic that assumes change through rational expectations and evaluations concerned with causality. Instead, this study assumes that policies can prompt unexpected responses in the targeted population, and this interplay can yield a variety of outcomes – some of which can be outside the intentions and expectations in policies.

The adopted framework assumes that policy instruments and actors are endogenous to research systems. In other words, policies and actors co-exist in a particular set of funding arrangements and exchanges. This study attributes autonomy to the actors to interpret policies and pursue their interest through the opportunities offered by policies. This can be seen as a pragmatic use of signalling theory (Bird & Smith, 2005; Connelly et al., 2011), where policies are seen as signalling mechanisms through which governments convey particular intentions (Flanagan & Uyarra, 2016; Nedeva et al., 2012; Reale & Seeber, 2013).

The following figure is an adaptation of the framework presented in Nedeva (2013) and Reale & Seeber (2013), which will be used to study the properties and effects of the Scholarship Programme.

Figure 12 Analytical framework



This framework is operationalised through the following dimensions:

- **Actors**: 1) S&T national funding agencies. These allocate funds to individuals, groups of researchers and research organisations. 2) national researchers, who carry out specific research in alignment with the values of their scientific community and with national research priorities. 3) Research organisations that enable researchers to enact their expertise.
- **Policy objectives:** these refer to policy rationales.
- **Interactions:** this refers to the funding arrangements; this is how funds are allocated by the funding agencies, i.e. the rules under which researchers and research organisations can access the offered funds.
- **Context:** this includes three categories; 1) the level of national investments in S&T as seen through the % of GDP. 2) The origin of S&T financial resources, and 3) the overall national S&T environment.
- **Effects:** this emerges from combining the implementation of the funding instrument with the responses of its beneficiaries. Impact can comprise intended and unintended effects, and can be influenced by and located outside the national research system.
- **Mechanisms that enabled change:** these, are assumed to comprise a wide range of relationships that relate to 1) the national research space, its historical and contextual conditions; 2) the characteristics of funding instrument, its place in the national research space and capacity to steer change, and 3) the characteristics of the individual researchers, their expectations, personal and professional circumstances and ambitions.

‘Policy’ here is a directed effort towards change. ‘System actor’ refers to beneficiaries, who possess intentionality and potentially conflicting interest, engage reflexively with their environment and take part in the policy process by pursuing immediate and future benefits. Interactions between policies and actors (who are also affected by external forces) occur in the research space.

7.5.1 Definition of impact and identification of effects (the issue of attribution)

It is not easy to determine with certainty what impacts were caused by a policy instrument or determine when a change is the result of policy alone, or whether this was led by other factors (the issue of attribution). In light of the motivations and exploratory nature of this study, this assessment adopts the definition of change or impact offered by Reale et al. who refers to impact as “any difference or change of social actors or phenomena that can be partially or wholly attributed to the establishment and functioning of funding schemes” (2014, p. 37).

The issue of attribution – that is identifying and exploring the mechanisms that may have produced change is one of the most persistent challenges in policy evaluation (Amanatidou et al., 2014; Edler et al., 2016). For instance, Bozeman and Sarewitz (2005), have suggested that most evaluations tend to assume a universal capacity in policies to produce change. As a result of this, evaluations tend to emphasise scientific and economic impacts, ignoring other similarly significant impacts.

Establishing a straightforward connection between a policy instrument and specific effects is a non-trivial task. According to Molas-Gallart & Davies (2006), this occurs because researchers are tempted to measure the exact degree to which effects correspond to policies. Finding this precise link faces some difficulties, for instance, the lack of comprehensive measurements and extensive data collection (Bäker, 2015; Nedeva, 2010). Additionally, effects tend to be delayed (Amanatidou et al., 2014; Reale et al., 2014), which makes connections between intervention and effects fuzzy. Other factors such as political ideologies, the introduction of new administrative measures, personal interests, misinterpretation of policy objectives, among others could also be attributed to their occurrence.

Scholars have developed different approaches to deal with the issue of attribution. For instance, Molas-Gallart & Tang (2011) proposed that tracing forward the interactions that a group of selected actors established can provide a viable solution to overcome this common problem. However, capturing policy-induced effects can be an elusive task, because impact may manifest in aspects that are not easily visible and quantifiable. These can include, for instance, awareness of particular issues, and changes in attitudes and values.

Policies for research training are commonly studied under the assumption that the improvements accrued after training; notably, wages and career development, are the result of the public intervention (Auriol et al., 2010; Edler et al., 2016; Lee, Miozzo, & Laredo, 2010b). However, considering only the intended, measurable and visible effects runs the risk of adhering too strictly to the idea of linear causality and neglect the varied effects-producing forces and changes induced.

Notably, attributing effects solely to the implementation of a policy can be problematic. Firstly, the context where instruments work is much broader than that covered by the scope of its beneficiaries; policies operate in a system with multiple actors, all heterogeneous and pursuing their interests. Secondly, beneficiaries are exposed to external opportunities, which can limit the capacity of policies to produce the intended change.

Consequently, instead of starting from measuring and attributing effects, and following the framework in this section, this research identifies and categorises policy impact according to 1) policy rationales and funding arrangements, 2) properties of the policy instrument and characteristics of its beneficiaries, 3) opportunities that this instrument offers and reactions of beneficiaries to these, and 4) changes reported by its beneficiaries, which can be operationalised in benefits and disbenefits. This approach will enrich the understanding of how policies work and how change happened.

In the context of identifying change and the mechanisms by which policy generates specific effects, it was also considered relevant to distinguish between direct and indirect impact. The first is the changes that can be easily identified and attributable to a policy intervention in the actors that responded to the opportunities in that measure. Indirect effects are the result of other actors associated with those who are directly affected by a policy. In other words, indirect impact results from the exchanges between those reacting and responding directly to a policy, and those that adjust their behaviour as a consequence of those responses (Nedeva et al., 2012).

Policy measures can produce change by the mobilisation of financial resources. These convey signals to their potential beneficiaries concerning the conditions and opportunities in these resources, this will be a direct effect that materialises when the beneficiary is awarded financial incentives. Policies can also embody a sense of prestige or reputation for their beneficiaries, and this can be attributable to the existence of the policy itself and its properties. For instance, policies that are regarded as a symbol of research excellence can produce change in their targeted population, who may wish to be associated with the policy.

This approach and methodology imposes limitations, particularly concerning the generalisability of findings. However, it provides a detail-rich case that offers insight into the relationship between policies and change and the heterogeneity of actors.

7.5.2 Scope of analysis

In order to provide a focused and appropriately bounded in-depth analysis of a policy instrument, this research will examine the Scholarship Programme. The focus of the analysis will set on the development of the nanoscience and nanotechnology sector in Mexico (see Chapter 5). The study will identify changes in two different levels of social aggregation, notably, the direct beneficiaries of the Programme (fellowship holders), and changes that are transferred to indirect beneficiaries (national employers).

Arguably, due to the international component in the Programme, the host universities and international employers would also receive benefits from the Programme. However, the unavailability of data made it difficult to undertake this line of inquiry. Thus, changes will be discussed in connection with the national conditions and efforts to promote change in the research system.

7.5.3 Assumptions

The assumptions in this study follow from the literature review in chapter 6 and the selected analytical framework in this chapter. The central assumption is that research actors are not only driven by policy pressures; the implicit dynamics and workings of science also affect their decisions. More specifically, it has been assumed that:

1. The international mobility of researchers is shaped by S&T policies and by the practices of global science.
2. Mobile researchers would respond to the opportunities offered in policies, and to how these correspond to their future ambitions.
3. The ambitions of mobile researchers extend beyond the capacity of national policy efforts.

7.6 SUMMARY

Current concerns about the effects of international mobility led to this study, which has adopted a realistic policy analysis approach to identify how policy interventions shape this phenomenon and possible impact. Two frameworks were briefly presented, namely the Triple Helix and Mode 2 approaches, and the innovation systems and the research fields and policy spaces approach were reviewed in detail. The innovation system framework provided a coherent view of the interactions between policies, actors, and research capacities in a nation-state. The operationalisation of this framework revealed some limitations for this research due to its innovation-growth bias. Its foundational and empirical bias towards innovation implies that policies are successful when these solve inefficiencies in the system. However, it precludes the study of other related outcomes. Additionally, for the particular context of Mexico, the innovation system framework does not accommodate adequately the national conditions for science and technology.

The selected analytical framework (RF&RS) in this study positions the system's main actors, interactions and interests in the context of policy intentions, funding and other external variables as influences in policy outcomes. The adopted framework does not locate innovation as the central component of the system and does not see this as the only type of contribution or change that policies can produce. Instead, it will shed light on the understanding of how change occurred and the mechanisms that enabled it. This framework is characterised by two central dimensions. Firstly, funding arrangements; i.e. who provides the funding, how much, why and for what. The second dimension includes the interactions between actors; i.e. what opportunities policies provide for its beneficiaries, how do they act upon these and what explains their responses. Thus, the characteristics of policies and its beneficiaries are crucial for capturing the process underpinning the policy process.

This framework will help guide the examination of a policy instrument put forward in the empirical chapter of this thesis. The framework draws on a review of the relevant literature on STI studies and policy evaluation. The framework guides the empirical analysis in two ways. First, to identify and contrast the policy process with the produced change. Second, the framework helps to identify and discuss the effects reported by beneficiaries in terms of their current concerns and context. This is also important because this will allow for a reliable assessment of the policy instrument in light of the actual change in the research system.

CHAPTER 8 RESEARCH METHODOLOGY

8.1 INTRODUCTION

This chapter presents the epistemological underpinnings of this research and the methodology. The chapter first introduces the epistemological foundation and then describes the methodology followed, outlining the research strategy, data collection methods and data analysis techniques. The chapter also contains a detailed description of the participants that informed this study, along with the ethical considerations in this research and limitations encountered when conducting fieldwork.

8.2 RESEARCH PHILOSOPHY

Research paradigms are beliefs, concepts and assumptions about how the world operates and the positions and relations of individuals in the world (Kuhlmann, 2003; Sanderson, 2002). Research paradigms orient thinking and research endeavours (Guba & Lincoln, 1994). These beliefs are logically interconnected in a way that they justify the use of specific methodologies to answer particular questions. These translate in how researchers address research, as this is determined by their perception of the nature of knowledge and what they believe can be known in the world (Bell et al., 2019).

There are different research paradigms in social science research, yet the most common are positivism, post-positivism and constructivism. Positivists and post-positivists see the world as a single and objective reality that can be measured and known (Guba & Lincoln, 1994; Saunders et al., 2016; Saunders et al., 2012). Researchers within these streams rely on quantitative methodologies and believe that generalisation can be achieved using rigorous quantitative techniques, where causes determine effects (Creswell, 2007; Saks & Allsop, 2007). Meanwhile, researchers from the constructivists paradigm and interpretivist paradigm assume that there are multiple subjective realities, and that it is possible to co-create understandings for a phenomenon (Bell et al., 2019). Researchers with these philosophical stances tend to rely on qualitative methodological techniques. They generate patterns of meanings and interpretations, which are socially and culturally embedded in individual experiences (Mackenzie & Knipe, 2006; Rubin & Rubin, 2005).

An alternative approach, in between these paradigms, is critical realism. This view combines elements of the two views mentioned above. Researchers within this approach assert that the world is in constant change and that there is no perfect knowledge or understanding about it. In other words, under the critical realist paradigm theories are imperfect (Robson, 2011; Wynn & Williams, 2012). They assume that there is an observable, objective reality subjected to the knowledge of social actors in a given situation (Danermark et al., 2005; Wynn & Williams, 2012). As expressed by Bhaskar (2008), things exist and act independently of our descriptions, but we can only know them under particular subjective descriptions. Three components are at the core of this paradigm: 1) reality can be studied independently of the subjective human perceptions or experiences; 2) researchers views and perceptions affect their view of reality, 3) structures, such as theories and empirical work can enable or constrain researchers to pursue specific actions in a particular setting (Sayer, 1992). This implies that the subjectivity of the researcher has a significant impact on the research, which carries essential limitations to the problem under study.

This research attempts, first, to contribute to the understanding of how policies work and, second, to the standings about scientific mobility. Having in mind how problematic this can be from a critical realist perspective, for examining the mechanisms that underpin a social phenomenon can be virtually impossible, since the structures that originate the event may be concealed (McAvoy & Butler, 2018). This study develops an in-depth understanding and analysis of the interplay between policy implementation and effects in Mexico as an already existing phenomenon. For that, it adopts the critical realist approach to study how policies work in reality, and it draws primarily on S&T literature.

This study adopted a survey as one of its data collection instruments. Surveys are commonly used as a collection method of quantitative research on a set of variables, which outcomes are reported through a series of statistical answers. Survey methodology is normally driven by the intent to find correlations and causations that will serve as basis for generalisations and is commonly used in the positivists paradigm (Creswell, 2014). However, the purpose of this work was not that of a quantitative study. It instead aims for in-depth and rich information. The justification for using survey responses is provided in further sections.

8.3 RESEARCH STRATEGY

This research is exploratory and qualitative. Inherent to this research is to understand how policy structures, interactions between actors and their motivations enable the emergence of specific outcomes. The qualitative case study research was identified as appropriate for addressing the research questions presented in Chapter 1. This is due to its flexibility for studying "social phenomena specific to time and place" (Ragin & Becker, 1992, p. 2). Qualitative case study research enables real-life settings with participants living the phenomenon under study. It allows for exploring what, how and why questions in complex phenomena, drawing on comprehensive descriptions and analysis of that instance and in its particular context (Morra & Friedlander, 1999, p. 3). Additionally, there is not a single, cohesive, and comprehensive theoretical framework to explain how policies work in reality. Concepts around policy analysis are immature, and there is not yet a consistent basis to explain and interpret change in research systems. In situations like this, qualitative approaches are recommended (Creswell, 2014).

Qualitative research is deemed an appropriate research strategy for it will allow identifying relevant instances in the process of implementation of the Scholarship Programme. Furthermore, the choice of qualitative case study provides the opportunity to collect comprehensive primary and secondary data from the national context and actors involved. This will allow producing substantial evidence for the phenomena under study.

Despite the richness and flexibility that characterises qualitative research some of the limitations that scholars recognise are the propensity to multiple interpretations, lack of methodological rigour, tendency to subjectivity, and limited evidence, as mentioned by Bell and Bryman (2007) in Creswell (2009). The lack of capacity for generalisations that qualitative data offer is also an additional criticism towards qualitative research. However, the richness and depth that qualitative data affords to social phenomena allow for finding relevant patterns that quantitative approaches disregard (Cassell & Symon, 2004; Lee & Cassell, 2013).

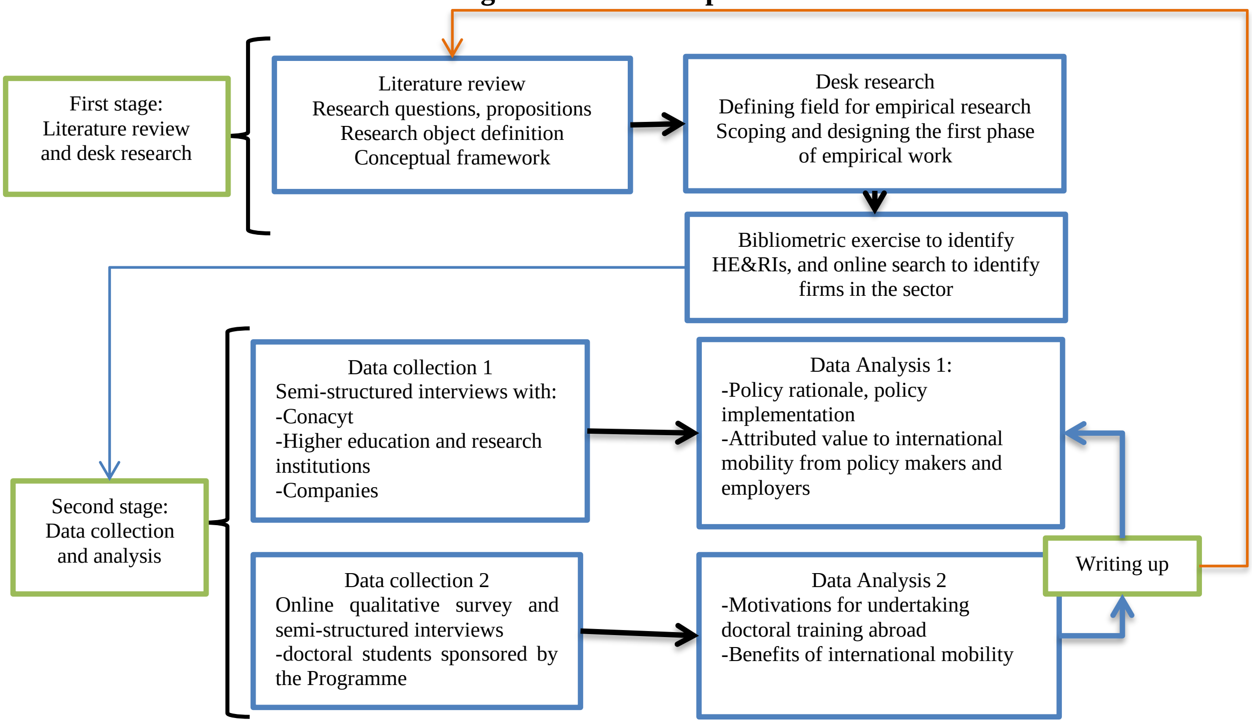
8.4 RESEARCH PROCESS

The overall reasoning that guided this work started with the first-hand experience on S&T policy implementation and evaluation, while working in a state-level government in Mexico. Initial ideas on international mobility and its effects on sender countries guided the literature review presented in Chapter 6, where concepts such as knowledge and skills (human capital), and its relation with the advancement of S&T capacities are the theoretical foundations in the study of international scientific mobility. The literature review was motivated by the need to understand how scholars and policymakers address this phenomenon. The, the literature review guided a line of inquiry into examining why countries invest in sending their nationals abroad to acquire advanced research training and the changes that can emerge from this.

The course of this reasoning can be addressed from different viewpoints and theoretical basis. There are policy studies on highly skilled mobility (sometimes referred as migration) that look at this phenomenon by relying on macroeconomic data, and running quantitative models to show effects on productivity and quality of the research outputs. Other studies have focused on individual career paths, productivity in research outcomes and international collaborations. Most studies assume direct transfers of individual benefits into wider benefits in the research system in the form of technological change, innovation, and economic development. In consequence, if people do not return to their home country, these countries are seen as losers of talent, while receiving countries would be winners. Other studies have looked into the factors promoting mobility, return and no return, providing a broad and complex picture of this social phenomenon.

An overall assumption of this study is that the international scientific mobility of researchers is a type of mobility like no other. Researchers are active participants, whose behaviours are governed not only by market signals but also by cognitive and collegial values. Thus, one question that has not yet been explored in the literature is how national policy furthering international mobility operates in combination with the pressures for change in the production of scientific knowledge. To address this enquiry, this work was designed in two main stages, as shown in Figure 13.

Figure 13 Research process



The first stage consisted of desk research that included conducting a literature review. In this stage, the research questions were refined, propositions and a conceptual framework were developed. The first steps towards the data collection started in this phase. These steps comprised the collection and review of official reports and previous related studies about international mobility in Mexico. These activities helped define the empirical setting where the research questions in this study were to be explored.

The empirical research design included defining a population to study. For this, several resources were consulted, notably, reports issued by national ministries and S&T policy bodies and studies about the technology sectors in Mexico. The sector of nanotechnology was selected to undertake the empirical work for this study after this exercise. Chapter 5 explains the reasons for this decision. After this selection, a bibliometric scoping exercise was conducted to identify the research institutions producing research outcomes in the fields of nanoscience, and which will become informants in this research. Also, to identify companies in the nanotechnology sector, an online search was used. Simultaneously, in this stage, a dataset of doctoral students sponsored by the Programme was built through online searches, and through formal requests to Conacyt for information.

The second stage included data collection and analysis, and consisted of three phases. In the first phase interview protocols were designed for each group of participants; policymakers, higher education institutions and companies. These interviews were conducted in Mexico during April and July 2017. The second phase involved the design and implementation of an online qualitative survey aimed at nationals whose doctoral training in foreign universities was sponsored by the Programme, and subsequent interviews with selected participants. The survey and interviews in this phase were carried out during October 2017-February 2018. Additional desk research was conducted throughout the data collection and analysis stages.

8.5 RESEARCH SCOPE

The scope of this research was delineated taking into consideration three key aspects: 1) the selection of Mexico, a sender of research talent, as an empirical case; 2) the selection of the Scholarship Programme within its modality of international training, and ultimately, 3) the selection of the nanotechnology sector.

The central unit of analysis in this study is the Scholarship Programme, a policy instrument funding the doctoral training of Mexican citizens abroad. This study explores the structure, resources, and rationale for the Programme to provide a detailed description of the context and practices guiding this instrument. These elements represent the national research space. Attention was given to the key components of the research system and their functionality. Additionally, this research examined the characteristics of the direct (fellowship holders) and indirect beneficiaries (employers of doctoral skills in Mexico) of the Programme. The empirical work is carried out within the nanotechnology sector, but the effects that can be, to a certain extent, attributed to the Programme are reflected at the national level. The analysis of how this operates in the particular context of Mexico brings some light into what factors cause particular effects.

8.5.1 *International mobility of highly educated people in the Mexican context*

Migration out-flows from this country have shifted from low-skilled to highly-skilled in the past two decades. This is due to improvements in the educational system at the primary and secondary level, and the expansion of higher education that provides greater access to this level of education to its citizens.

One of the main difficulties in the study of scientific mobility is to estimate or measure the flows of people. This is because there are no systems collecting information on the volume and educational level of migrants. Regardless of the lack of data, there is consensus that Mexico is one of the major exporters of talent in the world and one of the least attractive countries for researchers (Docquier & Machado, 2015; Tuccio, 2019a). Reports position this country after the Philippines and India as global exporters of research talent (Beine et al., 2008b; OECD, 2008e). A recent study conducted by Delgado-Wise et al. (2015) showed that per every hundred nationals with postgraduate education living in Mexico, 34 live abroad. Their study found that the USA is the favourite destination, with 82.2% of the total of nationals with postgraduate education living abroad. This is followed by Europe, which concentrates the remaining 17.8%, mainly in the UK, France, Germany and Spain.

Furthermore, their study has suggested that the number of highly-skilled Mexican nationals living abroad grew more than fourfold from 2000 to 2015. See Table 17. The increased outflows, particularly after the 2000s, can be explained by the saturation of the labour opportunities in HE&RIs, and other labour market-related factors, such as low salaries and low interest or opportunities for these people to enter the private sector. Other factors include S&T factors, such as financial incentives linked to productivity and seniority and low investments in research infrastructure (see Chapter 3). Other issues such as insecurity and violence may be factors driving the highly-educated to places that would offer a better quality of life.

Table 17 Number of Mexican citizens with postgraduate education living abroad

Year	1990	2000	2010	2015
Highly-skilled Mexican nationals living abroad	44,642	54,028	164,364	303,401

Source: Delgado-Wise et al. (2015)

The international mobility of researchers is a broad policy topic. This can be addressed by looking at how policies shape flows of people from one geographical destination to another. It can also be addressed by exploring how national funding bodies and international policy bodies influence this phenomenon. In this sense, Mexico will be a pertinent case to study the influence of transitional policy bodies, such as the World Bank and OECD in the adoption of policies by this country[70]. This study approaches this topic by looking into how policies work. This will mean to identify policy intentions and interactions between these and mobile researchers, which will require investigating the workings of policies within the dynamics of scientific mobility.

This research explores the effects of international scientific mobility using Mexico as an empirical case. Reasons for this are that this country has funded for more than five decades its research talent to undergo international mobility. Among developing countries, particularly in the Latin-American region, Mexico is an emblematic case in science and technology policy; this country was the first in this region to dedicate public funds to enhance the training of its researchers. Even in severe macroeconomic crises, this nation continued the instrumentation of such efforts. Moreover, despite the continuous claims of brain drain, which ignites controversies around the use of public money, the government continues to sponsor nationals to pursue advanced research training outside Mexico.

70 One of the latest initiatives on the migration of highly educated people, namely the 'Mexican Talent Abroad', a network of highly skilled professionals of Mexican origin living abroad, was the result of recommendations and advisory assistance from the World Bank. See https://embamex.sre.gob.mx/japon/index.php/es/133-educacion-ciencia-tecnologia/red-de-talentos-mexicanos-en-el-exterior

Studies addressing the issue of brain drain in this country have been able to underline the overall drivers and context behind the decisions of national researchers to migrate. See, for instance, Ortega et al. (2001), Castaños-Lomnizt (2004) and Boeri et al. (2012). The Scholarship Programme is the common examination ground in these studies, or general census statistics produced by the host countries. Most commonly, studies rely on quantitative estimations on the flows of people, destinations and work placements.

Arguably, other developing countries engaged in similar efforts such as Brazil could have functioned as an empirical case. However, a focus on Mexico is a suitable choice due to its long-standing reliance on international doctoral training and levels of mobility of highly-educated people, which are higher than in any other Latin-American country (Mahroum, 2000; OCDE, 2014; OECD, 2002a, 2015a). Additionally, Mexico continues sending doctoral students abroad without significant changes in the Scholarship Programme across the years. While, for instance, Brazil, Chile, Colombia and Ecuador have adopted strict conditions for return. Ultimately, taking Mexico as an empirical case is a sensible decision because, beyond claims of brain drain, little is known about what changes in domestic research can be reasonably attributable to the international experience.

8.5.2 The Scholarship Programme

The selection of the “Postgraduate Scholarship Programme”, funded and administered by Conacyt, as the primary unit of analysis was a pragmatic decision. The central goal of this programme is to create and strengthen national scientific and technological capabilities through international mobility. It has been, since its beginnings, a critical science and technology policy instrument in Mexico (Dutrénit et al., 2010; Luchilo, 2009), and its continuity through over five decades provides a considerable time frame for examination. Ultimately, this choice is in line with the academic literature on policy analysis, which asserts that policy instruments are the best empirical milieu for tracing effects (Reale & Seeber, 2013). S&T policy instruments are the means of public intervention to achieve particular goals or changes; this can include any programme, regulation, measure or programme directed to the pursuit of the desired change (Edler et al., 2016).

The Scholarship Programme (the Programme) is the oldest S&T policy instrument in Mexico and the first of this kind in all Latin America. More recently, Colombia, Chile and Ecuador have established similar strategies. During its first years of implementation, the Programme was the only source of financial support of public origin for those interested in pursuing advanced research training. Nowadays, there are other national and international funding sponsors[71], where national bodies include the Ministry of Education, Ministry of Energy, and Central Bank of Mexico via the Human Resources Development Fund (Fiderh). International sponsors are the US-Mexico Commission for Educational and Cultural Exchange (COMEXUS-Fulbright-García Robles), the German Academic Exchange Service (DAAD), and non-profit associations such as Brockman, Ford, McArthur and Hewlett, Mexico in Harvard Foundation, Mexican Foundation for Education, Science and Technology (FUNED).

A brief exploratory review of alternative sources for funds showed that countries such as Germany, USA, Australia, Canada, Finland, France, UK, Austria, and Japan, had, in 2018, about 40 different calls for applications for funds for international doctoral students. Some of those calls were directly targeted at Mexican students[72].

Other sources of funding include national higher education institutions and regional governmental agencies and private companies (Universidad de Monterrey, 2016). In some cases, applications are restricted to particular groups according to the source of funds and ultimate objectives. For instance, in the case of HE&RIs and companies,

[71] Retrieved March 2, 2018, from https://www.gob.mx/amexcid/acciones-y-programas/otras-becas-y-financiamientos
[72] Retrieved July 8, 2018, from: https://www.gob.mx/amexcid/acciones-y-programas/oferta-para-mexicanos and http://www.udem.edu.mx/Esp/Estudia-en-el-Extranjero/Documents/becas-posgrado-2018.pdf

resources are only available for employees, academics and students from the funding organisation. In other cases, funds are directed to a specific demographic group, for instance, the "Programme for Postgraduate Training for Indigenous People".

There is not disaggregated information about the beneficiaries supported through the different initiatives above. Some estimations presented in Andere (2004) have suggested that Conacyt is by far the largest funder of postgraduate training in foreign universities. His estimations, for a total sample of 4,544 students, showed that Conacyt sponsored 4,237 (93.24%) students; COMEXUS sponsored 200 students, and other funders provided financial support to 107 students. These estimates were corroborated in policy documents and academic studies, that also regarded the Programme as the most important source of funds for advanced training abroad, and crucial for the internationalisation of higher education in Mexico (EC, 2016; FCCYT, 2006b; OECD, 2009b; Ortega et al., 2001).

As suggested by the policy analysis literature, looking at policies through their implementation means looking at how they work in reality (Reale & Seeber, 2013). In that sense, examining the Programme will make it possible to understand the interplay between the programme and change in its beneficiaries.

8.5.3 Selection of the nanotechnology sector in Mexico

Recent contributions on the debate of brain drain convey the idea that international mobility is intrinsically beneficial for all the involved individuals and countries, and that policies should intervene to accumulate and distribute benefits. However, they do not yet explain how international mobility affects the configuration of knowledge. This relates to the process of transferring and translating individually located effects to the research system and the effects this produces in lack of adequate policies. Thus, a central question remains unanswered: what is the role of policies in the international mobility of researchers, and what are its effects for the researchers and domestic research organisations?

To explore the extent to which change in international mobile researchers is transferred into the domestic research system, this work investigates domestic employers, who are an additional layer of analysis in this study. This will allow for a detailed examination about how individual benefits are transferred to the national arena, what are those benefits and how are these beneficial for employers.

The selection of a relevant sector, which advancement relies on scientific and technical knowledge became crucial. This was because the knowledge-driven sectors require specialised skills, and their development shapes the future of research systems. Furthermore, by selecting a sector that is comprised by a comprehensive range of STEM disciplines, this research will offer an examination of several specialisations, rather than only one of two disciplines, that is a common practice among similar studies (Jonkers & Cruz-Castro, 2013; Reale et al., 2018). If choosing specialisations as sub-units of analysis, it would have required consistent data across each field. This is because each specialisation comprises intrinsic characteristics and circumstances that makes one and each of them a unique unit of analysis. Commonly, CV reviews and bibliometric data are used alone or in combination as empirical tools for this type of studies (Cañibano et al., 2008; Dietz & Bozeman, 2005; Jonkers & Cruz-Castro, 2013). However, most of those analyses look at the individual level giving only one side of the story. Additionally, the extent to which changes in a discipline or field can be attributed to a policy or other factors is often blurred.

The wide scope of sponsorship offered by the Programme to all areas of research was another factor that led to considering a sector to carry out this study. However, the data collected by the Programme is rather generic, and will only allow descriptive statistics, which are already presented in official reports by Conacyt. Available data shows the year of beginning and end of studies of the fellowship holders, country, and university where doctoral training was pursued and broad research area.

This study selected an in-depth assessment of the Programme, context, interactions with beneficiaries and effects. Nanotechnology was selected due to its dependence on multidisciplinary fields and highly specialised skills. With this in mind, this thesis aims to contribute to gaining a better understanding of how the Programme operates in the specific case of Mexico's nanotechnology and nanosciences sector and to identify how changes in fellowship holders influence or not change in domestic research. This can contribute to a better understanding of how the international mobility of researchers could shape the policies of the future.

Ultimately, the selection of nanotechnology was based on the attributed relevance to emerging scientific fields for their potential to further S&T capacities (Kay & Shapira, 2009; OECD, 2014b). Chapter 5 offers a more detailed justification for this decision. The criteria used in this delineation exercise were:

1) The field is emergent and attracts the interest of public and private actors
2) It is a multidisciplinary scientific field and a transversal technology
3) It is a field that is not yet well-established in Mexico

A review of national and international reports on the Mexican S&T system was conducted for this delineation exercise, and drew on the following sources:

- OECD Mexico's Innovation Policy Review,
- The Rio country report[73]
- The Mexican Special Programme for Science, Technology and Innovation (PECITI)[74]
- Annual reports issued by Conacyt, and reports conducted by Mexican Advisory Forum for S&T.

This review showed that Mexico had accumulated significant capacities in the fields of chemistry, biology, physics, and engineering, but concerning nanotechnology, this is not moving at a considerable pace in comparison to other developing countries, such as Brazil, and China.

[73]The Research and Innovation Observatory (RIO) monitors, analyses and assesses research and innovation developments, main challenges, and conditions at country and region levels to support better policy-making in Europe. See https://rio.jrc.ec.europa.eu/?country=be

[74] This is the national policy document that comprises the fundamental guidelines, rationales and objectives for science, technology and innovation. See http://www.siicyt.gob.mx/index.php/normatividad/nacional/programa-especial-de-ciencia-tecnologia-e-innovacion-peciti

There is not a particular policy in Mexico for the development of emerging technology sectors and priorities in the PECITI are vast and open to interpretation in the policy design and implementation settings. Some priorities are[75]:

1) Automation and robotics
2) Development of biotechnology
3) Development of genomics
4) Development of advanced materials
5) Development of nanomaterials and nanotechnology
6) Advanced manufacturing
7) Development of renewable energies

These priorities incorporate the creation of frontier knowledge and pervasive technologies, where the need for specialised knowledge and training is patent. Within this set of priorities, nanotechnology meets the criteria mentioned above. Thus it is possible to say that due to its scientific, economic and political relevance, nanotechnology brings together a wide range of actors from the public and private sector, and it is a multidisciplinary field.

The selection of this sector also concurs with the literature on emerging technologies and its potential impact on developing countries. Literature had asserted that through nanotechnology developing countries can accrue endogenous research and innovation capacities It has also emphasised that countries must invest in increasing scientific skills and infrastructure as part of a comprehensive policy strategy to be able to harness the benefits of nanotechnology (Hung & Chu, 2006; Islam & Miyazaki, 2009; Tang & Shapira, 2012). Nanotechnology is expected to revolutionise industries and society by fostering the convergence between previous and new technologies. Such promise

[75] Translated from PECiTI 2014-2018 (2014)

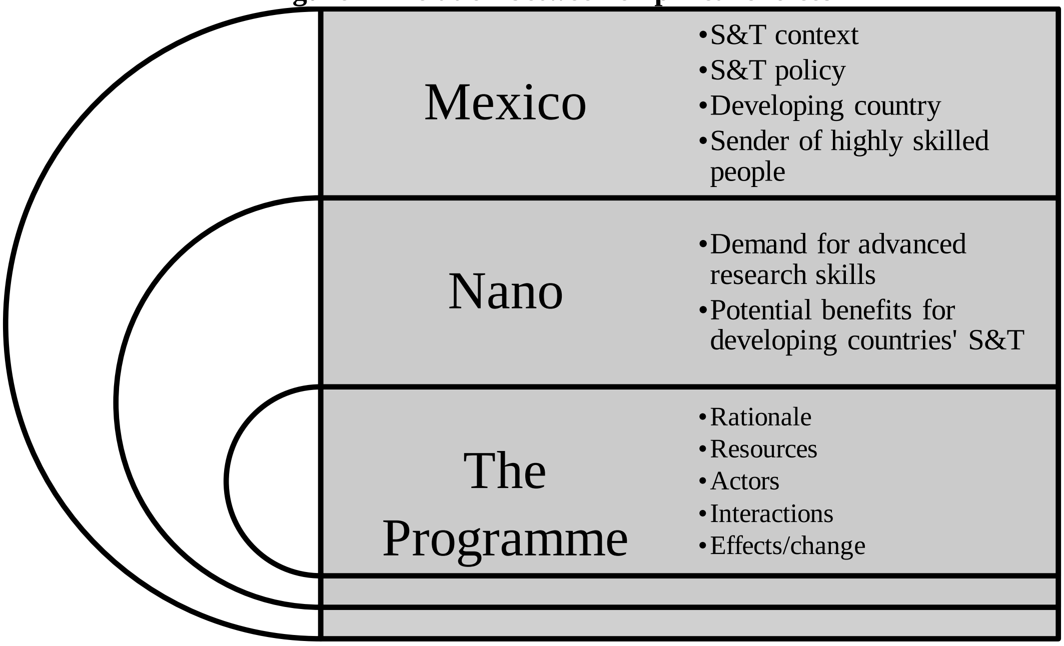
for transformation represents a challenge for developing countries, because these have to engage in capability building initiatives and, at the same time, have to move faster and more purposively in order to create a considerable scientific and technological basis (Bozeman et al., 2007; Dewick et al., 2004).

Thus, the nanotechnology sector is the empirical setting in which this study explores doctoral training within international mobility as framed in the research questions. In this research, nanotechnology incorporates a wide range of practices that overlap on the whole spectrum of natural sciences. From chemistry, physics, and engineering, nanoscience spans over other fields such as medicine, materials science, and electronics. More importantly, it is a ground where national funding arrangements and global research meet.

In this research, nanoscience refers to the scientific activities that provide the basis for technological developments, and which tangible outcomes are publications (books, reports, articles, theses). Nanotechnology encompasses the design, characterisation and production of products or systems at the nanometre scale, which applications can be of value in the medical, cosmetic, textile, and construction market sectors (The Royal Society & The Royal Academy of Engineering, 2004).

In summary, this study explores an international mobility instrument for the training of doctoral students and its significance for the nanotechnology sector in the context of Mexico. Figure 14 illustrates the relationship between each selected empirical component of this study.

Figure 14 Relation between empirical choices



8.6 SAMPLING STRATEGY AND METHODS

Scientific research and doctoral training are not bound to national borders, but funding streams directed to these activities tend to be national. Most commonly, S&T funding efforts represent the interest of governments in building or strengthening the necessary research capacities to leverage their position in the knowledge economy.

The selection of participants in this study required two different sampling exercises and data collection methods. The first exercise was set to identify the actors enabling international mobility, on one side, policymakers, and the domestic organisations that require doctoral skills (HE&RIs and companies), on the other. The second exercise was directed at the beneficiaries of the Scholarship Programme (fellowship holders/fellows). Figure 15 reports the sampling criteria.

Figure 15 Sampling strategy and identifying criteria for the interviews and survey

Selection criteria for interviewees

- Policy makers
  - Play a key role in the design and implementation of instruments furthering doctoral training through international mobility
- Higher education and research organisations
  - Have the resources and infrastructure to perform research activities in nano related fields
  - Conduct research the nano related fields

  *Publications served as a proxy indicator of current research activities
- Companies
  - Use nano-materials in the production process
  - Perform development activities that involved the use or development of nano-materials, intermediates or enabled products

Survey sampling: Fellowship holders in STEM disciplines

- Fellowship holders who completed their studies in the past 10 years
  - Doctoral degree was granted by a foreign university
  - Received funding from Conacyt for their doctoral studies (total or partial funding)
  - Completed postgraduate education after 2008
  - Holds a degree on STEM fields
- Fellowship holders in current training
  - Enrolled in a doctoral programme in a foreign university when completing the survey
  - Receiving funding from Conacyt for their doctoral studies (total or partial funding)
  - Enrolled in the STEM fields

8.6.1 Identifying the policy makers

Conacyt is the key actor in Mexico's S&T policy; it designs, funds and implements the Programme. Conacyt was the logical starting point in this study. As a publicly funded agency, the names of people behind the Programme were easily identified on the official website[76]. Simultaneously, general online searches were used to gather contact details when not displayed on the website.

8.6.2 Identifying the actors in the higher education and research sector

These were identified in a report, issued by the Ministry of Economy, that mapped research capacities in the nanotechnology sector in Mexico. A basic bibliometric scanning exercise on Scopus was conducted to validate the information in this report. Although research outputs are not a direct indicator of demand for doctoral researchers trained outside Mexico, it served as an indicator of implied demand for doctoral skills and as indication research resources and infrastructure in HE&RIs.

The scientific production available on Scopus helped identify the organisations publishing theoretical and experimental research in English language outlets in science, technology, engineering and mathematics fields (STEM) by using the prefix "nano". Previous reports have suggested that 56 HE&RIs were involved in activities related to the development of the nanotechnology in Mexico (Materiales Avanzados, 2008; Záyago-Lau & Foladori, 2010). However, in this exercise only eight organisations indicated capacities to translate their research efforts into journal publications. This relates to their historic core mission, capacities and resources for research. This is because not all 56 are research-oriented; some are regional universities whose primary mission is to train new generations of professionals for the local labour market. The ten top publishing HE&RIs were selected for this sample.

[76] Retrieved March 8, 2018, from https://www.conacyt.gob.mx/index.php/becas-y-posgrados/becas-en-el-extranjero

The targeted potential informants were directors of research centres, heads of departments and research group leaders. Contact information was gathered consulting the official websites of the identified HE&RIs. When this information was not available, further online searchers were carried out using the names of the identified potential participants.

8.6.3 Identifying the actors in the private sector

Companies were identified via secondary resources such as the report on nanotechnology in Mexico, published by Conacyt and Ministry of Economy. Other sources included: a) lists of beneficiaries of public programmes linked to research and development in nanotechnology; b) the national registry of technological enterprises, and c) an academic study of the national nanotechnology sector by Zayago et al. (2013).

This process of identification started with general online searches using the following keywords: "empresas nanotecnológicas en Mexico" (nanotechnology companies in Mexico); "empresas y nanotecnología, Mexico" (companies and nanotechnology, Mexico); México y nanotecnología (Mexico and nanotechnology). These searches yielded the following sources:

- The report published by Conacyt and the Ministry of Economy in 2008 about nanotechnology in Mexico. This report is the first assessment of the nanotechnology sector in Mexico. The report, based on a survey, presents a list of companies that responded to the survey and claimed to be using or developing nanotechnology.
- Conacyt's website was another source of information about companies in the sector. Conacyt coordinates two programmes aiming to promote innovation in

the private sector, namely, the Innovation Incentives Programme[77] (PEI for its acronym in Spanish) and the Technological Innovation Fund[78] (FIT). The information available for these programmes consisted of calls for applications and lists comprising information on the funded projects from 2009 to 2016 for PEI, and from 2002-2016 for FIT. Lists contained the name of the company, the amount of the grant and name of the project.

- An additional source was the National Register of Scientific and Technological Institutions and Enterprises (RENIECYT) that contained the names of public and private institutions that have received public funds for science or technology activities. This database contained as of March 2017, 9,216 national and multinational companies registered with the following information: registry number, the name of the company, industry sector, economic activity, name of the state where located and size of the company. In order to identify potential interviewees, a search was conducted using "nano" as a keyword.
- Academic participants facilitated three contacts in the private sector during interviews.

In order to collect contact information of the companies identified in these sources, further online searches were conducted using the company' website, press releases, consultations in the Mexican Business Information System (SIEM) and the register of importers of chemicals supplies on the website of the Tax Administration Service (SAT). Additionally, the work of Záyago-Lau & Foladori (2010) and Zayago, et al. (2013), who mapped the nanotechnology sector in Mexico and created a website[79]

[77]Retrieved March 8, 2018, from https://www.conacyt.gob.mx/index.php/fondos-y-apoyos/programa-de-estimulos-a-la-innovacion
[78]Retrieved March 8, 2018, from https://www.conacyt.gob.mx/index.php/fondos-sectoriales-constituidos2/item/fondo-de-innovacion-tecnologica-fit
[79] http://nanoeconomiaenmexico.cinvestav.mx/Mapa
The information on the website resulted from a project funded by the The University of California Institute for Mexico and the United States (UC MEXUS).

contained contact details for some companies. Ultimately, personal contacts with experience in the private sector helped to gain access to two companies.

The targeted population to interview were the head staff in R&D departments and company owners. Authorities from the nano-cluster[80], an initiative fostered by the federal and a state-level government that mobilises resources from public and private sectors, were also considered as participants.

8.6.4 Identifying fellowship holders

The programme for doctoral training abroad has been in place since the 1970s, which suggests diversity between cohorts on motivations and benefits from their training. In order to minimise possible cohort effects and capture the current conditions and pressures for change in the research system in Mexico, a ten-year period was established for graduated participants. The sample includes fellowship holders (fellows) that had completed their training programme in the last ten years and fellows in training.

More than ten years will require respondents to remember information that occurred a long time ago, and which they might not remember in detail. This would represent a problem of accuracy in the data and the study (Buck et al., 1996). By exploring the ten-year sample, the study attempts to build a complete story and to highlight possible future scenarios in regards to policy and international mobility of highly educated people.

Due to personal data protection regulations, the information available on fellowship holders is generic and did not allow for an in-depth analysis. In response to this,

[80]See: http://www.nl.gob.mx/cluster-de-nanotecnologia-de-nuevo-leon-ac and http://www.clusternano.com/

complementary information was requested to Conacyt, and additional online searches were conducted to build a sensible core sample. Table 18 summarises the process by which doctoral fellowship holders were identified.

Table 18 Consulted resources for identifying survey respondents

Source		Data	Type of data
Conacyt's website for calls for applications to the Programme.	-	Results from calls from 2013 onwards.	List of fellowship holders by ID number. *No additional information in these source*
Requests via email to Conacyt. These requests were sensitive to privacy regulations.	-	Register of fellowship holders from 2005-2015.	1,829 in the list met the sampling criteria The list contained the following data: names of fellowship holders, year of start and end of funding, host country and university, and general research area.
Padrón de becarios Conacyt (register of scholarship beneficiaries/ Conacyt fellowships holders); Padrón de becarios y exbecarios Conacyt (Conacyt's fellowships holders grantees and ex-fellowships holders)	-	Register of postgraduate students who received funding from Conacyt for their studies in domestic and foreign universities from 1991 to 2013.	From the 12,699 entries on this registry, 843 students met the sampling criteria, but contact details were not available. The list showed the following information: general research area of specialisation; postgraduate level (masters, PhD, short stay, post-doctoral fellowships, sabbatical stays, and technical specialisations). It also showed the year of start and end of the funding. In most cases, it contained the name of the university and country that hosted students.
General online searches using the following query: mexicanos altamente capacitados en el exterior (highly educated Mexicans abroad)	-	Register of Mexican researchers abroad, elaborated by the Mexican Academy of Science under the project: The Atlas of Mexican Science.	The Atlas is organised by research field, and contains the names of researchers, institutions where doctoral education was completed, employment affiliation details, and country of residence. In some cases, email addresses were available. From the Atlas of Mexican Science, 28 names matched the sampling criteria.
	-	Register of the Mexican System of Researchers Abroad (SNI en el extranjero).	A spreadsheet similar to the register of NRS abroad was initially built consulting the results of the annual calls for applications, and one more was obtained by a request to

		Conacyt. The data given by Conacyt showed 648 entries containing full name, research field, research area, affiliation, and country of residence. No contact information was available. Using names, a few online searchers were conducted in order to collect contact details. This resulted in 147 entries of names and contact information. From these, 26 met the sampling criteria.
	- Meeting registers from the Global Network of Highly Skilled Mexicans abroad were found through online searchers.	Retrieved information from the Global Network in most cases contained the full name of participants, country of residence and email address. 58 contacts match the sampling criteria in the registers from meetings for the Global Network

Online searchers were conducted to retrieve contact details and to select the contacts that met the sampling criteria. A database containing the information of 223 was built through these sources.

8.7 DATA COLLECTION

A combination of semi-structured interviews and a qualitative online survey were used to explore the research questions in this study. The use of multiple sources of information helped to substantiate interpretations and to present the phenomena as accurately as possible (Gray, 2004; Hammersley, 1992).

8.7.1 Semi-structured interviews

In science and technology studies, semi-structured interviews are widely used, especially when research involves the study of multiple actors (Somekh & Lewin, 2005). Moreover, participants in this study are not homogenous. Their attitudes and interests vary, in addition to the differences in contextual conditions, which can also influence their responses. In this context, this research adopted interviews, as a flexible and reliable tool that provides consistency and allows for bringing together into a coherent analysis all variances (Somekh & Lewin, 2005; Yin, 2011).

In summary, due to the exploratory nature of the research questions in this thesis and the heterogeneity of participants, interviews were the core data collection technique in this research. Interviews facilitate access to information that is not publicly available and enables to understand the beliefs and rules that govern interviewees' attitudes. Additionally, they allow for corroboration of findings from other resources. The interviewer can set a pre-array of themes and questions, and can also introduce new questions to complement the interviewing process (Creswell, 2009; Hancock & Algozzine, 2006), which makes them essential to producing a comprehensive case study.

Correspondingly, four interview guides were developed (the general template can be found in full in Appendix 1) according to the following rationales:

- Interview guide for policymakers. These will allow for understanding the policy rationale, design, and implementation. This was complemented with documentary analysis.
- Interview guide for higher education and research organisations. These will enable this study to understand the motivations for hiring researchers trained abroad and the benefits they perceived from this.
- Interview guide for the private sector. These will enable this study to understand the motivations for hiring researchers trained abroad and the benefits they perceived from this.
- Interview guide for a selected group of doctoral students that responded to the survey and were willing to participate in a set of follow-up questions.

The interview guides aimed to obtain and validate information on the research system in Mexico. In particular, interviews aimed at gaining insight into the expectations and attitudes towards doctoral training and international mobility. The interviews will explore a diverse range of topics, such as the conditions of national research and S&T policy, the connection between the rationale of the Programme and the current conditions of domestic and global science. Also, these will include the participant's views on the opportunities in the Programme, and ask about the benefits or any other effect they may have perceived as a result of their participation in it.

Interviewees were first contacted via e-mail and in some cases via telephone calls. Interviews lasted about 40 minutes, and all were recorded after participants gave their consent. Notes were taken during each interview, and all interviews were later fully transcribed and complemented with the pertinent field-work notes.

8.7.2 Survey

This study used a qualitative survey to collect the attitudes and motivations of fellowship holders. The survey aims to capture the motives underpinning their decisions to study abroad and the benefits and experiences that the international training affords. Responses will help present a detailed picture of the motivations, expectations and changes in doctoral students trained abroad. Moreover, it will provide a reference point to triangulate the information provided by other participants during interviews. The questions in this survey are presented in full in Appendix 2.

Fellows are scattered across different locations, making interviews a resource-intensive method. This survey is the response to that challenge and consists primarily of open-ended questions. This type of survey was selected by its capacity to capture the voice of participants (Jansen, 2010). The survey was tested in a pilot exercise in October 2017, where participants were doctoral students and graduated researchers in foreign universities funded by the Programme. After the pilot exercise and amendments to the survey, this was sent to the contacts identified through online searchers and formal requests. In order to increase the response rate, more participants were reached out through social media groups, who have identified themselves as postgraduate students funded by Conacyt, and other groups of highly skilled Mexican citizens living abroad. Table 19 shows the outlets through which the survey was disseminated.

The survey was developed using the Qualtrics® platform and delivered using the link that is automatically generated by this platform. After disseminating the survey and receiving some initial responses, a follow-up request was sent to the participants that had left the survey incomplete.

Table 19 Platforms for the dissemination of the survey

Targeted platform	Potential reach	Details
Invitation via email	223	Contacts from the database created in the identification of participants exercise. Personal contacts were also asked to disseminate the survey.
Social media groups	73,270	The targeted groups self-identified as: -Becarios Conacyt en el extranjero (postgraduate students abroad funded by Conacyt) (944 members) -Becarios Conacyt (Conacyt funded postgraduates) –leaving abroad or in Mexico (64,610 members) -Becarios Conacyt en UK (Conacyt funded postgraduates in UK) (6,148 members) -Becarios Conacyt en Estados Unidos (Conacyt funded postgraduates in USA) (1,478 members) -Cátedras Conacyt (Chair positions funded by Conacyt) (520 members) -Red de investigadores mexicanos en el extranjero (Network of Mexican researchers living abroad) (3,592)

In regards to survey responses on effects (benefits/disbenefits) from international doctoral training, particularly in those concerning job prospects abroad, it was considered necessary to confirm whether the respondents had employment outside Mexico. Follow-up questions in the survey asked about employment status, type of employment, position and geographical location, but not all participants living abroad responded to this question. In response to this, when possible, information was collected through online searches on the participants' professional webpage, this yielded information about the employment status for 73 participants, which represents 91% of the graduated cohort sample.

8.7.3 Policy documents and reports

In order to construct a reliable study about Mexico's policy objectives and effects concerning the international mobility of doctoral students, secondary sources were also reviewed as part of this study. The focus was primarily on policy documents and reports published by Conacyt. Documents included different versions of the Special Programme for Science and Technology (PECITI) and calls for applications to the Scholarship Programme. Reports included self-evaluations and evaluations conducted by third parties on S&T policy and the Scholarship Programme. Information in these documents helped validate the findings from interviews and survey responses.

8.8 DATA COLLECTION RESULTS

The following tables summarise the number of participants per category and level of responses to the online survey.

Table 20 Data collection results from the interviews

Participants	***Contacted***	***Interviewed***
Higher education institutions	40	27
Companies	45	20
Fellowship holders that responded the survey	10	10
Policy makers	8	2
Totals	103	59

Additionally, two interviews were conducted with authorities from the Nano-cluster and the S&T ministry in Monterrey, and one more with a leading member of the Nanotechnologies Standardization Committee from the Centre for Metrology and Accreditation. These and the contributions from policymakers were a crucial source of context information, contributing to a general understanding of the conditions for S&T policy and development of nanotechnology in Mexico. Due to the intellectual interest and the ambition of the study to go beyond immediate policy intentions, the contributions of policymakers were deemed to be of little value. In this sense, because policy intentions and implementation are stated in the rules of the programme, a documentary analysis was a more reliable research method.

Responses from 57 interviews and 144 survey responses constitute the basis of this study

Table 21 Data collection results from the survey

Selection of useful responses	
First data cleaning	*Responses*
Recorded responses	189
Views only and tests exercises	16
Respondents that completed less than 20% of the survey (passport questions)	11
No reliable responses. Unreadable characters	18
Final responses after cleaning	144
Second data cleaning	*Responses*

Respondents that completed more than 50% but less than 100% of the survey	16
Participants that completed 100% of responses	89
Total responses considered in the study	**144**

8.9 RESEARCH APPROACH: ASSESSING THE POLICY PROCESS FROM INTENTIONS TO IMPACT

Translating policy intentions into effects is a process that connects national interests with individual interests in a complex environment, where external signals also influence how beneficiaries behave and how they enact the opportunities provided by policies. As elaborated in the conceptual framework in Chapter 7, studying how interactions unfold to produce specific effects means breaking it down into its central components, namely actors, perceptions and interests and contextual conditions. Following Nedeva (2010; 2013) this research suggests that policy instruments represent a set of opportunities to its potential beneficiaries and that their participation also affects the change policies could produce.

Consequently, the theoretical foundations in Chapter 6 guided the analysis and interpretation of findings, particularly on the factors furthering the mobility of researchers. In order to identify possible effects of the Programme, this research looked into the effects or changes that actors expected and considered realised from undergoing the international experience. This means identifying the policy rationale, motivations of doctoral students for undertaking training abroad, and reasons that drive employers to hire fellows. Also, it means assessing whether the interests of actors and reported effects lead to the intended change in the national S&T system. For instance, what changes in domestic research can be attributable to the implementation of the Programme? Moreover, to what extent the Programme enabled high-quality research skills and improved research activities in domestic research organisations?

8.9.1 Analysis: studying policy implementation by listening to central actors

Qualitative data from open-ended questions in the survey and interviews were organised and analysed using the thematic encoding and data from closed-ended survey responses were analysed with simple descriptive statistics. The coding was theory-driven, informed by previous research. The analysis was carried out in three steps. First, an initial exercise consisted of identifying the participants' interests and involvement in the Programme. This initial exercise facilitated the process of understanding the perspective of participants on the studied issue. Second, the analysis aimed to identify the contextual conditions that could influence the responses of participants. In this phase, the struggles, financial and structural, at the national system emerged. In the third phase, the analysis focused on reported effects and their relation to the Scholarship Programme.

The analysis was not motivated by an interest in showing the shortcomings of the Programme. Instead, it explored, in a comprehensive manner, what was occurring within the Programme and the research system, and why. In particular, the analysis aimed to show how this case can illustrate that policies do not produce change on their own, but that change is the result of a variety of factors. The analysis resulted in an illustration of a broader struggle between national, international and research pressures affecting the participants and produced effects. In addition to enriching the understanding of how S&T policies work, this analysis will contribute to the understanding of the international mobility of researchers and its effects on individual researchers and the sender country.

8.10 RELIABILITY AND VALIDITY

In order to assure reliability and validity in the interpretation and explanation of data, this study resourced from two measures. The first required cross-checking the design of instruments for collection with the supervisory team. The second measure was to consult a scholar with expertise on Mexico's S&T policy and migration studies before data collection endeavours started. Additionally, to encourage participants to give as many details as possible without fearing negative consequences from their contributions, it was emphasised during interviews that their contributions will be used for academic purposes only and personal information will be anonymised.

8.10.1 Reflexivity

This is a process aimed to ensure the validity of findings by preventing personal values to influence interpretations (Creswell & Miller, 2000; Denzin & Lincoln, 2018). In social research, it is not always possible for researchers to completely distance themselves from the studied object. In this sense, reflexivity becomes essential in the recursive relation between interpretation and reality. This means that researchers must be aware of their role in the research process and the possible implications of this involvement in their analysis (Ibrahim & Edgley, 2015; Saunders et al., 2016).

Reflexivity was crucial throughout the research process in this study. However, there is bias in this study; this is because the author is a fellowship holder. During the data collection process, interviewees' responses resonated with personal views. At the same time, this bias allowed the researcher to make direct questions on specific issues that are not always openly discussed. It also facilitated, due to language and cultural familiarity, a more accurate assessment of the participant's contributions. All data were collected and analysed following professional practices as a social scientist. Findings challenged prior understandings and assumptions about S&T in Mexico. Discussing findings with the supervisory team also helped to keep objectivity throughout this research.

There is also sampling bias in this study, particularly on the fellowship holders that participated with responses to the online survey and subsequent interviews. There is high participation of fellows from the University of Manchester, this because of geographical proximity that facilitated requesting their participation in this research.

8.10.2 Ethical considerations

Throughout this study, ethical considerations were present at all stages. Interviewees and survey participants were asked informed consent to participate. Sensitive and personal information was anonymised.

PART IV EMPIRICAL RESULTS AND DISCUSSION

CHAPTER 9 THE IMPACT OF INTERNATIONAL MOBILITY IN DOCTORAL STUDENTS AND DOMESTIC EMPLOYERS: MOTIVATIONS AND REPORTED EFFECTS

9.1 INTRODUCTION

This research aims to identify the changes or effects on the direct and indirect beneficiaries of the Scholarship Programme. Chapter 4 offered a review of the rationale in this programme, its resources, and its position as an S&T policy in the Mexican research system. Following the debates about the international mobility of researchers, presented in Chapter 6 in this thesis, it became clear that the motivations behind this process range from professional to personal reasons. Also, the literature in that chapter emphasised the two dominant debates and policy approaches on the effects of mobility for both sender and receiving countries, which comes down to losses and gains. Chapter 7 concerned the importance of the relationship between policies and change in research, which might have occurred due to pressures outside the scope of intervention.

This thesis draws on a survey and semi-structured interviews as primary data collection methods. It also relies on secondary data such as policy documents, policy briefs and reports. It addressed the issue of attribution by identifying the mechanisms that enabled effects and conditions or opportunities created by the policy instrument, which comprises its historical and contextual properties and its implementation.

This chapter analyses the impact of the Scholarship Programme in the direct and indirect beneficiaries and is organised as follows. Section 9.2 presents the results of the qualitative survey and subsequent interviews with fellows. This section describes the characteristics of the fellowship holders and motivations that led them to undertake doctoral training outside Mexico. This section then proceeds to analyse the effects of the international experience in these fellows. Section 9.3 presents the analysis from the interviews with domestic employers, which will focus on motivations for hiring international researchers (those that have been trained abroad) and benefits that they have perceived as a result of this. Section 9.4 discusses and concludes.

Impacts/changes are presented in terms of benefits and challenges reported by the participants in this study. This chapter relies on 144 responses from fellowship holders to a qualitative survey and ten subsequent semi-structured interviews with selected fellows. It also builds on 47 semi-structured interviews with HE&RIs and companies.

The two interviews conducted with policymakers are not included in these results. Their contributions helped validate the information contained in policy documents and reports, and which has been presented in Chapter 3 and 4 in this thesis. Their responses offered relevant information about the conditions in which the Programme operates i.e. origins, financial and governance constraints.

9.2 SURVEY AND INTERVIEWS OF FELLOWSHIP HOLDERS: CHARACTERISTICS, MOTIVATIONS AND REPORTED BENEFITS

The following section analyses the responses to the questionnaire sent to fellowship holders. It also analyses the responses of the subsequent interviews with selected respondents. This involves the presentation of some basic descriptive statistical analysis, though most of the analysis will be qualitative guided by the theoretical framework in Chapter 7.

9.2.1 Survey responses

9.2.1.1 A descriptive characterisation of the fellows

This section draws on survey responses and describes the principal characteristics of the respondents. Before presenting the results, it is worth noting that the number of fellows (144) that participated in this research represents 10% of the total fellowships that Conacyt allocates annually for international postgraduate training programmes.

This characterisation comprises the specialisations pursued by fellowship holders and benefits and challenges as a result of their scientific training overseas. This will allow for exploring ‘what’ and ‘how’ individual benefits translate, or not, into benefits in the research system when looking at the responses provided by domestic employers. This section also presents countries of destination and HE&RIs where fellowship holders were trained and the sources for financial support that they considered to fund their doctoral courses.

Fifteen doctoral students that responded to this survey had applied for a fellowship to the Scholarship Programme and external funding schemes simultaneously. Their applications in all instances turned out successfully, and after having secured foreign funds, these students declined the sponsorship offered by the Programme. Six of them received funds from the Science Foundation Ireland (2), the German Academic Exchange Service (1), the Monbusho Scholarship[81] (1), the Project Invisibles[82] (1), and the Industrial Convention for Research Training[83] (1). The other nine were funded by the host university in the USA (3), in Spain (3), the Netherlands (2), and the Gates Cambridge Scholarship UK (1). Their responses are included in this analysis due to similarities with the core sample concerning motivations and overall international training experience.

Table 22 provides a summary of the characteristics of survey respondents.

Table 22 Summary of survey responses

Description of respondents N=144
Doctoral training status
- 56% of respondents completed their PhD in the last ten years (graduated cohort)
- 44% were in current doctoral training at the time they completed the survey (in training)
Country of residence
- 65% of respondents live abroad
- 35% live in Mexico
Gender
- 29% female respondents
- 71% male respondents

The total sample comprises the responses of fellowship holders that had completed their doctoral courses when responding to the survey (56%). These are named here,

81 Funded by the Japanese Ministry of Education, Culture, Sports, Science and Technology
82 A European project for research on experimental and theoretical Physics
83 Conventions Industrielles de Formation par la Recherche, in French, and Funded by the French Ministry of Higher Education, Research and Innovation

for differentiation purposes, as the ‘graduated cohort’, and the respondents still undergoing training (44%) are referred to as the ‘in training cohort’.

The employment and residence status of respondents in the graduated cohort are presented in Figure 16 and Figure 17, respectively.

Figure 16 Employment status of the respondents in the graduated cohort living in Mexico, n=50

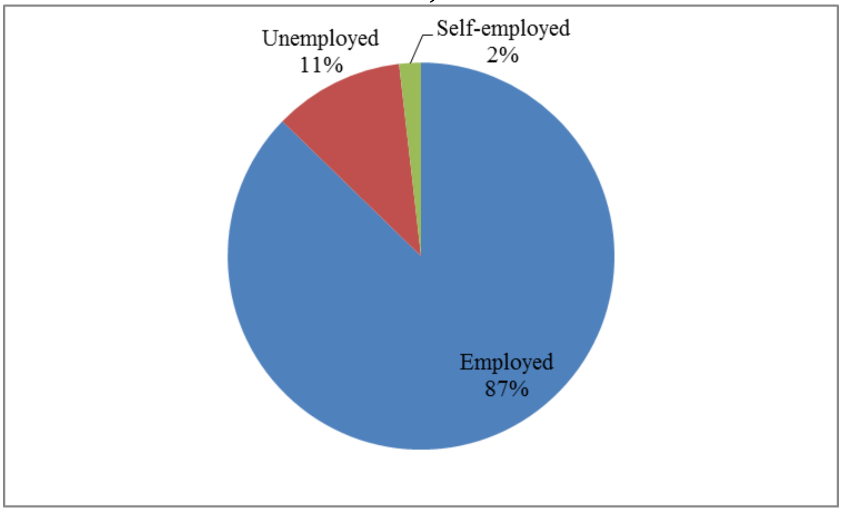
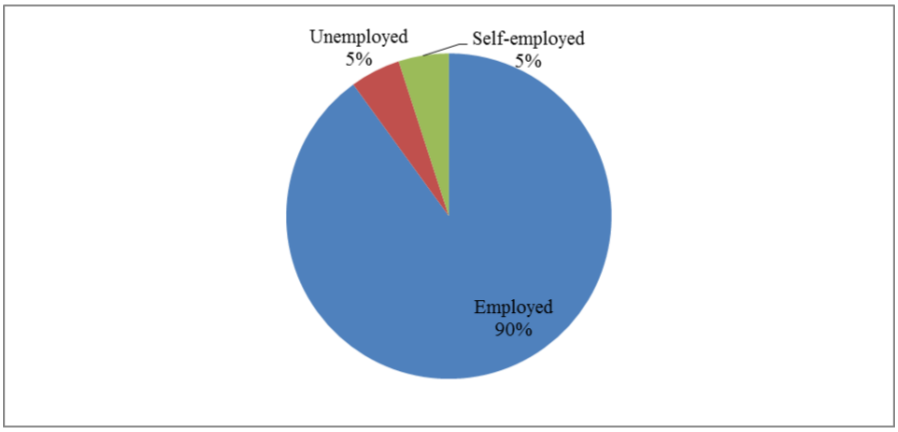


Figure 17 Employment status of the respondents in the graduated cohort living abroad, n=30



In regards to gender, the results show that female respondents represent one-third of the total sample and male participation accounts for the remaining two-thirds of responses – see Table 22 and Table 23.

Table 23 Gender of survey participants

Characteristic	Female (n=42)	Male (n=102)
Graduated	23 (55%)	57 (56%)
In training	19 (45%)	45 (44%)
Living abroad	30 (71%)	64 (63%)
Living in Mexico	12 (29%)	38 (37%)

9.2.1.1.1 Specialisations: fields, applied and theoretical research

Due to the empirical choices in this study, responses came from fellows trained in STEM fields, particularly in nanotechnology and material sciences – see Table 24.

Table 24 Specialisations of fellowship holders

Field	Count	%
Materials sciences and nanotechnology	32	22
Chemistry	27	19
Physics	21	15
Engineering	17	12
Biology and biotechnology	14	10
Mathematics and computer sciences	13	9
Biomedicine	12	8
Biochemistry	5	4
Bioengineering	3	2
Total	**144**	**100 %**

There were differences between cohorts concerning specialisations. The most evident was the increased number of current fellowship holders in Bioengineering and Biomedicine. The opposite occurred in materials sciences and nanotechnology (see Table 25). It is worth noting that the Programme encourages applications in all hard science fields[84], and there are no established quotas or prioritisation for any particular scientific area of study. Thus, this variation across cohorts can be interpreted as preferences expressed by fellowship holders. However, the research areas prioritised

[84] On average, each year, Conacyt receives applications in the following proportions Mathematics, Physics and Engineering (39%); Biology, Chemistry and Biotechnology (24%).

by host HE&RIs can also play a role here, as fellows may align their research interests to those of the supervisor.

Table 25 Fields of specialisation between cohorts

Field	Graduated cohort (n=80)	In training cohort (n=64)
Materials sciences and nanoscience and nanotechnology	25%	19%
Chemistry	21%	23%
Physics	18%	11%
Mathematics and Computer Sciences	14%	3%
Engineering	12%	11%
Biology	6%	14%
Bioengineering and Biomedicine	4%	19%
Total	100%	100%

In regards to the purpose of the research project conducted by fellows, 129 (89%) reported their project as applied, and 15 fellows carried out theoretical or basic research projects (11%). The high percentage of respondents in applied research projects can be, to some extent, linked to the fact that for 42 (39%) of the respondents, their research formed part of larger collaboration projects with non-academic partners, mostly private companies. These companies came from sectors such as health, automotive, aerospace and energy. Another 27 (19%) projects were funded by the public sector in the host country, namely, health, energy, environment and food public agencies.

9.2.1.1.2 Destinations: countries and HE&RIs

As shown in Table 26, the United Kingdom, Spain, the USA, Canada, France and Germany were the leading destinations among respondents. The cohort of graduated fellows preferred Spain, Canada, Switzerland and the USA. The cohort of participants still in training favoured the UK, which concurs with the numbers reported by Conacyt, but this result can also be attributed to sampling bias.

In the first decades of operation of the Scholarship Programme the USA was the preferred destination. The recent trend towards European countries may relate to the entrance costs of higher education in that country, in particular to the tests in admission requirements[85].

Table 26 Preferred destinations by graduated and in training fellows

Host country	Sample (N=144)	%	Graduated cohort	In training cohort	Change
UK	66	46%	22	44	22
Spain	21	15%	16	5	-11
USA	18	13%	11	7	-4
Canada	10	8%	8	2	-6
France	7	5%	5	2	-3
Germany	6	4%	4	2	-2
Switzerland	5	3%	5	0	-5
Ireland	2	1%	2	0	-2
Japan	2	1%	2	0	-2
Netherlands	2	1%	1	1	0
Belgium	2	1%	1	1	0
Sweden	2	1%	2	0	-2
Slovakia	1	0.7%	1	0	-1
	144	100%	**80**	**64**	

In total, 74 HE&RIs in thirteen countries hosted fellows. Table 27 shows that the University of Manchester hosted 20.14% or 29 respondents. This is the only institution that concentrates participants in such magnitude; the remaining 115 were distributed in small numbers across different institutions. It must be noted that a strong selection bias may be operating in these results.

Table 27 Host countries and institutions

Country	University	Number of respondents
Belgium	Catholic University of Leuven	2
Canada	University of Montreal	3
	University of Toronto	2

85 Entry tests are a common requirement in the USA; the most common is the Graduate Records Exam (GRE), which would demand from the student time for preparation and financial resources.

Country	University	Number of respondents
	University of Western Ontario	2
	University of British Columbia	1
	University of Calgary	1
	McGill University	1
France	University of Toulouse	2
	University of Grenoble Alpes	1
	Pierre-and-Marie-Curie University	1
	University of Avignon	1
	University of Bordeaux	1
	University of Nantes	1
Germany	Max Planck Institute	4
	Bielefeld University	1
	Duisburg-Essen University and the Fraunhofer Institute for Microelectronic Circuits and Systems	1
Ireland	National University of Ireland	2
Japan	Toyohashi University of Technology	1
	Chiba Institute of Technology	1
Netherlands	Wageningen University and Research	1
	Utrecht University	1
Slovakia	Slovak University of Technology	1
Spain	Polytechnic University of Catalonia	4
	Autonomous University of Barcelona	4
	Autonomous University of Madrid	2
	Polytechnic University of Madrid	1
	University of Cadiz	1
	Ramon Llull University	1
	University of Cantabria	1
	University of Navarra	1
	Polytechnic University Valencia	1
	University of Cordoba	1
	University of Zaragoza	1
	University of Santiago de Compostela	1
	University of Alcala	1
	August Pi i Sunyer Biomedical Research Institute	1
Sweden	Uppsala University	1
	Chalmers University of Technology	1
Switzerland	Swiss Federal Institute of Technology Lausanne	2
	University of Zurich	3
UK	University of Manchester	29
	University of Sheffield	7
	University College London	5

Country	University	Number of respondents
	University of Birmingham	4
	University of Cambridge	3
	University of Edinburgh	2
	University of Bristol	2
	University of Sussex	2
	University of Oxford	1
	University of Leeds	1
	University of Lancaster	1
	University of Warwick	1
	University of Essex	1
	University of Leicester	1
	University of St Andrews	1
	University of Swansea	1
	University of Lincoln	1
	Queen Mary University of London	1
	University of Plymouth	1
	University of Huddersfield	1
USA	University of California, San Diego	4
	University of Arizona	2
	Ohio State University	1
	University of Houston	2
	The University of Texas at El Paso	1
	University of Iowa	1
	Arizona State University	1
	Kansas State University	1
	University of California, Irvine	1
	Universidad de California, Davis	1
	University of Delaware	1
	Massachusetts Institute of Technology	1
	Rice University	1
13 countries	**74 host HE&RIs**	**144 participants**

9.2.1.1.3 Reported alternatives for external funding sources

The survey presented respondents with a hypothetical situation involving their application to the Programme not being successful and asked about alternative sources of funds (national and international) they would have contemplated in such a case. The relevance of this question is that the Programme is commonly regarded as the primary funding source for doctoral training. This question will enable the identification of other sponsors intervening in the international mobility of Mexican doctoral students.

For the hypothetical situation of an unsuccessful application, 37% responded that they would have considered applying to foreign funding schemes. Sixteen (11%) respondents reported having applied to foreign funds in parallel to the Programme, from these, fifteen accessed successfully foreign funds and one had an unsuccessful application. Ten (7%) respondents indicated that they would have used their own funds to pay for their studies. In regards to considering other national sources of funds, 89% of respondents indicated that they would have re-apply to the Programme in the next call, and would consider instruments such as Fiderh[86].

These responses showed that participants applied to the Scholarship Programme due to their familiarity with it. However, alternative sources, more attractive than the Programme in terms of monetary support, are becoming accessible to Mexican doctoral students. This may prompt Conacyt to adopt new forms of implementation or to change its scope; for instance, it could increase the monthly stipend and prioritise areas of research linked to domestic research problems. It could also extend the number of fellowships and financial support through collaborative research projects between domestic and international HE&RIs.

9.2.1.1.4 Motivations for studying abroad

Investigating the motivations of international doctoral students is fundamental to the study of impact. Motivations can help understand their interpretations and responses to the opportunities signalled in the Programme, and to assess the extent to which their interpretations concur with the objectives in it. This will help to understand whether change or impact was the response of fellows to the incentives offered in policies or to other factors.

[86] The Fund for the Development of Human Resources is a federal trust fund administered by the Central Bank and that operates as a loan.

Table 28 outlines the responses to a question that suggested seven possible reasons, informed by theory, to undergo international mobility. This question also offered a choice for respondents to add other motivations. The added motivations will be analysed in the qualitative responses section in this chapter.

Table 28 Motivations for studying abroad

Motivations to study a abroad	Frequency	%	Graduated cohort %	In training cohort%
To increase my possibilities of finding a job abroad	89	62%	35 (44%)	54(83%)
To work with a leading research group	87	60%	46 (58%)	41 (63%)
To migrate	87	60%	51 (65%)	36 (55%)
To harness the support from my supervisor in Mexico in the admission and funding process, and familiarity with the Programme	83	58%	48 (61%)	35 (54%)
To increase my opportunities for a better job in Mexico	72	50%	36 (46%)	36 (55%)
Research interest not available in Mexico	70	49%	36 (46%)	34 (52%)
The techniques of interest not well developed in Mexico	57	40%	34 (43%)	23 (36%)

For both graduated respondents and those in training, the most important motivation for pursuing doctoral training outside Mexico was the possibility of finding a job abroad after graduation. Fellowship holders were attracted to the best research milieus to acquire high-quality skills, expecting that this would facilitate their entry to the international labour market. In principle, this does not mean that the participants would find the desired job abroad, but this may have profound implications for national research. This is because fellows might not be interested in returning to Mexico, which can be seen as detrimental to the sending country (brain drain), but also because they might return feeling frustrated and discouraged to continue their scientific career in the country. In that case, international mobility may take a different form in the eyes of mobile researchers, and they may perceive it as a cost rather than as an advantage since they could have studied in a domestic institution and become part of a research community that would help to consolidate their career. On a different interpretation, the interests of mobile researchers to remain abroad can bring later development of linkages and transnational networks. It can also promote alternative career paths.

Responses showed some variances when disaggregating data in cohorts, and these were that finding a job abroad was more significant for fellows still in training (83%), but fewer of them indicated migration (55%) as their primary motivation. These results contrasted with those from graduated fellows, who seemed more motivated by the idea that studying abroad would allow for migration (65%) than for finding a job abroad (44%). Explanations for this are that the emigration, referring to the decision of not to return, of fellowship holders is a controversial topic. Some fellows may feel morally bound to return after graduation, while others may evaluate their choices in terms of attractive career prospects outside Mexico.

Being part of an international scientific community was the second most relevant motivation among respondents (60%). This related to having the opportunity for producing relevant scientific research and access sophisticated technologies, which may be conducive to prestige and promising career prospects. It is possible to assume that respondents thought of the reputation of supervisors, research groups and host HE&RIs as advantageous in validating their place in an international community. The underlying assumption in these responses could be that 'learning from the best' would facilitate the transition of the participants from international doctoral students to international researchers.

Responses to the question about motivations also showed that mentors, who provided past research training in Mexico, incentivised respondents to undergo international doctoral education (58%). This may be because having a doctoral degree is a requirement for any academic position in domestic HE&RIs, and some institutions may prefer researchers with foreign degrees[87]. Also, it might be that international

[87] A few decades ago, between the 1970s and the 1990s, holding a foreign degree would guarantee a job in domestic HE&RIs, regardless of the quality of the researcher and the alignment of their research interests with those of the employer.

mobility, in its different types, is a common trait in domestic research communities. Thus, during their undergraduate and masters' courses, fellows become aware of the relevance of the relevance of international mobility for the local academic labour market, and they mirror this practice motivated by a potential place in this community. These responses were larger among graduated fellows (48%) than in those in training (35%), a possible explanation is the size of each sample, 80 and 64 respectively.

Accessing better jobs upon return was another motivating factor for 50% of participants. Ultimately, having access to the latest debates (49%) and techniques (40%) that were not well developed or available in domestic HE&RIs were also prompting the participants to pursue doctoral training abroad. A difference here was that these motivations were more significant for the graduated fellows (43%) than for the still in training cohort (35%). A possible explanation for this is that domestic research has improved in the past ten years; it provides students with high-quality research training in most of the scientific fields and relies on foreign HE&RIs for training in emerging fields. This can be seen as a matter of capacity of the system to adapt to the changing demands of scientific research, which depends on a long-term strategy for scientific and technological development, accompanied with sustained investments.

9.2.1.1.5 Plans for after completion of doctoral training: return and stay

This section presents the survey results concerning the plans of participants for returning to Mexico after the completion of their doctoral courses. The survey contained four possible responses. Table 29 summarises these results.

Table 29 Plans of respondents for after completion of training, N=144

Responses about plans after completion	%	Graduated cohort %, n=80	In training cohort %, n=64
Return	(62) 43%	(42) 51%	(20) 31%
The initial plan was to return, but this changed	(45) 31%	(24) 30%	(21) 33%
Stay abroad	(20) 14%	(7) 9%	(13) 20%
No response	(16) 11%	(7) 9%	(9)14%
Uncertain	(1) 1%	(1) 1%	(1) 2%
Total	**100**	**100**	**100**

Conacyt expects fellowship holders to return after they have completed their studies. The underlying reasoning in this expectation is that through the return, national science would benefit from the improved experience and research skills embedded in these researchers (returnees).

These results presented a mixed picture; this is because 43% of respondents had considered return as an option after completion, while 31% would prefer to stay abroad. There was a larger percentage of respondents with no plans to return among fellows in training (20%), in contrast with a reduced percentage (9%) of these responses from graduated fellows. This may be because 65% of the graduated participants returned to Mexico after completion. A 14% of 'no-response' came in mostly from the participants still in training. This result can be explained by the reticent attitudes towards the controversy around the emigration of fellows.

A total of eleven qualitative survey responses reinforced these results. The participants in these eleven open-ended responses framed their participation in terms of 'issues' in Mexico in contrast to the 'opportunities' abroad when justifying their plans for return and migration. Seven of these respondents (54%) mentioned the lack of state-of-the-art research infrastructure, resources for research and value of research conducted in Mexico (in terms of prestige and relevance) as crucial for their next move. Other factors underlying the attitude of participants in favour of migration were the low salaries and quality of life in Mexico (36%), along with mentions about insecurity and crime (10%). The view of these participants regarding national research was reinforced by reductions of funds for S&T during the past ten years and by unresolved social struggles in Mexico.

The Programme, strictly speaking, does not require fellows to return. However, if they want to access funds administered by Conacyt, fellows would have to provide the letter of release that this body grants to those that proved they have returned. Anecdotal accounts in the qualitative responses suggested that it was not unusual for the fellows to obtain such letters without having to return to Mexico. It should be noted that the

Programme's guidelines are vague and operate under the principle of the goodwill of the involved parties, leaving room for different interpretations.

In summary, the results from the descriptive statistical analysis of survey responses indicate that the aspiration for achieving status as international researchers and better career opportunities were the crucial motivations for undertaking international mobility. Also, these results indicated that international mobility could be a stepping-stone to migration.

After having identified the motivations for international mobility, the following sections are concerned with its impact on the fellowship holders and domestic employers, which will help to assess whether these motivations were justified and trace possible indirect impacts.

9.2.1.2 Impact of international mobility on fellowship holders

This section will analyse the actual benefits and challenges reported by participants. The benefits to national employers in the research system are analysed in further sections in this chapter.

The survey asked participants about the benefits they perceived as a result of the international experience and provided a set of options that could reflect, according to the literature, the opportunities that this affords for researchers. The perceived benefits were contingent upon the availability of these in Mexico. The survey included an open-ended question where participants listed additional benefits to those presented in the survey and elaborated on their responses.

The analysis of responses showed that international training came with a variety of benefits for fellowship holders. Survey results are summarised in Table 30.

Table 30 Impact of international mobility on international doctoral students, frequency of responses, N=144

Benefit	Only available abroad	Available in Mexico
Access to equipment and infrastructure	(117) 81%	(27) 19%

Benefit	**Only available abroad**	**Available in Mexico**
Access to collaborative research with industry and other actors	(104) 72%	(40) 28%
Access to cutting-edge techniques	(104) 72%	(40) 28%
Improvement of personal skills and capacity of adaptation	(99) 69%	(45) 31%
Access to access to technology markets and facilities for entrepreneurship	(96) 67%	(48) 33%
Prestige	(94) 65%	(50) 35%
Conduct state of the art research	(79) 55%	(65) 45%
Build international networks	(71) 49%	(73) 51%
Access to the international labour market[88] (n=101)	(50) 49%	(51) 51%

Respondents reported access to sophisticated equipment and infrastructure as the most important benefit of their experience as international doctoral students. This response needs to be understood in a context where Mexico is not as well-equipped as host countries, which provided participants with cutting-edge research infrastructure and hands-on interaction with this equipment. Thus, having access to these technologies is a direct impact of international mobility on the researchers.

The second most important benefit was the opportunities that participants had for engaging with non-academic actors. The presence of these actors in host countries' research systems provided participants with a different perspective on research, particularly on the role of industry in financing scientific endeavours and its monetisation. In cases where participants had direct contact with industry partners[89], they may have also extended their professional networks.

[88] In this particular item, 43 participants, 30% of the sample, did not select this response.

[89] As mentioned earlier, 39 % of participants' research theses were part of larger collaborations with private partners, but the nature of the interactions between fellowship holders and these partners are unknown.

Collaborative research with non-academic actors is a widespread practice across countries such as the UK, Germany, the Netherlands and the USA. In contrast, research in Mexico is almost entirely funded by the government. The private sector directs its investments to improving imported technologies rather than to new designs.

As a fast-moving emerging field, the advancement of nanotechnology rests on sophisticated and expensive techniques, such as optical lithography and physical and chemical vapour-phase deposition. Such methods require costly instrumentation and expensive components, and developing industrial application entails additional costs for testing potential uses. Developed countries like the UK, the USA, and Germany have accrued considerable advantage leading the progress in those cutting-edge techniques, from which the fellowship holders in this research have benefited during their training courses.

Having to come to a different country and learn new ways of doing things had an effect on the participant's capacity to adapt, which may have contributed to their social capital through the exposure to multicultural contexts and diversity of research approaches. A few anecdotes mentioned by participants in interviews indicated that some fellows did not adapt to the demands that living in a new country adds to the academic demands, and returned to Mexico. In this sense, overcoming personal challenges gave the participants a sense of confidence and achievement.

The results show that having access to contexts that facilitated and incentivised scientific entrepreneurship had a significant impact on the international experience of the participants. These results involved opportunities to learn about the use of intellectual property, access to information on technology markets and funds to commercialise possible applications derived from research. The significance of these results is that this, in contrast to these opportunities, most research in Mexico is highly theoretical. Doctoral students have little exposure to industries and applied research[90], and when applied solutions are developed, these rarely reach the pilot and pre-commercial stages.

The participants saw prestige as another opportunity enabled by international mobility. Prestige may give them more ‘visibility’ in their community and among potential employers, which resulted from working with an eminent and ‘connected’ group in a reputable HE&RIs and having access to its capital and support. The extent to which this benefit is realised or assumed will require further research. This could be addressed by examining the careers of participants, their contributions to research, and comparing these to those of researchers trained in domestic universities or who undertook shorter international stays.

As seen in Table 30, other reported benefits included conducting state of the art research, access to international networks and the international labour market. An interesting result here was that international networks did not seem as relevant in comparison to other reported benefits. Explanations for this can be that 10% of respondents considered that these networks could only be accessed through international mobility. The remaining participants indicated that networks could also be established while in Mexico, through the connections of supervisors, but that these may not be of the same quality and extent as those established when abroad.

9.2.1.2.1 Access to the international labour market

To get a better understanding of whether international training results in international jobs, the movements of the graduated cohort were mapped for 73 graduated fellows. The size of this sample results from the number of participants (out of 80 in this cohort)

[90] In recent years, Conacyt implemented a modality of postgraduate training that involves industrial stays and the development of solutions for companies. It also introduced a similar modality for the public health sector. There are not private resources in these initiatives. (See chapter 4).

that responded to section 4, which comprised a set of questions concerning the trajectories and geographical movements that fellows had after graduation.

The results showed that 36% of these participants have employment abroad, which considering their motivations for mobility, it is possible to say that their time abroad may have had a positive impact on their job prospects. Figure 18 illustrates the destinations of participants after graduation and

Table 31 contains details of their movements.

Figure 18 Movements after graduation[91]

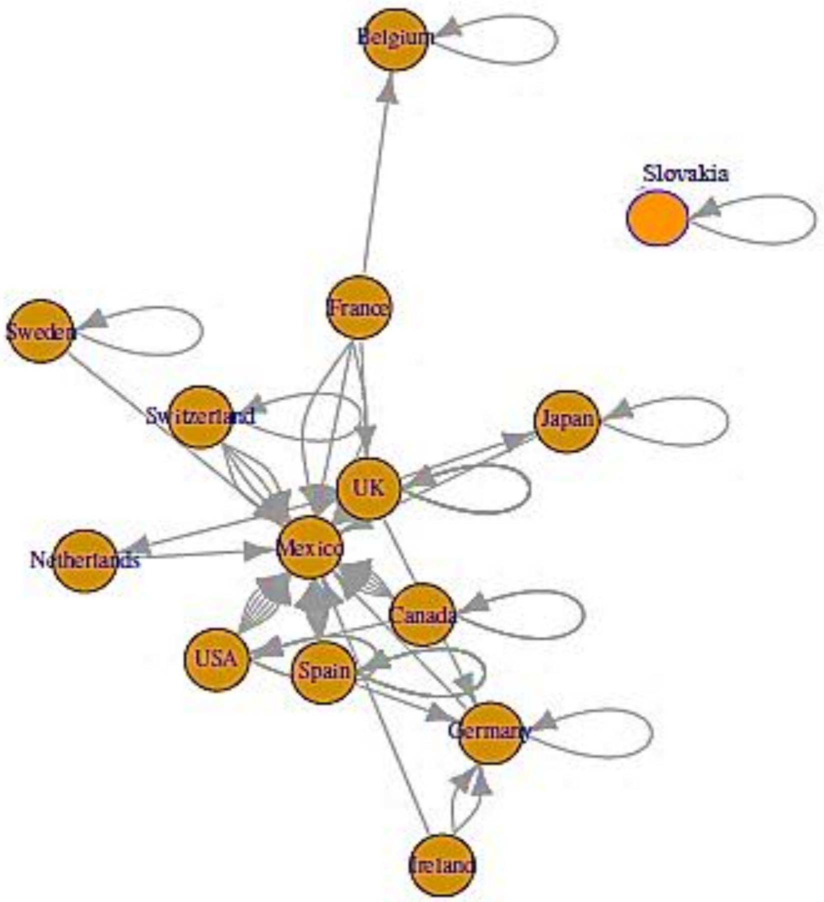


Table 31 Movements after graduation

Country of training	Country of residence	Total
The UK	Mexico	13
Spain	Mexico	10
The USA	Mexico	6
Canada	Mexico	5
Switzerland	Mexico	4
France	Mexico	3
Japan	Mexico	2
The Netherlands	Mexico	1

91 This figure was made with the use of R.

Country of training	Country of residence	Total
Ireland	Mexico	1
Sweden	Mexico	1
Germany	Mexico	1
The UK	The UK	5
France	The UK	1
Canada	Canada	3
The USA	The USA	2
Canada	The USA	1
Ireland	Germany	2
Germany	Germany	1
Spain	Germany	1
The UK	Germany	1
Spain	Spain	1
Sweden	Sweden	1
Slovakia	Slovakia	1
Japan	Japan	1
The UK	Japan	1
The UK	The Netherlands	1
France	Belgium	1
Belgium	Belgium	1
Switzerland	Switzerland	1
		73
Destinations after completion of studies: summary		
Destinations	Total	%
Mexico	47	64%
The UK	6	8%
Germany	5	7%
Canada	3	4%
The USA	3	4%
Belgium	2	3%
Japan	2	3%
Spain	1	1%
Sweden	1	1%
Slovakia	1	1%
The Netherlands	1	1%
Switzerland	1	1%
Total	73	100

The results showed that 38% of these stayed in the country where they obtained their doctoral degree, 9% moved to countries within the same region, and 1% graduated in the UK moved to Japan - a country with no close similarity to either the UK or Mexico.

The following table shows the positions and sectors for 23 of the participants living abroad (26 graduated fellows were living abroad, but only 23 provided information concerning their current job when responding to the survey).

Table 32 Jobs after graduation of the graduated fellows living abroad

Sector	Positions, n=23
Industry	Senior scientist (8%), Senior consultant (8%) Engineer (13%)*
Academia	Research associate (17%) Associate professor (4%) Post-doctoral fellowship (29%) Research group leader (17%) Assistant Professor (4%)

It is too early to assess if having a job abroad will translate into long-term benefits for these fellowship holders. However, the results above can allow for speculations concerning the interest of the participants to return, and the scenario seems to be not optimistic for Mexico. This is because, as mentioned in previous sections, results indicate that fellows would prefer to stay abroad and there are only two anecdotal accounts relating possible diaspora connections.

A considerable number of these participants returned to Mexico (see Table 31) 64% to be precise. The vast majority (87%) of these returnees were employed, 11% were unemployed, and 2% were self-employed. Table 33 presents the positions held by the 39 with employment.

Table 33 Jobs after graduation of the graduated fellows in Mexico, n=39

Position	%
Full-time positions as researchers (13) and associate lecturers (5)	46%
Postdoctoral positions funded by Conacyt through the Programme of *Catedras*	36%
Administrative positions in HE&RIs	15%
Research positions in the private sector	3%
Total	100%

In two cases, respondents' intentions to leave Mexico persisted despite having full-time positions for five years[92]. This feeling was emphasised by the participants with postdoctoral positions and the unemployed.

9.2.2 Qualitative survey responses and interview responses

This section draws on the responses of fellows to the open-ended responses in the survey and subsequent interviews with selected respondents. Open-ended responses enabled participants to add motivations and effects that they did not consider were offered in the response-option items. These questions aimed to prompt respondents to elaborate on their choice of response. An open-ended response field was added to the relevant questions in the questionnaire (see Appendix 2). The final section in the survey asked fellows whether they would be willing to be contacted for a follow-up interview. These interviews aimed to allow participants to follow-up specific points and develop arguments from the survey analysis and to gain a deeper understanding of some of the responses in the survey and explore general issues that arose during the initial analysis.

The selection of participants for subsequent interviews was based on their expressed interest, on a survey question, to partake in a follow-up points that were structured in an interview after the analysis of the survey responses. Another criterion was if participants responded to open-ended questions regarding the motivations for moving abroad and the impact of this experience. Initially, 62 respondents expressed an interest to participate, but only 21 had elaborated on their open-ended responses. To decrease the possibility of non-responses to requests for interviews, ten more participants that had indicated their interest to participate were selected. Thus, the selected sample consisted of 31 participants, from which, 12 belonged to the still in training cohort and 19 to the graduated cohort. To have some diversity among

[92] These participants had returned to Mexico through Conacyt' repatriation programme and were actively searching for jobs outside this country.

interviewees, the geographical location of potential participants was also considered. Selected participants were spread across America and Europe.

Invitations for interviews were sent via email, and two follow-up emails were sent to non-respondents. This gave a final 31% response rate (i.e. a sample of 10 interviewees). Five interviews were conducted in person and five via Skype. Table 34 contains the details of the interviewees.

Table 34 Fellowship holders interviewee details

Cohort	Location	Details
Graduated	Mexico	Female researcher working since her return in the private sector for a large company.
Graduated	Mexico	Male researcher working since his return in the public (education) and private sector (his own company).
Graduated	Spain	Male researcher working in the public (education) and sector (his own company).
Graduated	Brussels	Male researcher leading her research group in a university.
Graduated	UK	Female researcher leading her research group in a university.
In training	UK	Female doctoral student in her third year of studies
In training	UK	Female doctoral student in her second year of studies
In training	UK	Male doctoral student in his fourth year of studies
In training	UK	Male doctoral student in his third year of studies
In training	Germany	Male doctoral student in his first year of studies

Selection bias towards participants in the UK may be operating here, due to the proximity of the interviewees and the author of this work.

9.2.2.1 Additional motivations of participants to undertake international mobility: survey open-ended responses and subsequent interviews

The qualitative responses outlined in Table 35 reinforced some of the motivations reported in the close-ended survey responses in Table 28 and tended to replicate the survey responses on beneficial impacts of international mobility. It is possible to say that, often, motivations are based on expected benefits and that such benefits were realised or assumed by the participants during their time abroad.

Table 35 Other motivations cited by respondents, n=31

Added motivations	Mentions	%	Illustrative quote
To explore other ways of doing research	6	19%	"I wanted to learn how research works in another countries, and once being there, to connect with leaders in the field to land a job out there" (Fellow, USA 2)
To learn new things, new people and new cultures	5	16%	"I just wanted to learn about other cultures, how different societies operate, and to assimilate what I saw in them as positive" (Fellow, Mexico 13)
Luck and sake of adventure	5	16%	"I was looking for a PhD programme and saw the call for applications, which was part of an agreement between Conacyt and (my host university). So, I decided to apply thinking I would never be admitted or given the funds, but it all worked out in my favour" (Fellow, Mexico 4)
To improve English language skills	4	13%	"For me, practising my English was another important factor, because although you can learn this in Mexico, you still need to go out to practice" (Fellow, UK 7)
Always wanted to live abroad	4	13%	"Some of my family lives here, so I was already familiar with this place, and I can say that at some point or another I knew I would come live here" (Fellow, USA 1)
For professional development and career development	2	6%	"Although my area of research also exists in Mexico, there are much fewer possibilities for employment there. For me, the chance of getting a job abroad is was latent incentive" (Fellow, UK11)
The quality of the training course in the host HE&RIs	2	6%	"This university is the best, or at least I think so, in this area. They have all the equipment we need, and I can use them when I need them" (Fellow, France 1)
The reputation of the host university	2	6%	"What brought me here was the reputation of some researchers, those that are leading researcher in my area" (Fellow, UK 31)
To find a conducive environment for technological entrepreneurship	1	3%	"I wanted to start a technology business, but this wasn't easy to do in Mexico. So, I decided to come here to learn about intellectual property and expecting to access the funds that this country has for entrepreneurs" (Fellow, Spain 3)
Total	31	100%	

Overall, these motivations were rooted in research, professional and personal ambitions. Most of the statements of the participants were a combination of these elements. As noted by a respondent, whose interest to study overseas was prompted by "the unavailability of specialisations in the fabrication of fuel cells in Mexico and interests in better job opportunities and quality of life" (Fellow, Spain1).

It was not easy to distinguish in these responses, whether one motivating factor was dominant. The quotes used as illustrations in Table 35 are either preceded or followed by statements that related to more than one type of motivation, but with no particular emphasis or further elaboration on them. For instance, eighteen responses seemed to be more influenced by personal and opportunistic motives than by strict research or professional motivations. However, respondents could have been motivated by an interest in acquiring or improving soft skills, which are also of value in the research profession, as groups have become more culturally diverse. Also, domestic hiring practices may have affected their responses. This is because HE&RIs in Mexico require applicants to research positions to have some international experience, either in their doctoral training phase or their postdoctoral phase.

The qualitative responses validated and gave a richer picture of the survey responses. Interestingly, a contrasting picture emerged when responses concerning migration were compared to those in closed-ended questions in the survey, where 60% of participants indicated this as a leading motivation to study abroad. In the qualitative responses, migration (without the intention to return) did not feature as a prominent motivation. The respondents expressed strong opinions about how the research system of Mexico did not value scientific research and that, because of this, they would rather remain abroad. It was noted that respondents became reticent when addressing questions on return and migration, and tended to shift the conversation towards how they would try to contribute, in some way, to research in Mexico.

Interestingly, only two participants provided examples indicating established links with domestic universities. The rest focused their responses on the prestige that comes from being a researcher in a scientifically-advanced country, in contrast to the "lower prestige" that stems from conducting research in Mexico. The extent to which this sense of prestige in mobile researchers from developing countries can affect their intentions to return or to participate in diaspora networks requires further research.

The notion of prestige and its implications for mobile researchers and sender countries remain unexplored.

The reticence of participants concerning the decision of return or migrate can be explained by the controversy around this issue in Mexico. Migration can be seen as an opportunistic behaviour from the researchers that may have deliberately used the financial support of the Programme as a stepping-stone to migrate.

The qualitative responses also showed that the curiosity of the participants for learning other ways of doing research was another motive that influenced their decision to study abroad. As noted by an interviewee in the USA, “I already knew how research is done in Mexico, I needed to go abroad and learn something different” (Fellow, USA3). Improving the command of English was mentioned within the context of how having to live and study abroad encouraged participants to overcome the fear of communicating in this language and to feel more confident to communicate their ideas.

9.2.2.2 Additional reported impact: survey open-ended responses and subsequent interviews

The sampling strategy mentioned in section 9.2.2 was replicated here. The total responses in this section comprised open-ended contributions and interviews. The only difference is that the 31 participants, instead of 21, provided detailed reactions to this item in the survey.

9.2.2.2.1 Benefits

Due to the similarity of these qualitative responses with those presented in section 9.2.1.2 (survey responses), Table 36 was constructed according to the same categories containing survey response options. It also provides quotations to illustrate cases.

Table 36 Summary of other benefits, n=31

Benefit reported in the survey	Added benefits	Illustration of additional benefits
Equipment and infrastructure	-hands-on technical training -facilities to conduct research activities at a competitive pace	“This has been an excellent experience, because I get to use machines, and receive training about their working mechanisms” (Fellow, UK1).

Benefit reported in the survey	Added benefits	Illustration of additional benefits
		"In Mexico, you have to fill thousands of forms to request equipment, reagents, and this, simply, consumes the time that you should otherwise dedicate to research" (Fellow, UK2).
Collaborative research with industry and other actors	-awareness on the relevance of orienting research towards practical or societal challenges -access to non-academic contacts -support for technology transfer and intellectual property protection	"I've noticed that research here is highly valued in the industry, and we work with companies and governments on trying to solve real problems" (Fellow, the Netherlands1)
New techniques	-high quality publications -multidisciplinary research	"These techniques are not available in Mexico, and are very expensive but using them makes it easier for papers to be published" (Fellow, UK4). "The techniques I'm using in my experiments were developed by experts in physics, human tissue and drug delivery, and I had to become familiar with all those topics" (FH, Spain2)
Improved personal skills	-confidence in communicating with peers -capacity to adapt to a new culture -facilitated establishing networks -broader perspectives	"overcoming the fear of speaking in English opened doors for me (…) Now, I feel more confident to approach colleagues and senior academics to exchange ideas" (Fellow, USA2) "That experience (acquiring doctoral training abroad) helped me realise my own limitations (…) I became more appreciative of diversity, cultural and academic because you meet people with new ideas, and new ways of seeing things, and this can make your research more interesting" (FH, Mexico1).
Entrepreneurship and access to technology markets	-Access to support on intellectual property -Awareness of the functioning of technology markets	"I developed most of the solutions that I commercialise now in my studies (…) Thanks to the knowledge I acquired on intellectual property, and on the potential uses we saw for my developments" (Fellow, Mexico1)

Benefit reported in the survey	Added benefits	Illustration of additional benefits
		"My research required very specific materials, and there were not many providers of these. I had to fabricate some of them, and I realised that there was a market niche there (…) and my laboratory received all the support from this university to start a company" (Fellow, Spain1)
Prestige	-work opportunities -access to resources -support from supervisor and access to their contacts and resources	"When I applied for this job, having been supervised by a well-known researcher gave me some advantage because my employer was aware of the quality and relevance of our work" (Fellow, UK5) "I've attended a few conferences receiving the financial support of my supervisor. In one of these conferences, I met a group from Mexico that was doing something similar to what I do. They managed to get some funding to attend the conference, but this was the only international conference that they would attend in the year. Whereas, I attend three or four international conferences in one year." (Fellow, UK7)
Conduct state of the art research/work with the best	-awareness of knowledge production practices, namely high impact publications -ideas exchanges and expert feedback -level of independence and responsibility -work in multicultural and stimulating environments	"I was always around people that set the stakes high in terms of the quality of research, and the level of productivity that we all should have (…) I had learned fast and adopted more productive approaches to research" (Fellow, UK3)
International networks	-job opportunities -collaboration -access to infrastructure -joint experiments, -co-supervision of postgraduate students -testing and prototyping -research and training visits	"I found my actual job through my colleagues. I think that the recommendations from my supervisor and academics that knew me helped me in obtaining this" (Fellow, UK8) "When I came back (to Mexico), I had nothing, only my desk and an office. My contacts abroad helped remain active by co-publishing and

Benefit reported in the survey	Added benefits	Illustration of additional benefits
		also helped to apply for external funds to establish my own laboratory" (Fellow, Mexico2)
International labour market	-familiarity with the research system -familiarity with hiring practices and expectations from people with doctoral skills -affinity of research interests and skills	"I think that it was because people in the group knew my work and because my thesis was part of a larger project funded by the EU. Also, I knew how the group worked, who was the expert in each area, and we all knew that this collaboration will bring mutual benefits" (Fellow, Spain2)

The participants considered the opportunity of being trained abroad as highly desirable, and as a *de facto* condition to conducting relevant research in global scientific communities. Evidence showed that international doctoral training could impact mobile researchers through a variety of benefits, which can bring varied effects on knowledge communities in the long-term. For instance, it can lead to co-supervision of doctoral students between researchers in different geographical locations and increased flows of knowledge through networks.

In addition to the results summarised in Table 36, a cross-cutting theme emerged in the analysis of the qualitative responses. This theme was labelled as "a new identity", and comprised the reflections and perceptions of respondents about themselves, their career and research practices. This new identity revealed in respondents a sense of the respondents belonging or being part of a global scientific community. Their accounts associated working closely with research leaders in their field with the possibilities of being recognised by their peers. The quotations in Table 37 serve as illustrations.

Table 37 Quotes signalling the emergence of a new identity in respondents, n=31

"Here you work with the best people, and you learn a lot from them, but you have to learn fast and do your best, so they can see you as someone of value, and recommend you, maybe for a postdoc or a collaboration" (Fellow, Germany2)
"If I had done my PhD in Mexico, I would've gained recognition there, but I think it would've felt stuck. Here, things are more dynamic, and I like that (...) things are done faster, there are more resources, and (...) I feel that what we do is important" (Fellow, UK 38)

"I didn't feel welcome in Mexico, they were researching things different to what I do, and I didn't feel as connected as I do here, so that sense of feeling like an outsider motivated me to return here" (Fellow, France2)
"(…) research here is valued, you get paid well, and you feel that this country values what you do. This is not what happens in Mexico" (Fellow, Spain2)
"They have (in the host country) different ways of doing research, and you learn to work in that way. I think, I feel I became a different person and researcher after coming here" (Fellow, UK 7)

It is possible to say that this new identity will influence the perceptions of participants towards domestic research, and lead them to assess the extent to which this overlaps with their new identity. Tensions could emerge when the new interests and ambitions of participants are distant from those of the local identities.

9.2.2.2.2 Disbenefits

There are individual costs to international mobility. These can range from the stress of having to adapt to a new culture and language to the personal financial cost incurred on travel and living costs. The survey did not consider a particular question concerning the disbenefits or challenges of studying outside Mexico. Instead, it placed an open-ended sub-question in all the questions concerning the different components of the international experience (see Section 4 in Appendix 2). Additionally, this particular topic was emphasised in the interview questions.

The analysis in this section builds on 22 open-ended survey responses and ten interviews. The responses contained significant information pointing to the potential disbenefits of international mobility. Both graduated and still in training participants commented on the need to increase the monthly living stipend due to the financial constraints that they encountered during their studies, and saw this as particular problem of the Scholarship Programme. The survey results indicated two related challenges that were more strongly mentioned by graduated participants. These were labelled here as "de-familiarisation" and "re-adaptation", and denoted a type of cultural distance between the participants and Mexico's research priorities and practices. De-familiarisation was mentioned as a sense of becoming unfamiliar with the domestic situation while abroad. This involved not keeping contact with local professional or academic contacts, and not being up-to-date with the changes or events changing the domestic research landscape. Among participants in the still in training cohort, responses referred to not having a particular link or collaboration with their mentors or colleagues in Mexico.

The results showed that de-familiarisation would later affect the process of re-adaptation in the respondents. They mentioned that they felt like “outsiders” when searching for jobs and carrying out research activities back in Mexico. The respondents indicated that they had to start over again and re-assimilate. Also, they had to adapt their expectations in regards to salaries, research agendas and availability of funds. Table 38 offers a set of quotations of participants’ responses as illustrations.

Table 38 Quotes signalling de-familiarisation and re-adaptation, n=31

“So far, I think I’m already adapted, but it wasn’t easy. It is tough to adapt to the ways of working in Mexico. There are much more bureaucracy, fewer funds and less infrastructure, so I had to adjust my research to the current possibilities, but it took me some time to accept this” (Fellow, Mexico 11)
“You return with different ideologies and routines, and it’s quite difficult to start again. Sometimes, what you want to do and how you want to do it is not well received by your colleagues there, and this can even provoke a hostile work environment(...) I thought that it was best to find a job here, that’s why I left Mexico again” (Fellow, Spain 3)
“Return is complicated even when you return already with a job since we have to build new connections with workgroups here (...) the main challenge is to "understand" the new bureaucratic ways and the way people operate here” (Fellow, Mexico 27)
“My adaptation has been horrible!!! It was such a shock because life in the city is very chaotic and very different from what I was already used to. (...) and I am just becoming familiar with the centres that are doing something similar to what I did in my PhD” (Fellow, Mexico 3)
“(...) my return was difficult because I came back without a job, without a source of income. Mainly because I didn't have the time to search for a job before I had to return, and I didn’t have connections that could’ve helped me with a temporary contract. Also, the deadlines for all the calls for postdoctoral positions have already passed, I didn’t learn in time that these calls were open (Fellow, Mexico 26)
“Adapting to life here has been very challenging, and it’s not just me. I have many colleagues that returned and are unemployed because no one in academia knows what they do (research)” (Fellow, Mexico 15)

These results indicated that coping with these difficulties prompted a fear of losing their identity as global researchers. Career development, international collaborations prestige and resources were mentioned throughout these responses. In order to start a career, the participants needed to adapt fast to new demands and, in some cases, adjust their research agendas, professional and personal ambitions to the local conditions and facilities. It emerged in these responses that sometimes respondents thought it would be better to find a job abroad and migrate again than to re-adapt. As put by a participant:

> *"when the time for me to return came, I had serious doubts, because I feared not being able to continue doing my experiments, and you know that if you want to remain present in the minds of your peers abroad, you have to do something interesting (...) you need money and to have it you need to have an established career, and for this you need publications. So, you see why many do not return or quit their jobs and leave again*" (Fellow, Mexico 17).

Responses did not provide evidence of returnees losing their identity. Their responses conveyed this fear as a reaction that stemmed from comparisons between the level and availability of financial and physical resources for research, routines and geographical proximity to academic leaders in the host country, against the possibility of having access to these in Mexico.

In summary, the analysis shows that international mobility can be significantly beneficial for mobile researchers and that disbenefits do exist, but these are not strictly the result of international mobility alone. The most mentioned issues among participants (misalignment between mobile researchers' research ambitions and domestic specialisations, lack of research positions, low salaries and lack of resources for research) reflect the overall difficulties that stem from the historical and structural origins of the Mexican research system.

9.3 INTERVIEWS OF EMPLOYERS: CHARACTERISTICS, VALUE PERCEIVED IN INTERNATIONAL TRAINING AND REPORTED BENEFITS

The next two sub-sections will examine interview responses from 47 domestic higher education and research institutions and companies. Due to data collection bias, the location of the interviewees were, primarily, Mexico City and neighbouring states. Figure 19 illustrates the geographical distribution of these interviewees.

Figure 19 Geographical locations of interviewees

9.3.1 Motivations and reported benefits from international mobility: the case of HE&RIs

9.3.1.1 A descriptive characterisation of HE&RIs

Interviews with HE&RIs included contributions from directors of research institutes, chairs of research departments and research leaders. Table 39 shows the affiliation and positions held by the 27 interviewees.

Table 39 Interviewed HE&RIs

	Name of HEI	Centre/institute	Total of interviews granted
1	National Autonomous University of Mexico (UNAM)	1. Institute for Research in Materials 2. Institute of Physics 3. Institute of Chemistry 4. Faculty of Science/Department of Nanobiology 5. Centre for Nanosciences and Nanotechnology 6. Centre for Applied Physics and Advanced Technology	Head of departments (4) Directors of institutes (3) Directors of centres (2) Leaders of research groups (1)

	Name of HEI	Centre/institute	Total of interviews granted
		7. Centre for Applied Sciences and Technology Development	
2	Centre for Research and Advanced Studies (Cinvestav)	8. Department of Chemistry 9. Department of Physics	Head of departments (2) Directors of centres (1)
3	Autonomous Metropolitan University (UAM)	10. Department of Chemistry 11. Department of Physics	Head of departments (2)
4	**Conacyt-**Centre for Advance Chemistry Research (CIQA)	1. National Laboratory of Graphenic Materials	Directors of centre (1) Leaders of research groups (1)
5	**Conacyt-**Potosi Institute of Scientific and Technological Research (IPICYT)	12. National Laboratory for Nanoscience and Nanotechnology Research	Directors of centre (1) Leaders of research groups (1)
6	**Conacyt-**Centre for Engineering and Industrial Developments (CIDESI)	13. Centre for Engineering and Industrial Developments	Director of centre (1)
7	**Conacyt-**Centre for Research in Optics (CIO)	14. Department of Nanophotonics and Advanced Materials	Director of centre and leader of research group (1)
8	**Conacyt-**Centre for Applied Innovation in Competitive Technologies (CIATEC)	15. Centre for Applied Innovation in Competitive Technologies	Head of department (1)
9	National Polytechnic Institute (IPN)	16. Institute of Nanoscience, Micro and Nanotechnologies	Directors of centre (1)
10	Mexican Institute of Petroleum (IMP)	17. Department of Nanotechnology	Head of department and leader of research group (1)
11	Autonomous University of Queretaro (UAQ)	18. Faculty of sciences/Research department	Head of department (1)
12	Autonomous University of Nuevo Leon (UANL)	19. Centre for Innovation, Research and Development in Engineering and Technology	Directors of centre (1)
13	Autonomous University of San Luis Potosi (UASL)	20. Centre for Application of Infrared Radiation, Energy and Materials	Directors of centre (1)

There was a widespread consensus among representatives of the relevance of strengthening collaboration links between academic and industrials. They mentioned this alongside the difficulties they perceived that hinder such collaboration. For instance, the respondents thought that companies have little interests in research and that in the cases where collaboration could exist, researchers faced the risk of not producing significant research outputs, notably, publications. This was because companies do not tend to invest in state-of-the-art research problems; they tend to ask for quick and low-cost solutions, where little scientific work is required. This would affect the possibilities of the researchers to produce valuable research work for their community.

In contrast, responses of representatives from those research centres created in the last decade, such as the campus of Cinvestav and UNAM in Queretaro, suggested greater collaboration with companies. These representatives stressed that they were created with a different legal figure within the organisational structure of public research centres. This legal figure allows them to negotiate directly with industrial partners and accrue the economic benefits from their collaborations. The following account illustrates these cases.

> *We were created under a different logic of that of doing research in the country (...) we must begin to see the attractiveness of the industrial sector (...) We are motivating the industrialists to work with us, in the sense that they would express their needs, and we will convince them, with facts, that we can help them be more competitive in the market."* (HE&RIs, 17)

Food, pharmaceutics, and aerospace were the most mentioned industries with which they collaborated. Representatives from regional universities, such as the Autonomous University of Nuevo Leon and the National Autonomous University of Queretaro stated that they orient their teaching activities to meet the needs of industries in their regions.

9.3.1.2 Motivations for recruiting national researchers trained abroad

The representatives were asked about the reasons that would prompt them to hire national doctoral graduates that underwent training outside Mexico. They saw international training as an indispensable component of the career of researchers, but their responses indicated a critical outlook on the significance and implications of international mobility for domestic research. On the one hand, they considered that international mobility should be strengthened at all levels in the domestic research system, which would include short academic stays and not only doctoral courses abroad. On the other, they drew on their personal experiences to express that international doctoral training did not always result in research excellence. This was mentioned alongside the competitive selection criteria for recruitment, in which mobility is highly valued and assessed through the quality of the research outputs and active participation in international collaborations.

Concerning the motivations for recruiting researchers trained abroad, Table 40 presents the most highly cited motives across the interviewees.

Table 40 Motivations for hiring mobile researchers, N=27

Motivation	**% of participants**
International networks	(27) 100 %
New ideas and broader vision on research	(25) 93 %
Diversity in organising research work	(25) 93%
New research topics	(24) 89%
International quality publishing skills and vision	(24) 89%
Technical skills	(20) 74%
English language	(19) 70%
Applied research skills	(15) 56%
Familiarity and interests collaborate with industries	(10) 37%

An interesting aspect that became apparent in these responses was that international mobility is a requirement for career progress in Mexican research organisations. In this sense, finding a postdoctoral position or a researcher willing to host them for an academic stay may be non-trivial tasks. The contacts of the colleagues that have been abroad can be crucial to connect local researchers with international colleagues. The international networks that fellows accumulate were reported as the leading motivation for hiring nationals trained abroad, followed by the possible new and varied ideas and visions that they could bring and transfer to their local peers. As put by an interviewee, “we all can benefit from their networks and their global vision on scientific research” (HE&RI, 15).

For these interviewees, the national researchers that had received training abroad were of particular significance for the process of renewing domestic research activities in a more dynamic way. This was mentioned in the context where domestic researchers could learn through mobile researchers about the latest debates around research problems. As put by an interviewee, “we need more experts on new technologies like graphene, that's why the researchers that studied in places with advanced understanding on those topics are of so much relevance to us" (HE&RI, 17).

Respondents stated that fellows could bring diversity not only to research topics but could also produce changes in the habits that pervade in domestic research training, because:

> *"Here, our doctoral students learn our bad and good habits, and those trained abroad learn new habits (...) we need these new habits to be aware and learn what the leading countries are doing and how. In this way, we can also change our practices"* (HE&RI, 27).

The interviewees thought that international doctoral training was crucial for national students to distance themselves from the 'paternalism' and 'protected spaces' that supervisors provide for them. This paternalism seemed to perpetuate old practices and prevented research communities from adopting more globally competitive practices. In this sense, international mobility could promote change in the research approaches and organisation of research in the home country.

9.3.1.3 Reported benefits from international research training

This section will analyse the actual benefits that participants identified as a result of international doctoral training. Many of the motivational factors for hiring mobile researchers were replicated as beneficial changes. This can be because the interviewees can regard benefits as realised motivations and perceive motivations as prospective benefits.

The participants referred to benefits or beneficial changes as an aggregation of positive consequences to domestic colleagues, doctoral trainees and research centres. Their responses attributed significant standing to the return of fellows; their participations involved sentences such as "when they return, they (…)" Due to overlapping answer types, interview responses were allocated into three overall categories. The first two categories comprised the responses that pointed to the awareness of new ideas and research approaches, and improvements to research. A third category included additional benefits. See Table 41.

Table 41 Benefits reported by HE&RIs

Categories	Cited benefits
Research Awareness	New ideas, different approaches to problems and new ways of doing things Broader views of scientific work A different attitude towards applied research and commercialisation
Research Improvement	Focus on producing international research Networks New techniques English language command
Added benefits	Visibility—engagement with broader audiences Promote internal collaboration Tend to produce more impactful/ambitious research projects Entrepreneurship

9.3.1.3.1 Research Awareness

Interviewees highlighted the significance of international mobility in terms of the role that mobile researchers could play upon their return, by bringing awareness of the topics researched abroad and how other systems organise their research endeavours and resources.

Representatives of HE&RIs noted that mobile researchers could introduce diversity in domestic research organisations through new ideas and approaches to research problems. Also, the respondents emphasised that mobile researchers bring new attitudes towards science, for instance, that they tend to be more interested in collaborating with industrial partners, finding applications for their research outputs and commercialising these. According to their responses, being aware of how things were done abroad was important, because this tended to prompt reflections in domestic researchers about the local practices that needed to be improved or replaced.

It is possible to say that international mobility could promote change in domestic research. This is because domestic research organisations would not only become aware of the relevant practices in other research milieus; they could also adopt those practices. The results of the responses relating to this are presented below as ‘research improvement’.

9.3.1.3.2 Research Improvement

Responses in this category included changes in practices and attitudes, and are grouped into two main benefits: 1) improved research quality and productivity and 2) access to networks.

The interviewees stated that researchers trained in dynamic research environments sought to remain 'global', i.e. to keep their status as international researchers. To remain global, mobile researchers would be inclined to publish in international journals and participate in international academic events. Along with this, the interviewees indicated that mobile researchers tend to propose ambitious research projects and use relevant techniques to position their research in global communities. The respondents thought that this orientation towards producing excellent research outputs could set new standards for productivity and quality, which would benefit local peers with less or no international experience, as they could align their activities to the new standards.

These responses also highlighted the impact that fellows could have on internal collaboration. The interviewees expressed that having researchers trained abroad encouraged domestic researchers to collaborate more actively. This may be because local peers may be interested in sharing ideas and working together with the fellows, who would also benefit from those possible collaborations, particularly in the early stage of their career upon return.

The interviewees reported that the competences of the fellows to conduct cutting-edge science had enabled them to establish new research areas, better aligned to the current global research challenges with the support and advice of the fellows that return to Mexico. The following quote illustrates this:

> *We have (fellows) that came back from Germany and the UK, and are experts in computational nanoscience and graphene. They've helped us modernise academic life in the institute; they brought the latest knowledge about their topics. They are also building the equipment we needed to start a new research area* (HE&RI, 08).

The formation of international networks was a consistent response and theme that cut across all the reported benefits. Interviewees gave numerous references about international networks, particularly, regarding how these connect researchers with similar interests and promote further mobility. In addition to this, respondents expressed that the international experience tends to make researchers more confident to approach colleagues overseas and establish new contacts and expand their networks.

These responses indicated a tendency in fellows to 'keep their international status', and that this prompts them to collaborate more actively in international projects, which could result in the following benefits.

- Co-authored publications
- Access to infrastructure
- Co-supervision of postgraduate students
- Mobility of researchers and students
- Invitations to participate in international committees and projects
- Co-design and development of solutions

Six interviewees reported that due to the collaborations of fellows with colleagues abroad, they had access to financial resources from transnational bodies. In these cases, the funds helped finance the acquisition of new equipment.

The interviewees referred to the extent and value of international networks along with the length of time fellows spent abroad. The longer the time overseas, the more opportunities researchers could have to start and extend their networks and refine common areas of interest.

Improved English language skills were a benefit mentioned in the context of how these reflected in the confidence of fellows to communicate their ideas outside local networks. The quote below illustrates how the respondents perceived these language skills as a significant impact.

> *"they (fellows) have already overcome the fear of communicating in English, and the fear of exposing their ideas to criticism (…) this is something you only experience when you're faced with a new research culture, in a place where you have to speak and write in English"* (HE&RI, 16).

Furthermore, proficiency in the use of English could facilitate international collaboration. Ten interviewees thought that the national researchers trained abroad also helped provide better training of domestic postgraduate students because they would conduct their courses in English. An important remark here is that in Mexico, citizens can access bilingual and multilingual education offered by private education institutions. However, the high cost of courses in these institutions may be prohibitive for the majority of the population.

9.3.1.3.3 Added benefits

The interviews with representatives of public research sector revealed additional benefits, and these concerned the attitudes of the fellows to engage with non-academic audiences; i.e. that fellows tended to be more able to reach stakeholders outside academia. Also, respondents noted that mobile researchers tended to be willing to take risks and apply to international funding calls and to propose ambitious and novel research projects. Several interviewees claimed that fellows come back better prepared to confront the risks involved in becoming entrepreneurs themselves. Interviewees thought that mobile researchers were more likely to pursue the economic benefits of scientific research as a result of their exposition to contexts and cultures led by the innovation-growth-approach to scientific research.

It was particularly revealing that the experience that mobile researchers could have in collaborating with industry was not a predominant motivation for hiring them. However, the interviewees emphasised the relevance of establishing productive links with companies, and that the researchers that return were better prepared to undertake this type of collaborations. For instance, the interviewees stressed the familiarity of mobile researchers with the use of intellectual property. Domestic incentives for research could have affected these responses; scientific publications are given a higher value than the developments and commercialisation of research-based solutions. Eight respondents, from recently established organisations, provided examples of how mobile researchers had been central to establishing collaboration links with industries: these respondents had mechanisms in place to incentivise researchers to "take their developments to the prototype stage and licensing or commercial stage" (HE&RI, 17).

These internal financial incentives did not compete with the national incentive system; researchers still have to achieve an 'excellent' rating in national evaluations, which involves publishing in international journals. The internal incentives are an attempt to steer academics to pursue more actively applied scientific research.

9.1.3.3.4 Negative effects

One main issue identified in these responses; this was the mismatch between the research interests of mobile researchers and those of Mexican employers. This surfaced mainly in relation to the availability of resources to finance ambitious research projects. The interviewees stated that mobile researchers had higher expectations for access to resources based on their experience of the situation in foreign HE&RIs. This can affect the process of adaptation that mobile researchers experience after return, and which, in some cases, can result in migration.

A few interviewees mentioned that sometimes returning researchers do not bring particularly improved research skills as result of their experience abroad. In these cases, international networks did not compensate for the lack of this.

> *(…) we want researchers that bring something additional to what we do and can find here, in terms of ideas, collaborations and so on (…) We have come across a few cases where they (the mobile researchers) return and have nothing to offer to the organisations. I'm not exaggerating; they bring nothing of value to research.* (HE&RI, 11)

9.3.2 Motivations and reported benefits from international mobility: the case of companies

9.3.2.1 Descriptive characterisation

The interviews included contributions from six large and fourteen micro and small-sized companies. Table 42 shows the core activity of these companies and the positions held by the participants.

Table 42 Interviewed companies

	Core activity	Department or area	Position	Size[93]
1	Polymers and coatings	Centre for Research and Development in Polymers	Director of Technology and development	Large
2	Power Cables and Power Transformers	Centre for Research and Development	Director	Large
3	Appliances	Department of Technology and Projects	Vice-president	Large
		Research and Development Department	Former director	
4	Electrical conductors	Centre for research and development	Director	Large
5	Polymers1	Department of Research and Development	Director	Large
6	Polymers2	Department of Research and Development	Manager	Large
7	Bio and nano engineering	-	CEO	Small
8	Microscopy and experimental services	Department of Research and Development	Director of Innovation	Small
9	Additives	-	CEO	Micro
10	New materials	-	CEO	Small
11	Engineering training	Department of Technological Surveillance and Research	Director	Micro
12	Coating Technologies	Department of Technology	Manager	Small
13	Engineering and technology	-	CEO	Small
14	Nanobiotech	-	CEO	Micro
15	Nano engineering	-	CEO	Micro
16	Nanomaterials and engineering1	Department of Research and Development	Manager	Micro
17	Nanomaterials and engineering2	-	CEO	Small
18	Nanomaterials	-	CEO	Small
19	Nanomedicine	-	CEO	Micro

93 This was defined by the number of employees: Micro (1-10), small (11-50), medium (51-100) and large (<100). Based on the classification of the National Institute of Statistics and Geography (INEGI). Retrieved March 8, 2018, from: https://www.inegi.org.mx/contenidos/programas/ce/2009/doc/minimonografias/m_pymes.pdf

	Core activity	Department or area	Position	Size[93]
20	Nanobiotech and electronics	-	CEO	Micro
Total			**20**	**20**

Large companies' R&D activities focused on improving the characteristics of existing products and testing potential new uses. Three of these companies reported having expanded into new markets by developing new nano-based products for the aerospace and automotive sectors. Another characteristic of these interviewees was that they collaborated with domestic HE&RIs when solutions required specialised scientific knowledge or expertise from multiple disciplines. Three of these companies reported collaborations with HE&RIs in the USA.

Micro and small companies were reasonably homogeneous in that they operated as R&D laboratories for other companies of all sizes. Consultancy, development, and testing of materials were the most mentioned services these companies offered. Eight of these companies also offered their own branded products in the additives, hygiene, and personal care markets. The micro and small companies tended to interact with domestic HE&RIs on two fronts supplying HE&RIs with specific reagents and materials, or relying on HE&RIs to access infrastructure and for advice on experimental design and techniques. An additional characteristic of these companies was that owners and leaders of R&D departments held doctoral degrees. In most cases, they had worked for HE&RIs before establishing their own company. Their services and products included water sanitation (2), antimicrobials (5), biomedicine (4), energy (6), construction materials (3), and food packaging (4).

9.3.2.2 Motivations for recruiting national researchers trained abroad

The primary motivation among companies for recruiting mobile researchers was to access their expertise in applied research. Their definition of applied research was that researchers would have acquired a good scientific basis to develop solutions to specific problems and, more importantly, that they would identify practical applications for their research outputs. These views surfaced in relation to how applied research expertise could reveal that mobile researchers could have developed insight to understand the needs of industries. A remark here is that interviewees emphasised that overall, domestic HE&RIs provide doctoral students with a high-quality scientific basis, but that they lack practical experience with companies.

The contention researchers learn ‘better’ techniques through international training pointed to a structural issue; i.e. companies do not find the skills they need in researchers trained in Mexican HE&RIs. Similarly, Mexican-trained researchers might not be interested in pursuing a career in the private sector.

A common belief among interviewees from companies was that fellows will be more aware of the economic benefits of research and that this could prompt entrepreneurship attitudes in those researchers. These interviewees believed that developed countries had established a closed relationship between science and industries and incentivised scientific entrepreneurship. In other words, they felt that undertaking scientific training abroad may have afforded the mobile researchers with a new perspective on the role of knowledge in society.

Table 43 presents the most cited motivations across these interviews.

Table 43 Motivations for hiring mobile researchers, N=20

Motivation	**% of participants**
Applied research expertise and specialised techniques	(19) 95%
Familiarity and interests collaborate with industries	(14) 70%
Access to international networks	(11) 56%
Interdisciplinary research experience	(9) 48%
English language skills	(7) 37%

The perception of the importance of international networks stemmed from the fact that the representatives’ companies had established collaboration links, and identified similarity of interest with research organisations and companies abroad. The following elements were identified as the expected benefits that the companies would access through the transnational networks of mobile researchers: 1) access to infrastructure; 2) new markets, and 3) co-development of products with foreign partners.

Notably, English language proficiency was not as crucial as technical knowledge among these interviewees, possibly since the financial cost of improving the English language skills of employees is lower than that incurred for advanced research training.

9.3.2.3 Reported benefits from international research training

Two main categories were identified in the responses concerning benefits, namely, 1) new attitudes towards scientific research and 2) access to the human and social capital of these researchers. The first concerned the ideological baggage and attitudes that national researchers have towards research in companies. The second concerned more tangible aspects that companies can access via mobile researchers. Table 44 shows the benefits in each category.

Table 44 Companies: reported benefits

Categories	Identified benefits
New attitudes to scientific research	Familiarity and interest to understand the needs of industries Different approaches to research problems
Access to human and social capital	New techniques Knowledge and information Infrastructure Networks

9.3.2.3.1 New attitudes to scientific research

Responses concerning the inherent benefits of international mobility were common amongst the interviewees, but their responses revealed that the 'fresh' attitude that mobile researchers will have towards research was of particular relevance. This benefit was recurrent in the context of the familiarity and 'more' open attitude to listen and understand the challenges that private companies face concerning the use of scientific and technical knowledge. Interviewees expressed that mobile researchers were not only aware of the potential economic benefits in research but that they were also willing to use their expertise to solve practical problems. These responses were more to personal attributes than to scientific prowess. The following quotes illustrate this:

> *We are interested in their attitude and their willingness to learn (…) if they know how to work in the laboratory, to put together an experiment and have a reasonable scientific basis, then the rest is only about their attitude*

> *towards the work that we do. Unfortunately, we have had some researchers that come from excellent local universities, who are good at what they do but did not adapt to the work culture and the pressures on the industry (Industry, 17).*
>
> *The researchers that have studied abroad, more often than not, have some experience working with companies, even if not directly, they become aware of what we need" (Industry, 01).*

The participants affirmed that they valued such an attitude because the researchers trained abroad would have a 'different' vision towards research that they would not easily find in domestic researchers. The participants believed that having been exposed to new ideas and cultures about 'how' and 'for whom' to do research, would have prompted in the mobile researchers a new approach towards the economic and practical value of scientific knowledge. This came up in discussions of how national researchers seemed to struggle to reconcile between the pressures from academia with the pressures, concerning time to develop solutions and involved costs, when working with companies.

9.3.2.3.2 Access to human and social capital

Applied research skills in mobile researchers provided the interviewees with technical know-how, from which they learnt the latest techniques and used these into some of their process and products. In some cases, the technical expertise of these researchers resulted in new applications and improvements to equipment and research processes.

Another reported benefit was that the researchers trained abroad tended to offer not only access to research skills but also valuable information on specific markets. It emerged that the mobile researchers that had returned and worked for companies would keep them informed of new advances, technology trends, and potential users and partners. Specific characteristics included the use of intellectual property rights. As one interviewee noted, "those who came back from Canada and the UK are quite familiar with the use of patents, regulations on the use and commercialisation of nanotechnologies" (Industry, 16). Additionally, they can be experienced with technology monitoring; "they keep us updated on what new technologies are out there, and how we can access or compete in those markets" (Industry, 10).

The interviewees that had carried out or planned to conduct experimentation, prototyping and testing of materials emphasised access to infrastructure as an important benefit along with the international networks that researchers had established abroad. The value that interviewees attributed to networks was that these would enable researchers to exchange ideas, establish alliances for the training of personnel and co-development of solutions. These responses indicated that the international connections made by mobile researchers during their studies abroad were a force for improvement, as noted by a participant:

> *"They (researchers trained abroad) keep us moving forward (...) they discuss some ideas with their foreign contacts, this way we see if what we are doing here can be done better, or if there is a new technique or options to improve what we are doing" (Industry, 03).*

For the interviewees, both the expertise and networks of mobile researchers were important because they help them learn about new applications, techniques and markets that would otherwise not have been appreciated.

The significance of international mobility for domestic companies lies in a combination of professional, personal, and, possibly ideological, traits in mobile researchers.

9.3.2.4 Reported challenges/disbenefits

The interviews indicated that these researchers tended to propose costly solutions, were not familiar with domestic research funding mechanisms and had not developed significant connections with domestic HE&RIs. As such, the challenges reported at the aggregated level could not be strictly coupled as a result of international mobility only, but are the result of a combination of structural issues in the research system and a mismatch in the research agendas and resources of the employers and mobile researchers.

9.4 SUMMARY

9.4.1 Motivations

The results from the survey and the interviews highlighted the motivations and value of scientific mobility at two levels of aggregation; micro-level (fellowship holders/researchers trained abroad/mobile researchers) and meso-level (HE&RIs and companies). At the micro-level, motivations were fuelled by an interest for dynamic research environments and 'prestige', expected as a result of having been exposed to the best scientific environments. Despite the lack of openness of fellows concerning intentions to migrate in survey responses, qualitative responses revealed this as a motivation for undergoing international mobility and applying to the Scholarship Programme. Additional motivations indicated a sense of immersion in international culture, adventure, and escape from social issues in Mexico, such as violence and insecurity associated with organised criminal activity.

Individual motivations were largely pull factors, such as quality of research in the host country, access to the latest technologies and the opportunity to learn from reputable scientists in prestigious HE&RIs. These motivations were expressed in anticipated statements that conveyed, as a general expectation, that the international experience would enable the fellows to achieve personal and professional ambitions.

Among employers, responses suggested a particular interest in accessing refreshed views, new attitudes, new research practices, international contacts, infrastructure and new techniques. These responses illustrated the interest of domestic research communities to improve their research activities and the value of international mobility in contributing to this. Table 45 summarises the primary motivations and benefits reported by the participants in this research.

Table 45 Summary of motivations and benefits of international mobility

Participants	Fellowship holders	Higher education and research institutions	Companies
Motivations	• To increase possibilities of finding a job abroad • To work with leading research group • Prestige • To migrate • Support of domestic supervisors of previous training and familiarity	• International networks • New ideas and broader vision on research • Diversity in organising research work • New research topics • International quality publishing skills and vision	• Applied research expertise and specialised techniques • Results and market-oriented work culture • Networks

Participants	Fellowship holders	Higher education and research institutions	Companies
	with the Programme		
Benefits	• Access to sophisticated equipment • State of the art knowledge and techniques • Collaborative research with non-academic actors • Prestige • Improved language skills • Networks	• New ideas, different approaches to problems and new ways of doing things • Broader views of scientific work • Networks • Access to infrastructure • New techniques	• New ideas, new cultures and different approaches to problems • New techniques • Networks • Knowledge and information • Infrastructure

9.4.2 Reported benefits

The results suggest that the benefits at the individual level concentrated on the improvement of research skills, as a result of access to sophisticated equipment and enabling research infrastructures. In addition to the improvement of their language skills, access to new techniques and collaborative research with industry, prestige was mentioned as a benefit associated with international research training. The fellows expected to become more visible in the global community; however there was no concrete evidence about their visibility or whether this was the result of international mobility. However, visibility can be assumed as a direct impact from this, as the fellows had been offered the opportunity to interact face-to-face with colleagues with similar and complementary interests in their research field, which could confer a greater degree of visibility and reputation.

Access to international networks and the labour market were less reported, although subsequent interviews confirmed the relevance of networks, particularly for career development and presence in the global scientific community. In line with the interest of the fellows to become and remain global, the results showed that 53% of them remained or intended to remain abroad and that those that returned were searching for better opportunities outside Mexico. These attitudes toward migration were attributed to the opportunities and resources that they would have accessed abroad in developed research systems.

Benefits at higher levels of social aggregation or indirect benefits on domestic HE&RIs and companies varied according to their missions. However, both respondents of the private and public sector agreed that the researchers trained abroad would bring new attitudes towards research, research practices, and familiarity with overseas work cultures. Significant differences in this set of results were that for HE&RIs, scientific research skills, diversity and networks were of particular relevance, while for companies, technical skills and the attitude of fellows towards practical research were more significant. This finding indicated that international mobility was essential for the improvement of domestic research, firstly as it enhances the human capital and social capital in mobile researchers, and secondly as wider benefits can be transferred to domestic employers. However, the benefits embodied in individual researchers are not transferred automatically to the research system – the benefits that domestic employers would harness depend on their research agendas and resources.

Access to international networks appeared as an important issue in all interviews and cut across all benefits; the results indicated that these networks might be the component where individual benefits could be transformed into wider benefits regardless of the location of researchers.

In summary, the benefits derived from international mobility go beyond having access to the knowledge produced in developed countries, which can be accessed through published work. Results suggest that researchers adopt a global identity through their interactions within their international communities while abroad. This new identity fosters new research interests, knowledge practices and ambitions for their career trajectories. The benefits from domestic employers were generally an aggregation and deployment of the benefits that had been accrued by fellows. Results show that the opportunity of having to work with physically embedded technologies and learning sophisticated techniques made both researchers and employers aware of the demands in global research. Along with this, the opportunity of having to work in competitive research milieus made them aware of the practices that have helped these settings face such demands and the possibility to adopt these practices.

9.4.3 *Identified common challenges*

These were not strictly linked to international mobility alone and were out of the scope of intervention of the Scholarship Programme. The challenges identified in these results exposed the structural issues in the research system in Mexico. These issues allowed an understanding of the results of this research in light of the influences that may have affected the responses of participants.

The responses indicated the following systemic issues as factors that hinder the transfer, absorption and utilisation of the benefits identified above.

One issue was the contradiction concerning the intentions of the Scholarship Programme to enhance domestic research *vis a vis* the lack of research positions in HE&RIs, and supporting mechanisms for early career researchers. This concerned two particular issues, notably, the need for renewing the scientific base of Mexico, which was contingent upon the conditions for the retirement of senior academics and the incentives in the National Researchers System. An important remark is that the HE&RIs considered the programme, administered by Conayt to attract fellowship holders, "Catedras Conacyt" [94] as necessary to offer positions to those that return after graduation.

Another issue was the lack of financial capacity of domestic organisations (HE&RIs and companies) to meet the expectations of the returnees, who anticipated high salaries and access to research resources, such as they would have abroad.

All interviewees from HE&RIs and companies expressed concerns about the process of de-familiarisation and re-adaptation that fellowship holders undergo when they

[94] See: https://www.colef.mx/posgrado/wp-content/uploads/2016/11/TESIS-Arce-Miyaki-Oyuki.pdf; http://www.educacionyculturaaz.com/conacyt-reducira-a-la-mitad-catedras-para-investigadores/; (consulted on 20/02/19)

return. Responses suggested that fellows have become accustomed to working with specific equipment and well-financially-supported conditions. Mainly, this view arose in relation to the tendency of fellows to suggest costly solutions and expect resources and equipment that they would have accessed abroad. Responses also suggested a specialisation gap that was particular to applied research skills, and that related to the financial capacity of domestic HE&RIs to conduct applied research, which requires expensive infrastructure and techniques, which are not available in Mexico. This was also, to some extent, associated with the effects of the lingering ideology that public research should produce benefits for society, not for private industrial interests. This ideology characterised the emergence and evolution of the national research system in Mexico until the 2000s, and hindered the development of applied research capacities.

The significance of these results is that reconciling the interests of returnees with the capacities of domestic employers may delay the process of adaptation and prompt returnees to leave the country again. However, it could also cause employers to adapt and devise strategies that would allow them to better harness the international experience embedded in mobile researchers. Similarly, the lack of resources and equipment could incentivise the fellows to retain and strengthen their transnational networks.

Another identified issue was that, while abroad, fellows tended to lose touch with their professional contacts back in Mexico. This situation may increase their interest to remain abroad, as they would find no incentive in returning without having a network of support among domestic peers. Also, they may not be aware of how their research interests fit into the research conducted in Mexico. Another issue, closely linked to this, was the lack of strong connections between domestic employers and fellowship holders living abroad (diasporas). There was insufficient information to draw any conclusions in this regard, but only two of the participant fellows and three of the 47 employers informing this study reported some form of collaboration.

The results also revealed that the research agenda and ambitions of returnees do not overlap with the facilities offered by domestic research organisations. This was closely connected with references about the opportunities fellows would have in Mexico to continue conducting state-of-the-art research, access to resources and support for applied research. Prestige and reputation were mentioned in terms of how they could lose these as a consequence of return.

CHAPTER 10 DISCUSSION AND CONCLUSIONS

10.1 INTRODUCTION

This thesis has examined the case of Mexico to explore the three central research questions. This study aims to elucidate the impact of the Scholarship Programme, an initiative that sends nationals to pursue doctoral training overseas and explain the mechanisms that produced such impact. The context in which this Programme is implemented and the characteristics of its beneficiaries have been essential in identifying the influence and limitations of this instrument to produce changes in Mexico's research system. Due to the international component in the Programme, this thesis has addressed its research questions combining the literature on international mobility with scholarly works on policy analysis.

While there is much research on the quantifiable benefits and negative consequences of international mobility to the sender countries, such as the increased productivity of researchers and international collaboration (Cruz-Castro & Sanz-Menéndez, 2010; Franzoni et al., 2014), diaspora effects (Tejada, 2012; Zweig et al., 2008) and brain drain (Beine et al., 2006; Lowell & Findlay, 2001), this phenomenon remains under-researched. Moreover, its study is biased towards the human capital (brain drain approach) that labels effects in terms of gains and losses, which has prompted reactive policy responses to compete in the race for talent. Even the more recent approaches, notably, circular migration and diaspora, are influenced by the brain drain approach (see Chapter 6), leaving the wider spectrum of effects underrepresented.

Consequently, related policy instruments are often framed and examined in relation to the exceptional responsibility that policymakers attribute to them. The primary responsibility or expectation of policymakers in these resides in the idea that the international mobility of researchers is an essential factor of transformation in domestic research, i.e. international mobility can boost the scientific capacity of nations. This reasoning is rooted in the 'utilitarian' understanding of how scientific knowledge can be used to foster economic growth. It is not uncommon to find research studies that define international mobility policies as either successful or unsuccessful, depending on whether nations were able to increase their knowledge stocks as a result of particular measures. Most studies have undertaken quantifications of the increased human capital in researchers, and conceptualise benefits as an aggregate of mobile researchers.

Existing evidence on flows of researchers indicates that international mobility has become the norm in the scientific profession. For instance, this has become a standard selection criterion in the labour market for research skills and a crucial factor for career development. Similarly, scientific research training has a strong international component, but policies are circumscribed in national funding spaces. In consequence, countries, driven by the fear of losing this talent to other countries and the negative consequences thereof, formulate arrangements to provide international training and research facilities to their nationals, and to attract them back and retain them. Most developed countries can also devise instruments to attract foreign research talent. The policy logic is to accumulate research talent as much as possible, for this is a sign of research excellence. Instruments furthering the international mobility of researchers are rooted in the human capital theory that assumes that there is an optimum level of skills and knowledge. They also assume that researchers would respond to the market signals and that this would make efficient use of their embodied capital in the system.

Influenced by the same rationale, since the 1970s Mexico has been sending nationals abroad for advanced scientific training to increase and improve its scientific base, which is ultimately expected to offer benefits for society and the economy. However, this intention shows contradictory effects. It has been essential in increasing the research capacities of its citizens; evidence for this is that Mexico is the third largest provider of high-skilled personnel to the international labour market. On the other hand, the domestic research system remains underdeveloped, and the flows of talented nationals leaving for other countries have increased. The most recent version of the USA census suggests that the tendency of inwards highly-skilled migration from Mexico has increased by 15% in the past ten years and that in-flows of Mexican nationals with doctoral education has increased 19%.

It is not surprising that the literature presents Mexico as a net loser of talent. However, Mexico continues sending people abroad despite this claim with little or no substantial changes to its long-standing instrument for mobility, i.e. “the Scholarships Programme”.

This research adopted the Programme as the empirical unit of analysis, but rather than a purely innovation-economic-biased approach, it examines the effects that the recipients have realised as a result of undergoing international mobility. Thus, this thesis relies on a realistic and comprehensive framework for the analysis of change in S&T, namely research spaces and field spaces to assess how the impacts reported by the beneficiaries can be linked to the Programme or other relevant factors (see Chapters 7 and 8).

This research involved a contextual approach and several aspects of policy implementation. This allowed for an in-depth examination of international mobility, its underpinning factors and effects on the mobile researchers and domestic employers in Mexico. The research process in this study was to first conduct a literature review of the research and policy approaches to international mobility. Based on this, this thesis puts forward a series of assumptions and propositions to undertake the research in more detail (see Chapter 6). In the absence of a specific structure for identifying and explaining the effects from such complex policy interventions, this thesis adopted the research fields and policy spaces framework to define domains of possible consequences attributable to the Programme. This framework was originally proposed to illustrate the emergence of new arrangements of science within the European context. However, due to its flexible and holistic nature, this was selected in this study – see Chapter 8 for a detailed review of this framework and justification of its use.

The empirical work consisted of a review of Mexico’s S&T policy context. The more detailed analysis included the participations of doctoral students sponsored by the Programme (fellowship holders/fellows) and trained in nano-related fields. A qualitative survey and subsequent interviews with selected participants were the data collection instruments to collect their contributions. Also, this research included interviews with potential employers of research skills, namely HEI&RIs and companies in the nanotechnology sector.

The nanotechnology sector was selected as a suitable empirical setting to investigate the research questions due to its potential to increase the research bases in developing countries opportunities and because its progress depends on cutting-edge techniques and facilities, which are not common in developing countries. The detailed justification for the selection of nanotechnology is given in Chapter 5.

The rest of this chapter summarises findings and offers some answers to the research questions by drawing on the empirical results in this thesis. It discusses findings providing an in-depth assessment of the effects produced by the Programme in its beneficiaries, which will examine how fellows respond to the potential opportunities in the Programme - in other words, how the Programme led to specific effects on fellows, and how these may have affected national HE&RIs and companies. The main findings of this work and the summary of answers to the research questions conclude the thesis. This chapter contributes to the understanding of the international mobility of researchers and policies in the wider theoretical and policy debate. Finally, it puts forward directions for further research.

10.2 ANSWERS TO RESEARCH QUESTIONS

This thesis addressed the following overarching research question: What impacts do international mobility policy instruments offer for sender countries? This question was divided into sub-questions to explore the potential benefits in a disaggregated manner, by identifying the benefits in the direct and indirect beneficiaries of the empirical unit in this research, namely, the Scholarship Programme. The second question was concerned with the factors that could explain those benefits, namely, to what extent the identified changes can be attributed to policy instruments or to other factors influencing their emergence? This question was motivated by the interest to understand ‘how’ policies work.

What impacts do international mobility policy instruments offer for sender countries?

This question was addressed by responding to the following sub-questions: **What impacts do international mobility instruments offer for their direct beneficiaries?** Using the Scholarship Programme led by Mexico, this study finds that at the individual level, three main general domains were identified as potentially being affected by international mobility, i.e., human capital, social capital and physical capital.

In the case of Mexico, this research finds that impact on individual researchers comprised direct improvement of skills and knowledge, which stemmed from having the opportunities to 1) access equipment and infrastructure, 2) access collaborative research with academic and non-academic actors, and 3) improve or acquire the latest techniques. The strong presence of physical infrastructure as a reported benefit can be particular to the emerging technology fields, which rely on physically embedded objects and costly techniques.

In addition to the benefits above, the experience of having pursued doctoral training outside the home country was not only academically and 'potentially' professionally beneficial for mobile researchers. Arriving in a new country with different language and culture represented a challenge that led to the enhancement of generic skills in mobile researchers. Among the most mentioned were: 1) improvement of the English language command, which is the *de facto* language of research; it facilitates collaborations in transnational networks, access to foreign research funds, and the positioning of research work in international research journals, and 2) confidence to undertake new challenges.

Similarly, mobile researchers adopted an identity as international researchers, which was also a motivating factor pushing them to pursue advanced research training abroad. The international academic experience was the mechanism that enabled them to assume this identity. Considerations of the 'value of research', which are linked to the financial resources available for S&T and opportunities to access better jobs in the host countries, played a significant role in the professional and personal transformation that they underwent.

The researchers conveyed a strong conviction towards 'remaining international' – keeping their new identity, which means being able to continue producing high-quality research outputs with sophisticated methods. This finding can be interpreted, under the accumulative brain drain approach, as potential harm for the sender countries because in searching for the expected resources for research, researchers could permanently migrate. Another possible interpretation for this finding is that the interests of researchers to remain global might yield benefits in their place of work. This is because they could engage in relevant research topics, using sophisticated techniques and research practices that are aligned to those of the international research communities, which will, in turn, affect their immediate environment. Also, in the case of permanent migration, mobile researchers could connect with their home country and form transnational knowledge networks.

In line with the above, this new identity relates to the perceived capacity of mobile researchers to produce excellent research. This identity embodies views about themselves and their work in the research communities they aim to belong to. The perception of such identity will affect the professional ambitions in mobile researchers, which will affect the negotiations and decisions entwined when reconciling the local and international research settings and professional ambitions.

Along with this, prestige was also the result of international mobility that occurred due to a halo effect. This means that the reputation of research milieus will reflect on the reputation of mobile researchers and might affect the quality of their research outputs and work opportunities. This assumption may not be far from reality in the sense that reputable research systems offer the necessary conditions and resources to produce high-quality research, which is also conducive to researchers' reputation. However, the extent to which, and the mechanisms by which the reputation of host research training organisations affects the career development and productivity of the mobile researchers remains to be tested. Such a task is out of the scope of this research, but some references on how international mobility affects productivity can be found in Jonkers & Cruz-Castro (2013) Haveli et al. (2016) and Franzoni et al. (2015). Also, Muller et al. (2018) provides a critical assessment of how domestic employers appraise quality or added value in researchers trained abroad against those trained in-house. Their study showed that the value attributed by employers to international mobility was significantly more important than the proven quality in returnees (selection effects).

The study also found that international mobility on its own is a benefit for researchers, who are, in addition to expecting to enter the global labour market, eager for experiencing new environments. Explanations behind their attitudes related to professional ambitions, personal preferences and quality of life.

The Programme enabled changes in its direct beneficiaries in the form of knowledge, skills, and reputation. Also, it can be a stepping-stone towards permanent migration.

In summary, the fellows have improved their academic and personal capital, and their professional and personal aspirations became stronger during their time abroad, which will affect their expectations and intentions to return. They are also now equipped with new sets of values and views about how research should be done and expect to access the jobs and resources that would allow them to capitalise their experience.

What impacts do international mobility instruments offer for their indirect beneficiaries?

The response to this question comprises a second and third dimension of benefits that can be attributable to public intervention. These benefits are a combination of human capital and networks that contain dimensions such as social capital and tangible capital embodied in mobile researchers.

As suggested above, thanks to international mobility, researchers are exposed to broader views on research problems, professional networks (academic and non-academic contacts), diversity of ideas and global research practices. Through these connections, they build the social capital that will become crucial when finding their first job, for career development and also to perform relevant research. For instance, they can collaborate with international peers and access equipment, financial resources, and further mobility.

Domestic employers can also benefit from this social capital through face-to-face interactions with returnees. For instance, HE&RIs can update their domestic research interests and become aware of more productive research practices. Companies can access applied research expertise and favourable attitudes on the economic value of research. In this sense, access to international networks is the component of impact from which it is possible to derive indirect benefits for the system. These networks connect the mobile researchers and their domestic colleagues with research infrastructure, collaboration projects, and external funds. These benefits were found to occur in cases where mobile researchers had returned to the home country. The return of the mobile researchers enables direct interactions between them and their local colleagues in a common organisational setting and goals. This study did not, however, find significant indications of connections between Mexican researchers living abroad and researchers in Mexican research organisations.

An unexpected finding was that among mobile researchers, particularly those that did not return to the home country, international networks are seen to be beneficial, but not as significant as for domestic employers. An explanation for this is that the proximity between these researchers and their contacts facilitates collaborations and face-to-face interactions, which may lead them to see networks as an implicit component of their profession, whereas, for domestic employers, these networks are a link to international research, financial and physical resources, and ideas that could otherwise be difficult to access.

10.2.1 Synthesis of common themes

The similarity of benefits across mobile researchers and domestic employers allowed an analysis of what and how direct benefits are transferred to higher levels of aggregation. The analysis considered the benefits identified by researchers and the mechanisms by which they enact these benefits, which allowed identification of the issues that hinder their transference to HE&RIs and companies in the research system in Mexico.

The analysis used core concepts of S&T studies and new emergent propositions on human capital theory. Following the interpretation offered in section 6.4.5 of the Literature Review and section 7.5 of the Analytical Framework, researchers live in a space shaped by a diversity of influences within their social structures and context (Bozeman et al., 2001; Cañibano & Woolley, 2012). Researchers engage in activities and relationships that give them access to technologies and a sense of global identity;

of belonging to a community. International mobility entails not only changes in the human capital of researchers but also involves enhancements in their tangible and social capital.

Thus, the analysis was structured into three themes (see Table 46). Additionally, Figure 20 shows what benefits are transferred to domestic research organisations.

Table 46 Common benefits

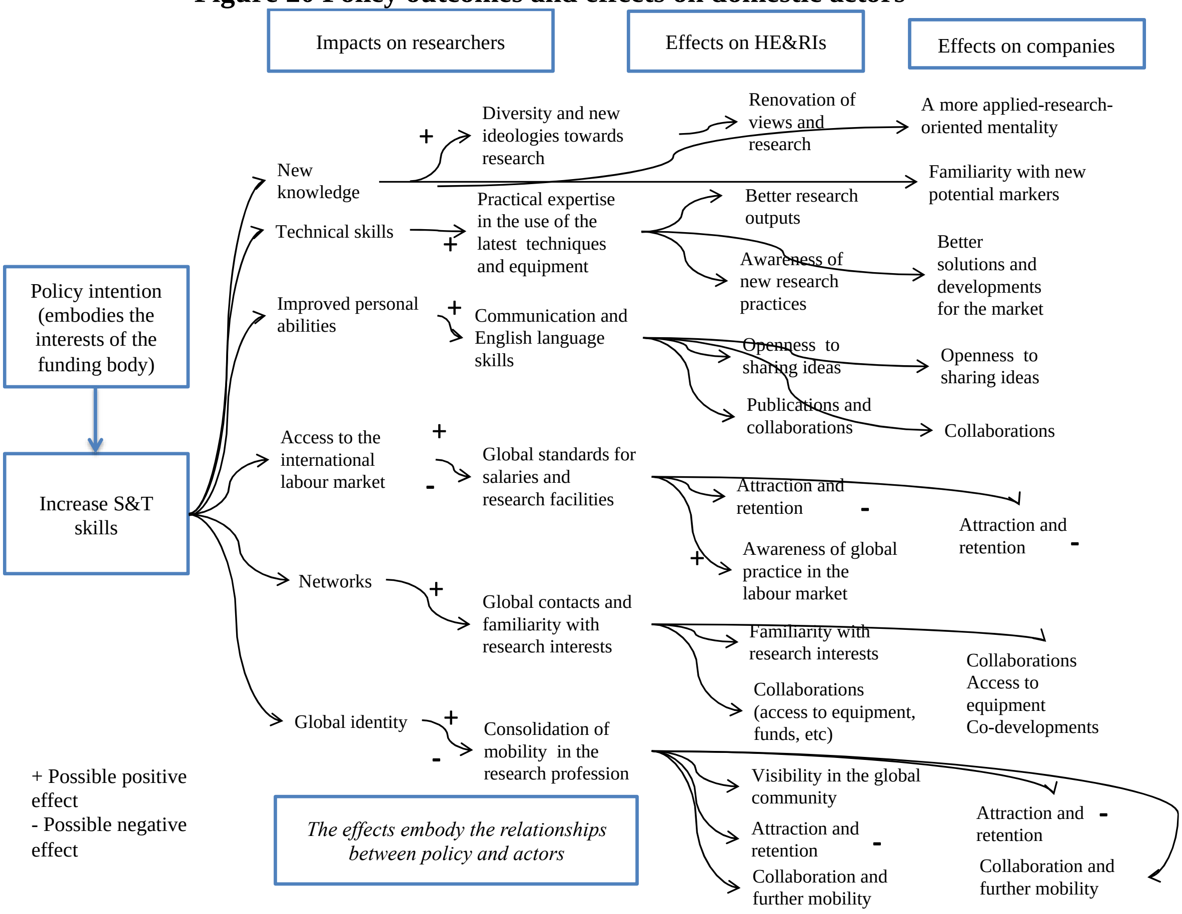
Theme	Fellowship holders	Higher education and research institutions	Companies
Tangible capital	• sophisticated equipment • research facilities • extra funds	• sophisticated equipment • research facilities • extra funds	• sophisticated equipment
Social capital	• networks • community: shared understandings and practices • diversity (views, cultures and approaches)	• networks • awareness of practices • diversity (views, cultures and approaches)	• networks • diversity (views, cultures and approaches)
Human capital	• new knowledge • technical skills • improved personal abilities • access to the international labour market	• new knowledge • technical skills	• new knowledge • technical skills

The first theme refers to access to equipment and facilities to conduct R&D activities. Representatives of HEI&RIs seemed to value the overall experience of having hands-on access to these facilities, while for companies, the value of these lies in the cost of purchasing specific equipment that may only be used sporadically versus the cost of having experiments conducted by their partners abroad.

The second theme comprises the practices and approaches adopted by mobile researchers and their transnational ties. Here, their visibility and belonging to a global research community are also part of this theme. Among HE&RIs and companies this relates to being aware of international research practices and access to the extended networks of mobile researchers. The third theme refers to the stocks of scientific and technological knowledge and skills in the researchers and their familiarity with the global labour market. Most of the benefits in this theme are located in the mobile researchers and require direct interactions with local peers in order to be transferred to the domestic research system. International networks are beneficial for all the involved actors and do not require strict physical interactions between the mobile and local researchers to deliver benefits for the research system.

Figure 20 illustrates the impacts from direct to indirect beneficiaries. This figure is an extended version of the framework presented in Chapter 7, where policy intentions meet with the interests and decisions of beneficiaries in a particular context. The configuration of the research space here encompasses the immediate benefits that the policy instrument offers for its beneficiaries, in combination with the national S&T policy and current conditions of the research system. The research field embodies the benefits that mobile researchers attribute to being part of a prestigious research community and producing relevant research. An important point is that researchers are affected, or live in more than one research field; the incentives offered by national policies, and those provided by the host country.

Figure 20 Policy outcomes and effects on domestic actors



One implication of this analysis is that the institutionalised forms of production of knowledge in developing countries should enable stronger links between the researchers that return with local peers across research organisations, be these public or private.

Another implication for the overall research system is that awareness of global research practices and global identity can increase the potential for unlocking existing practices that hinder the transformation of domestic research. This can be attributed to the collective interests that are often closely associated with the progress of knowledge and reputation, which can facilitate change as researchers are not reluctant to alter their practices in order to attain a more reputable status in the research community. Lastly, international mobility policy instruments should continue to focus on improving individual research skills, but should also focus on domestic research organisations. They concentrate the benefits of international mobility and can enable, through their activities, the distribution of benefits/research capacities. In other words, research organisations have the capacity to enable mobile researchers to be vehicles of change.

10.2.2 Common challenges and their link with policy and systemic issues

A combination of unintended effects of international mobility surfaced mainly concerning the conditions of the national research system. These are presented below and are discussed in light of their influence on the effects above.

10.2.2.1 Mismatches between personal expectations and domestic research

This mismatch presents a challenge for domestic employers and emerges as an effect of the new identity adopted by mobile researchers. This study identified a tension between the interests of these researchers to preserve their international status with the conditions and opportunities for them in domestic research. Mobile researchers perceive that the conditions of the national research context may negatively affect their international status, and thus, their identity. This is because they believe that research conducted domestically is not as well-positioned and as prestigious as the research performed abroad. Their views were influenced by the 'low' prioritisation of research in the home country, which is visible in the low investments in R&D and low salaries for researchers.

Another mismatch relates to the high expectations of mobile researchers for better salaries and facilities similar to those offered abroad, but which domestic employers cannot always offer. For instance, in Mexico, the salaries of researchers in public HE&RIs are established by federal higher education and finance authorities, and additional financial incentives are contingent upon productivity and seniority (see Chapter 3). Moreover, the renewal of the academic base in Mexico, which is a pressing challenge, is a window of opportunity for HE&RIs to harness the Programme.

However, the lack of resources to create new positions for early-career researchers and low incentives for the retirement of senior academics creates a paradoxical situation. This is because, on the one hand, the Programme offers the skills that

HE&RIs need to produce better research, but, on the other, they cannot attract and retain researchers. In this sense, it is fair to say that HE&RIs in Mexico cannot compete with the conditions and incentives offered by advanced countries concerning research.

Another similar challenge within this mismatch is the organisation and dominant practices of domestic research. This emerges in relation to the fact that mobile researchers, particularly those specialised in applied research, expect to continue conducting similar research under similar conditions. They have gained considerable sensitivity about the economic value of applied research and broader opportunities regarding the utilisation of scientific knowledge. This is because international mobility affords a valuable experience for the mobile researchers that goes beyond the academic experience, in the form of awareness and expertise on the commercialisation of intellectual property and entrepreneurship.

In Mexico, academic research is mainly theoretical; this is due to the still lingering notion that research should not be seen as a private good (see Chapter 3). This view is evolving; Mexican researchers are becoming more aware of the possible gains from the utilisation of knowledge. However, this change is occurring slowly. HE&RIs regard research as being primarily an academic profession and have not yet fully adopted the innovation –utilisation and commercialisation of knowledge– vision. On the other hand, the private sector does not undertake a wide range of R&D activities. In addition, the lack of an adequate governance structure –at the system and organisational level– that will allow researchers to procure economic benefits from their research outputs delays this realisation.

10.2.2.2 De-familiarisation and re-adaptation

Having to change context and research settings represent a professional and personal struggle for mobile researchers. Returning to the home country implies having to re-adapt to its political and social environment, particular funding arrangements and priorities concerning domestic research. Professionally, this process can affect the productivity and career progress of returnees. It can also prompt feelings of being undervalued by the country, and frustration when their expectations are not met. This process can also occur when researchers move to a destination other than the country of training and are not offered the expected opportunities. Interestingly, they feel that this process is more difficult in the context of having to return to the home country.

The de-familiarisation with local research practices and agendas also affects domestic employers in that the process of re-adaptation may be delayed by how returnees reconcile their new status and aspirations. This can also affect the type and extent of individual benefits transferred to domestic employers. For instance, returnees have become accustomed to working with the latest and often highly sophisticated equipment. Having to return and work in a resource-constrained context can represent a professional and personal struggle for the returnees, for they will have to adapt their ambitions concerning their research interests, research practices and access to resources.

Although it is not possible to pinpoint how the process of adaptation may prompt in returnees the fear of losing their new identity and their place in the global community, it is possible to assert that domestic employers play a crucial role in enabling these researchers to return and continue active in their international networks. Domestic employers, particularly HE&RIs make the process of adaptation smoother for returnees by offering the conditions for them to remain global. Thus, one implication of adaptation is that researchers may migrate our of a fear of losing their international identity, although, this can also lead them to be proactive and search for resources from international funders and networks, and can also incentivise internal collaborations. How returnees reconcile the process of re-adaptation along with keeping their international identity is a question that requires further research.

This thesis finds that mobile researchers can become de-familiarised with domestic hiring practices, domestic research priorities, and local funding arrangements. In consequence, they may find themselves at disadvantage when applying to local job openings and calls for funds. Feeling unfamiliar about how things are done in their own country can make them feel like ‘outsiders’. This occurs not only because mobile researchers become unaware of the priorities for the domestic employer, but also occurs due to the lack of significant local contacts that could make the transition of return smoother. An important finding in this regard is that the time spent abroad is a phase in which mobile researchers had little or no contact with previous academic and professional contacts in the home country. This may be because they find no incentive for remaining connected with their domestic peers and the pressure to adapt to the host country can demand their complete attention. Interestingly, this disconnection can explain the absence of diaspora links in this particular case.

This study was not designed to inquire about the potential effects derived from the process of adaptation. However, based on the evidence in this study, it is possible to posit that domestic employers and policy measures can make the process of adaptation smoother for the researchers willing to return. This could have profound implications on the long-term effects on the domestic research system. This is because the benefits that home countries can receive are, to some extent, defined by the capacity of domestic employers to enable researchers to keep their global identity.

10.2.2.3 Imbalances in the benefits of international mobility

Findings in this research highlight a concentration of benefits to research-oriented HE&RIs. This is because these organisations, due to their mission, provide mobile researchers opportunities that are better aligned to their expectations, such as access to resources and prestige. For instance, these organisations tend to offer extra funds to returnees to prevent possible delays in their adaptation and ultimately in their productivity.

This study finds that companies in Mexico are interested in recruiting researchers with international research experience. However, these companies, particularly micro and small companies, cannot offer researchers the salaries they could command and expect. In this sector, the beneficial impacts of international mobility are concentrated in large companies, which offer better salaries and have the resources to invest in research and development. These companies also access the benefits of international mobility through collaborations with domestic HE&RIs.

10.2.2.4 Few incentives for return

This research finds that mobile researchers have conflicting opinions about returning to Mexico. Their intentions indicate that, if possible, they will remain abroad, with a combination of opportunities for career development, common research interests and the prestige of host countries in the research system. In regards to national factors deterring their interests to return, quality of life and organised-crime violence are the most relevant. This means that the interest of mobile researchers to remain abroad relates to their professional ambitions, but also to the possibility of living in a safe environment.

In summary, this study shows that the most common reason for not returning to Mexico is that they fear losing their international identity.

To what extent has policy contributed to the emergence of the identified changes? Or what other factors influence the emergence of these changes?

The Scholarship Programme provides direct financial support to the nationals willing to undertake their doctoral training outside Mexico. In this sense, the movements of Mexican citizens to the most prestigious international research organisations, and access to high-quality training and infrastructure are positive impacts attributable to the Programme.

In principle, the Programme holds significant potential to improve science in Mexico. However, this research finds that the Programme is not adapted to the global dynamic of scientific mobility such as world-leading collaborations, circular mobility, and the diaspora. It shows little, if any, alignment to how it can prompt advancements in the domestic system. Interestingly, policymakers and practitioners behind the Programme are aware of the competitiveness of the international labour market and the interests of the fellowship holders to enter such a market (Chapter 4). This awareness has not yet permeated into positioning the Programme as a strategy for change, mainly because its position in the general context of S&T policy in Mexico limits its capacity to produce substantial changes in domestic research (Chapter 2 and 3). The Programme is not framed within a set of broader science, economic or industrial policies; it is a stand-alone instrument with great ambitions but a reduced financial capacity and scope of intervention.

There was a disconnect between policy intentions and the characteristics of beneficiaries. This disconnection may create some unintended, and possibly negative, consequences that will require further interventions to address the consequent problems. For instance, when abroad, mobile researchers disconnect from the domestic S&T landscape – research priorities, funding mechanisms, local contacts – making remaining abroad more attractive, as returning will entail uncertainty and costs. Addressing these issues will require extending the scope of the Programme to introduce mechanisms that could connect fellows with domestic research institutions. This means transforming the Programme from a capacity-building mechanism, directed at individual researchers, to a policy that can change national research by enabling domestic organisations to absorb and diffuse the benefits of international mobility. Considering such a change would also mean moving towards instruments that would allow returning fellows to remain connected with transnational networks.

The Programme shows strong legacy effects on the core practices of S&T in Mexico. Despite being driven by the science-innovation-growth aspirations set out in the OECD policy model, this shows little policy-learning on its own. For instance, the Programme operates only at the individual level, influenced by the human capital outlook, disconnected from broader social and economic policy efforts. This is because, despite the ambitions for research capacities and economic development, this research finds that the Programme has a limited financial capacity and restricted domain of intervention in the research system. These conditions in the Programme have their origins at the very core of the system, notably:

1) The lack of coordination between actors. This is visible in that industrial, economic and social policies have not acknowledged the capacity of the Programme to produce innovations and growth;
2) The notion that international mobility is beneficial on its own right. This reflects in a linear policy approach that assumes that by sending

nationals abroad benefits would emerge organically in the national research system;

Based on the evidence presented here, it is possible to say that the Scholarship Programme brought about several effects on its direct and indirect beneficiaries. It affords mobile researchers with a unique set of opportunities through their doctoral training in the best research milieus. However, translating these benefits to the domestic system proved to be a pressing challenge. The only exception to this is the networks that researchers build abroad and their interest to remain global, which mobilise them to engage in international collaborations from which their local peers also benefit.

The impact of the Programme is, to some extent, due to the opportunities that it provides for the fellows to be trained abroad, which is by itself a direct benefit. The fellows respond to the opportunities presented by the Programme, i.e. its financial support and prestige, and their responses are mediated by the conditions of domestic the research system and personal interests. In this sense, the benefits reported cannot be attributed in their entirety to the Programme. There are other social influences at play, such as the global nature of scientific research that motivates the researchers to remain global, and which triggers aspirations and decisions that also affect the impact here reported here. Also, the need for a safe place to live influences the perceptions and decisions concerning the opportunities offered by the Programme.

10.3 REVIEW OF FINDINGS

The Scholarship Programme plays a crucial role in affording Mexican doctoral students the opportunity of training in the best and most dynamic research institutions worldwide. The Programme was designed to create a scientific base and to advance domestic research and innovation (see Chapter 3 and Chapter 4). The rationale for providing public support for international doctoral training is rooted in the assumption that the individual benefits from advanced training and state-of-the-art knowledge will transfer to the wider research system which will, in turn, further international competence. In terms of its capacity to produce these intentions, findings showed a mixed picture; the Programme enables the enhancement of scientific research skills and knowledge, but its effects are differentiated across beneficiaries. The benefits embodied in the fellows do not translate automatically into benefits for the system upon return and the research facilities and broader social conditions affect the transfer of these benefits to domestic research organisations.

The Programme proved to be relevant for the improvement of doctoral training, particularly in emerging fields. By sending nationals to study in advanced research systems, the Programme affords them the opportunity of working directly with the best people in their fields, giving them access to sophisticated techniques and latest debates. Lastly, investigating ‘what’ and ‘how’ individual benefits are transferred to domestic employers exposed some of the issues affecting the intentions of the Programme, such as the narrow scope of intervention of the Programme that focuses only on individual researchers, rather than on the research system and lack of connections with the fellows abroad.

10.3.1 Review of findings on policy

The findings in this study contribute to the growing body of research that attempts to understand the relationship between science and policies (Langfeldt et al., 2019). The results suggest that investigating science and technology policy instruments takes place in a complex research setting, in which their potential to produce change needs to be examined considering the opportunities that policy instruments offer to their beneficiaries. In this regard, the issues associated with the instrument itself, and the endogenous conditions for S&T should also be considered. This helps distinguish the links between policy-generated impact from other influences affecting researchers behaviour, their characteristics and their expectations.

Findings in this study contribute to previous studies dedicated to the analysis of policies, which recommend more comprehensive models about what worked, how and why in policies (Borrás & Edquist, 2019; Reale et al., 2014). In this regard, this study confirms that policy interventions can be expected to impact domestic research, but also confirms that ambitions in policies should be accompanied by adequate resources, i.e., funds and governance legitimacy to guarantee the diffusion of benefits. Similarly significant, this study finds that understanding the characteristics of beneficiaries is essential to understand the extent to which policies can cause them to adopt the expected behaviour and the extent to which their interests influence the power of policies. In other words, the characteristics and interpretations that beneficiaries make of policies can explain the capacity of policy instruments to produce change.

The results in this research show that the rationale for the Scholarship Programme associates the international mobility of researchers with benefits at the research system within a linear model of policy thinking. In other words, the Programme is a clear representation of the widespread notion that government investments in science, in this particular case, international doctoral training, are implicitly beneficial. This instrument is led by an input-based logic that favours quantitative indicators and with little room for reflection on how, intentionally or not, the Programme has changed domestic research. More importantly, the quantifiable-results oriented approach in the Programme does not allow for reflective work on how it can change the current and future state of the research system in Mexico.

In consequence, this research shows that the lack of a comprehensive policy approach in the implementation of individual instruments can produce unintended effects. This is because the traditional approaches underlying policy interventions – that operate at a narrowed scope – do not correspond to the broad and changing relationship between the opportunities that policies can provide for their beneficiaries, and the reactions of these to such opportunities (Diercks, 2018; Reale et al., 2014). These findings also confirm the need for realistic approaches in the study of policies (Pawson & Tilley, 1997), which should consider different levels of aggregation to reveal the mechanisms that may have produced specific impacts and how these unfold over time (Nedeva, 2010; 2014).

Ultimately, the results agree with Laudel and Blieck (2019), who suggest that policymakers tend to set high expectations on S&T policy for accruing as many benefits as possible. Such expectations translate into high expectations from the producers and users of knowledge, who should generate more and better outputs. However, policies can only do so much in terms of how researchers respond to the opportunities offered by policies. This study shows that researchers are not only governed by policy interventions but that research-related factors such as facilities, quality of research outputs and the reputation conferred by global research communities also influence their behaviour. In this regard, it concurs with Nedeva, et al. (2012) in that S&T policies should be studied through the impacts they have on the actors in the research systems.

10.3.2 Review of findings on the impacts of international mobility

The results presented in this research are consistent with the widespread positive attitude towards the international mobility of researchers and confirm the growing attention to mobility as a critical factor for career development (Ackers, 2005b; Jacob & Meek, 2013), and the improvement of domestic research in developing countries (Lowell & Findlay, 2001; Tejada, 2012).

Due to the empirical choices made in this study, the findings here draw on a sample of mobile researchers in STEM fields, and in particular in nanotechnology and nanoscience related fields. It was not possible to detect differences in applied and theoretical fields regarding the motivations and effects of international experience. Such differences have been highlighted by Cañibano & Bozeman (2009) and Zubieta (2009), who showed that patterns of mobility vary across disciplines. However, this is rather difficult to interpret in this study because a strong sampling bias is operating. It is possible to infer that, due to the multidisciplinary and technology embedded nature of these fields, emergent research fields serve as attractors of mobile researchers. Most of the emergent fields require hands-on interaction with physically embedded technologies, which would most probably prompt researchers to be more mobile than those that can access data and other research resources without having to move location. This idea mirrors previous research that has examined how the mobility of researchers is shaped by a multiplicity of cultures, ideologies and interests (Cañibano et al., 2011; Heffernan & Jöns, 2013; Jöns, 2007), and which has found that research that relies upon physically embedded technologies encourages mobility (Laudel & Bielick, 2019). Conversely, it contradicts that of Rostan & Höhle (2014), who suggest that international mobility patterns are similar regardless of the demands in the specialisation of researchers.

Additionally, findings in this research confirm that international mobility is not necessarily driven only by the economic benefits that researchers expect in terms of higher salaries they will receive in the host countries. The study finds that international mobility of researchers is a complex process underpinned by varied research-related, career and social factors, and personal preferences (Azoulay et al., 2017; Reale et al., 2018; Stephan et al., 2015). Thus, findings in this study contest what is commonly discussed in the human capital approach that has focused on the economic determinants of migration (Mountford, 1997; Tremblay, 2005).

This study showed that the conditions offered by research systems to produce state-of-the-art research, and prestige and the resources that may accompany this, are key factors shaping the flows of mobile researchers from Mexico to other (often more developed) countries. This agrees with the findings of previous works about the motivations for scientific mobility, such as those by Jöns (2007), Børing, et al. (2015), Delicado (2010) and Siekierski, et al. (2018). In addition, this study finds that social aspects in the home country, notably, personal security issues are often behind the decisions of researchers to go abroad. An instance for this is that clashes between drug-cartels and government security forces have driven scientists to abandon field sites, interrupt experiments or even change their research interests. In this sense, the younger generations of researchers see in their advanced international training a possibility to start a life away from this environment.

Another important finding is the strong sense of mobile researchers to want to belong to a global community in highly reputable places, which can be explained due to the prestige, resources, and opportunities to produce excellent research. This is consistent with the literature on international mobility, which notes that researchers are attracted to contexts with a high concentration of research advancement, research facilities, increased investments in S&T and well-renowned researchers (Casey et al., 2001; Heffernan & Jöns, 2013; Musselin, 2004b). Also, the results suggest that international mobility expands the margins of what researchers consider familiar and shapes their identity (Lam, 2014;2018). The global identity adopted by mobile researchers encourages them to remain global as identified from statements on how they envisage their career trajectory, collaboration interests and personal ambitions. This will affect their perceptions about returning to the home country, which may be seen by some as an undesirable career move as this may involve adjusting their research agenda due to the lack of research infrastructure and resources. Such adjustments may affect the positioning of researchers in their community; i.e., their contributions to the global production of knowledge. On the other hand, some findings showed that the general interest of researchers to remain global encourages those that return to consolidate their international networks.

Migration can be the ultimate aim of undergoing international mobility and mobility may be a stepping-stone for permanent migration, as has been presented in previous studies such as Baláz et al. (2004). In addition, the results indicate that finding a job abroad can be seen as a critical peak of success among mobile researchers from developing countries. What is interesting is that obtaining a job was not seen as a career move that will make the researchers more attractive to the home country but was a strategy to increase the possibility for them to remain abroad. This can be interpreted in two ways; first that the international experience may be ultimately combined in a new configuration of global researchers that are defined by their status or sense of 'being global' as they pursue their careers. Alternatively, researchers from developing countries have little interest in returning to their home country and that this attitude relates to personal preferences and social factors.

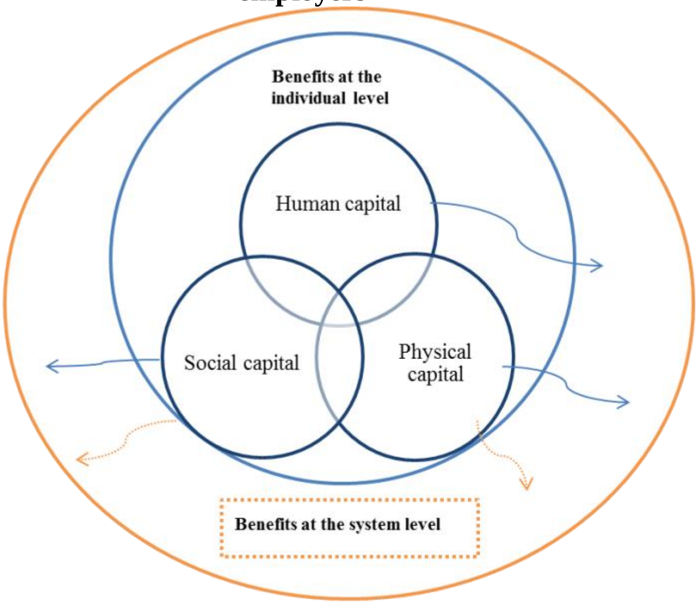
There is insufficient literature on this issue and its implications for science policy. Most studies assume the decision for not returning or permanent migration is a consequence of international mobility itself, i.e. the international labour market absorbs mobile researchers (Delicado, 2010; Gibson & McKenzie, 2012; Parey & Waldinger, 2008). Other studies suggest that the most productive foreign-born researchers tend to remain abroad (Gaulé & Piacentini, 2013) and that in the face of a competitive labour market, some mobile researchers will ultimately return to the home country (Lowell & Findlay, 2001). There was not substantial evidence on the extent to which the expectation of remaining abroad is realised among researchers or about how they reconcile the pressure to remain abroad and the possibility of returning. Such expectation is contingent upon a limited pool of jobs prospects, organisational interests, and migration regulations of the host countries. This study did not focus on the productivity effects on the researchers trained abroad although data showed that 30% of those that stayed abroad work in the private sector, and 20% had permanent positions in academia, whereas, an overwhelming majority of those that returned to Mexico work in academia and 64% have permanent jobs. This study found that mobile researchers had firm intentions to remain abroad. These intentions might be related to the search for a better quality of life. Exploring possible reasons for this will require further research.

A common benefit shared by mobile researchers and domestic employers is that of gaining access to international networks; which comprise professional contacts that enable researchers to create and transfer knowledge (Bozeman et al., 2001). This supports the work of other studies concerning the social or connective component that results from improvements in the human capital of researchers (Bozeman & Mangematin, 2004; Cañibano & Woolley, 2012). The significance of this finding is that networks seemed to be the only result that can connect mobile researchers with the home country. Also, the results confirm that networks are portable (Bozeman & Corley, 2004; Scellato et al., 2015) and that most of the benefits of international mobility remain embodied in the mobile researchers themselves (Cañibano & Potts, 2018; Cañibano & Woolley, 2012). Transferring these benefits into the wider research system is not a trivial task; the benefits for domestic employers are less obvious.

As a consequence of these networks, HE&RIs and companies in the home country can access research infrastructures, large collaboration projects and extra funds. In this sense, international mobility offers domestic organisations the possibility of doing better research and access to international connections. However, unlike previous studies, findings here show that benefits are not only related to co-authorship collaborations (Baruffaldi & Landoni, 2012; Jonkers & Cruz-Castro, 2013). International mobile researchers also bring awareness of different ways of doing research, new notions of quality for research outputs, increased collaborations with non-academic actors and awareness of opportunities concerning the commercialisation of research outputs.

Although the benefits of the international experience reside, predominantly, at the individual level - in the form of advanced knowledge and skills - this research finds that social and tangible capital is the intersection where individual and more extensive benefits can occur. Figure 21 shows the relationship between individually embedded effects and their possible transfer to the research system.

Figure 21 Analysis of the impacts of international mobility in researchers and domestic employers



Blue arrows: effects that can be transferred upon return.
Orange-dashed arrows: effects that could be transferred through diaspora.

In the context of co-authorship and co-supervision of students between mobile researchers and domestic HE&RIs, these benefits occur regardless of the location of researchers. This means that long-term return might not be a necessary condition to extend this benefit to local research groups. However, this requires specific incentives and structures for researchers to find common interests and collaborate. This study did not find substantial evidence on diaspora effects or connections between the mobile researchers living abroad and researchers in the home country. This can be due to the different notions of what collaboration with domestic peers means for researchers. For instance, for the mobile researchers living abroad, it means presenting their work at a conference in Mexico, leading a workshop in a national university or providing professional advice to a company in this country. While for domestic researchers, it means working together in relevant research projects on a long-term sustained basis.

This study finds that face-to-face contact between mobile researchers and domestic peers is of significant relevance in transferring benefits into higher aggregated levels in the research system. While domestic employers value highly the global research skills and networks capital in mobile researchers, this research did not find indications of diaspora collaborations. This means that the transfer of individual benefits into knowledge spill-overs requires more than personal ties with national researchers living abroad. Face-to-face interactions might promote trust and shared understandings that will facilitate knowledge flows and assimilation of these. This finding is consistent with results presented in Czaika & Orazbayev (2018). The relevance of physical interactions might be due to the intensity and quality of exchanges and transactions between mobile and local researchers. With this in mind, this thesis posits that due to the individual embeddedness of the benefits resulting from international mobility, in order to procure wider effects, it will be essential to establish mechanisms that facilitate the return of fellows that have been trained abroad. Such mechanisms can be short-stays or longer stays. This finding can be interpreted as a challenge to the emerging perspective about diaspora, which asserts that international mobility is beneficial for the researchers and the home country research system regardless of return (Fangmeng, 2016; Meyer, 2006; Saxenian, 2005). Collaborations can produce more significant effects on the home country if researchers can meet face-to-face, but this is not always necessary.

The diaspora approach has already been questioned by Gaillard & Gaillard (2003a) and Cañibano & Woolley (2012), because of the limited evidence to support its claims. The primary claim of diaspora scholars is that the networks that connect the mobile researchers living abroad with research collectives in their home countries are a tool for research improvement and development (Kenney et al., 2013; Seguin et al., 2006). The diaspora proposition has its foundation on a cost-based view that seems to be blind to the urgency to offer alternative frameworks and solutions to the consequences of brain drain for the sender countries. Diaspora proponents emphasise that developing countries can benefit from expatriates at a low cost by using already existing resources

(Thorn & Holm-Nielsen, 2006). However, as shown in this research, diaspora effects do not occur automatically; they require knowledge structures and active nodes to promote the flows and exchanges of knowledge. A similar argument is presented in Gaillard & Gaillard (1998, p. 112), who assert that without grounds for significant exchanges, there is little scope for a responsive diaspora.

This interpretation brings to light the incipient understanding of how the international mobility of researchers can benefit the overall research system in the context of multiple motivations and geographies. In this regard, this research agrees with Cañibano and Woolley (2012), in that overcoming the limitations of the current theoretical frameworks on scientific mobility will require untangling the relationship between scientific research and human capital. Also, it will need to investigate how mobility can reconfigure the production of scientific knowledge. This is because improvements in human capital are responsive to policy measures, but science-related motivations might not be as responsive as these are linked to norms and values that regulate researchers' behaviours and expectations.

This study substantiates previous findings that there is a process of re-adaptation upon return (Carr et al., 2005; Castaños-Lomnitz, 2003). In this particular case, the results indicate that cultural misalignments could discourage return among mobile researchers and that this can be explained by the tension between global and domestic research practices and identities. According to the results of this study, this tension seems to be caused by differences in local funding arrangements, hierarchical structures in domestic academia, the perception of not being valued by the home country, the fear of losing the global status and weak ties with local peers.

Most commonly, the existing literature has addressed the issue of adaptation in the host country and portrays this as a sense of personal self-realisation (Ackers, 2008; King et al., 2016). However, how returnees reconcile this tension and its potential implications in their careers are under-researched topics. Initial work on this was presented by Nedeva et al. (2012), who found that mobility can be detrimental for researchers' future research activities because they had adopted specific methods and became used to working with specialised and expensive research equipment, which they cannot access on their return.

Results show early indications that mobile researchers can become de-familiarised with the domestic research interest and funding mechanisms, which can delay their re-adaptation process and career trajectory. This process relates to how they would adjust their career expectations, research agenda, and future geographical moves – as they may decide to migrate again – and career progression. It also relates to possible cultural shocks and frustration when re-entering the home country's routines and organisation of knowledge. There are several explanations for this de-familiarisation or disconnection. For instance, the pressures to adapt to the host research system and academic activities, and the need to adapt to the host country's culture and language that become priorities. The lack of relevant local contacts before moving abroad and lack of infrastructure to connect them can also explain this. Another possible explanation rests upon the intentions of these researchers to remain abroad, who will, in turn, dedicate their efforts to achieving a competitive profile for foreign employers. Similar findings are provided by Jöns (2007), who found that academic visiting scholars in German HE&RIs diminished their interactions with colleagues in the home country. Wang et al. (2019) and Li & Tang (2019) reported related results for Chinese mobile academics.

However, unlike the findings in Jöns (2007) that drew on data from researchers that had already advanced their career after graduating from their doctoral studies, in this work, mobility takes place at the training and early-career stage of researchers. Thus, it is possible to assert that this disconnection can occur due to atypical research interests and patterns of knowledge production in the home country that do not align with the new ambitions of mobile researchers. Possible implications for this disconnection concerning the return and career development of mobile researchers are presented in Baruffaldi & Landoni (2012), who highlighted that the linkages that researchers keep with the home country, while abroad, are conducive to widespread benefits for both the mobile researchers and domestic research system. This study, however, does not provide explanations about how this disconnection occurred and what factors may have influenced its emergence.

In summary, this study demonstrates that international mobility is beneficial for researchers, but a few considerations need to be stressed: 1) international mobility is a multi-factor phenomenon, shaped by research interests and personal motivations. For instance, the global identity and advanced research milieus seem to be key factors underpinning the intentions and realised impacts of international mobility; 2) the individual benefits of the international experience to researchers are not easily transferable to the research system; 3) the length of time spent abroad can produce a distance between mobile researchers and the home country.

This study indicates that the relationship between policy intentions and the interpretations and decisions of their beneficiaries exerts far more differentiated impacts than usually assumed in the scientific and policy literature.

10.3.3 Contributions to Theory

This study has made theoretical contributions to the scientific international mobility and policy evaluation literature by examining changes in research within the interplay between policy implementation and the characteristics of mobile researchers. It has introduced several theoretical constructs from the international mobility of researchers literature that have not yet been discussed. These are global identity; de-familiarisation and re-adaptation.

As has been shown through the characterisation of motivations and effects reported by participants, this research has shown that scientific research is not fully responsive to policy pressures, as contribution that follows from the exploratory nature of this study that looked beyond policy intentions and included a wide spectrum of changes in domestic research.

This thesis looks at two levels of actors in the research system i.e. mobile researchers and domestic employers because the intended target of change is the research system. This level of disaggregation was an empirical and analytical decision derived from the assumption that effects at higher levels of social aggregation result from the enactment of the individual benefits. Higher-level effects can be an extension of the individual benefits, but there could also be benefits which are not exclusively the result of the benefits to the researchers. This research was particularly interested in understanding how individual benefits are transferred and translated into higher-level benefits.

10.3.4 Reflections on the analytical framework

While this research does not aim to refute the analytical frameworks pointing to quantifiable increases in the productivity of mobile researchers, this study problematises the traditional frameworks used to study change in research systems. The central assumption in this study is that the international mobility of researchers is a phenomenon shaped by factors that coexist in a space where the inner workings of scientific research overlap with individual decisions and policy interests. This is because although international mobility is not unique to the profession of research, this profession is more closely defined by the diffusion of knowledge, research practices and the sense of global scholarship, all of which relates to elements intrinsic to the production and organisation of knowledge.

This assumption derives from the analytical framework in Chapter 7 which takes a novel view on the workings of scientific research to explain change at different levels in a research system. In particular, the framework has offered a cohesive and inclusive ground for the interpretation of the findings of this study that aims to deepen the understanding of policies for scientific mobility. The RF&RS framework helped to link the characteristics of the researchers that form the unit of analysis in this study to the demands of their research communities.

The results showed that the direct financial support offered by policies to individual researchers play a significant role in encouraging their decision to move abroad to undergo high-quality scientific training. The study also showed that these researchers are not only driven by the initial financial incentives, but also by the expectation of performing relevant research in an encouraging environment. This related strongly to the expectations of researchers for finding a good job and gaining the recognition of their scientific community. The results also showed that international mobility brings benefits for all the involved actors, as well as costs. Individual benefits are not automatically transferred to higher levels of aggregation in the research system, there is a process of re-familiarisation and re-adaptation that the researchers that return to the home country will undergo. In this process, the incentives and facilities offered by domestic employers and the overall research system will be key factors in the type of benefits that the researchers will deploy and transfer. In this regard, policies promoting organisational research capacities are essential, as these can create the conditions for collaboration and knowledge flows.

10.4 IMPLICATIONS AND FURTHER STUDIES

There are two significant characteristics of this research. First, it looks beyond the conventional accounts of international mobility, notably, brain drain and diasporas. In line with the more critical scholarship on science policies and on international mobility, this study focuses on the motivations and impact as perceived by the direct and indirect beneficiaries. This study claims that the mobility of researchers consists of professional and personal aspirations for global identity as researchers, access to resources and quality of life.

Moreover, because mobility involves more than one research space, this study posits that collaboration could be a way to promote the transfer of benefits into higher levels of social aggregation. This will require moving from the notion of competition for talent between countries and shifting to joint efforts that can enable the redistribution of scientific knowledge and skills. Additionally, future research should evaluate the impact of mobility schemes that require researchers to return in terms of their effects on domestic research.

It is also important to consider that there should be accompanying incentives, such as world-leading long-term research projects, to attract mobile researchers back to the home country, not necessarily to stay but to establish collaboration links. Future research should investigate the extent to which these incentives attract mobile researchers back home and focus on the personal level rather than on purely output oriented measures of success. Also, the extent to which return and non-return conditions the definition of research agendas in domestic research teams and networks is an open question.

International mobility of researchers is crucial in the production of knowledge and the enhancement of research skills. This work encourages future studies to consider a constructive dialogue around this topic and to focus, for instance, on how scientific mobility changes the structure of the academic career, and its possible influence on the diffusion of practices, ideas, and networks. It is essential to understand how researchers reconcile the policy-generated incentives and pressures with those from research. Further research should also explore the knowledge transfer mechanisms between the national researchers abroad and their domestic peers, the existing patterns of collaboration, and new configurations of knowledge creation. Detailed-research is needed about the effects that are less tangible (e.g. adoption of a new identity) and the conditions that enabled these to occur.

This study has mainly focused on nano-related fields with a strong orientation towards applied research. Future work could be done on comparing how international researchers across different fields react to the opportunities offered by mobility policies and reconcile these with the practices in their fields and expectations. Also, further work could confirm and explore the effects that are transferred from researchers in other fields to research organisations. In this regard, more studies of domestic employers would help to elucidate patterns of changes occurring in different sectors in higher levels of aggregation. This would shed light on what changes or effects are taking place at the higher education and research level.

The analytical framework used in this study has been successful in generating evidence about the changes in individual researchers, domestic companies and research organisations. The framework can be used in these further works and treating all actors in the system according to their interests, functions and resources. Also, the framework allowed a consideration that change is defined by the actors, the context and the structure of national research arrangements. Moreover, this study has focused on a research field with specific characteristics – nanotech and tested how the RF&RS framework works. Further research could continue this line of investigation to demonstrate the power of the RF&RS as an approach to examine the more nuanced effects of policy on researchers and other beneficiaries across in different research fields.

Policymakers need to see international mobility in relation to its broader setting, and as a reconfiguration process that not only connects national researchers with research-intensive milieus; it connects researchers, research groups, and organisations with other research spaces. In consequence, policymakers should promote the advancement of domestic research communities simultaneously, for instance, to look at domestic HE&RIs and knowledge-based industries as hubs to connect with global researchers and translate individual impacts into the system. In the words of Jacob & Meek (2013), an environment that incentivises researchers to push the frontiers of S&T could be more attractive than economic incentives. Thus, S&T policy should invest in individual researchers and research organisations and facilitate the necessary arrangements to diffuse the benefits of international mobility in the research system.

In a similar vein, this study asserts that governments should foster the connections between mobile researchers with the home country in order to prevent their distancing and de-familiarisation. Policymakers should consider that although return will not always occur, a well-communicated understanding of how mobile researchers can contribute to the development of domestic research, accompanied with long-term sustained resources and career development incentives can be conducive to tangible and sustained collaborations. Similarly, it is crucial to improve the institutional conditions for recognising the benefits of mobility and incorporate these into broader policies.

In summary, this study identifies some of the existing gaps in the current Conacyt Scholarship Programme in regards to the benefits and challenges of international mobility for sender countries. It examined the impact of the Programme, a policy instrument led by the Mexican government that aims, through the international mobility of researchers, to improve its research capacities. The research examined the factors that can explain why the reported effects emerged in the way they did. This study concludes that international mobility policies can be conducive to change, i.e. to enable researchers to acquire the skills and structures to become global researchers, which could also be beneficial for domestic HE&RIs. The effects of international mobility policy instruments for the sender countries are mediated by the conditions of the national research system and academic interests of global and local research communities. Also, these effects are differentiated across direct and indirect beneficiaries and are transferred in the form of embodied knowledge following the return of the mobile fellows.

10.5 LIMITATIONS

The following limitations should be noted. First, the findings are based on a specific mobility instrument in Mexico and within a single science-driven sector, namely nanotechnology. The experiences of those from other research disciplines, such as social scientists, whose motivations for going abroad may be less dependent on physical infrastructures and instrumentation, are not presented here. It might be of value to compare groups from different disciplines; this could show how fellows from different research fields react to and interpret policies. Investigating the career paths of mobile researchers and comparing their migratory status could provide insights on the effects of policies in the long-term, as well as the possible indirect effects in the form of transnational networks. Additionally, further works could incorporate evidence from mobility schemes in which return is mandatory. It might be interesting to include these experiences and compare benefits and challenges.

Despite the focus on the social and policy dimensions of international mobility, this research does not investigate gender-based differences within the motivations and patterns of effects of international mobility. Further research should consider detailed attention to the specificities of gender in terms of opportunities, career and working conditions, and decision-making process. This is necessary to understand the factors and mechanisms that shape this phenomenon and its effects.

Although information from the survey was complemented with interviews and documentary analysis, results could only be seen as soft impacts that rely on personal accounts. This limitation is inherent to the qualitative nature of this study and is, in part, mediated by the use of information from different actors to obtain a broader outlook.

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APPENDIX 1 GENERIC INTERVIEW PROTOCOL

A. Benefits of international mobility

1. Please tell me, what is the process of integration of those with postgraduate education abroad in the organisation?

❖ Prompt: How does the organisation hire/recruits these personnel? Does the organisation receive funding when hiring this type of personnel? Who is the funding body?

❖ Prompt: How do you think the organisation benefits when hiring these personnel?

❖ Prompt: In your perspective what are the skills or knowledge that the organisation values in these personnel?

❖ Prompt: Please tell me about the core activities these personnel are hired to perform.

❖ Prompt: Are they hired under the same conditions, and to perform the same activities that does whose education was in domestic institutions?

❖ Prompt: Does the organisation incentives further interactions with the networks that this personnel formed abroad?

❖ Prompt: Can you please tell me about the reason for these incentives, and how do those incentives work, and its outcomes?

2. In your experience and perspective, in what way hiring personnel educated abroad affects the organisation's activities and performance?

❖ Prompt: Can you tell me why or on what experiences do you base this answer?

❖ Prompt: What are the benefits that the organisation seeks and obtains by hiring this personnel?

❖ Prompt: Have those benefits been obtained? How are those benefits capitalised?

❖ Prompt: To what activities are those benefits oriented: industry links, scientific research; international collaboration; entrepreneurship; regional development; development and/or leadership and/or addition to new research areas; technological development; commercialisation of technology?

❖ Prompt: Where can I explore more about these mentioned benefits?

3. Please tell me, does the organisation collaborate with Mexicans who work abroad?

❖ Prompt: What type of links are those: scientific collaboration; technology development; commercialisation of technology; communication channels to be informed about the newest research areas, and technological opportunities.

❖ Prompt: What are the objectives of this links?

❖ Prompt: How are these links established and kept?

❖ Prompt: Does the organisation receive funding to promote this type of links with Mexicans abroad?

❖ Prompt: Can you please tell me more about this funding (objectives, expected outcomes), and what the organisation has achieved through its use?

4. In your perspective, what are the challenges that the organisation faces when trying to hire and capitalise from those that studied abroad?

❖ Prompt: What are the challenges that the organisation faces when hiring personnel who studied abroad?

❖ Prompt: How does the organisation address these challenges?

❖ Prompt: Now, looking at those that studied abroad, in your experience, what are the challenges that you think they face, whether they return or not?

❖ Prompt: Do you think that what they learn abroad can be exploited nationally?

❖ Prompt: What do you believe will improve the process of capitalisation of those who studied abroad, regardless of their migratory status?

5. In your opinion and experience, do you think that hiring personnel who studied abroad and/or keeping links with Mexicans that do not return affects the development of nanotechnology sector?

❖ On what experiences or information do you base your answer?

APPENDIX 2. SURVEY

Introduction

Welcome to this survey on the international mobility of researchers.

This survey is part of the doctoral research that I carry out at the University of Manchester, which aims to understand the effects of doctoral education outside Mexico.

One of the main interests is to review these effects on the field of nanoscience and nanotechnology, where multidisciplinary includes different fields of science. For this reason, if you are Mexican and you carried out your doctoral education abroad between 2006 and the current year. Also, if you are Mexican and are enrolled in a doctoral programme abroad in areas such as chemistry, physics, biology, biotechnology, materials, engineering, nanoscience and nanotechnology, etcetera, your participation is essential to this study.

Completing this survey takes only 15 to 20 minutes. Thank you for your time and participation.

In the final section of this survey, you will be asked whether you are interested and willing to participate in the subsequent interviews that will be conducted to a sample of participants.

Your participation is of the utmost importance and is voluntary. I trust you can answer all the questions and provide as much detail as possible that applies to your case. You have the right to withdraw from the survey at any time.

This project was reviewed and approved by the internal Ethics Committee. All information provided will be treated as confidential and will be used exclusively for this research. The use and protection of the data collected in this survey is the responsibility of the author of this work, and all data is protected by the regulations applicable to the protection of personal data. The information is anonymised for analysis, so no data is associated with the participants.

Any questions or comments regarding the survey and / or research, please write to: mayrismt@gmail.com or mayra.moralestirado@postgrad.mbs.ac.uk

Please support us also by sharing the link to this survey with your colleagues and contacts:
http://mbs.az1.qualtrics.com/jfe/form/SV_38homzPzGpLwFO5

Thank you for your time and input!!

By clicking on the arrow indicating the following ">>" you consent to your participation in this survey

Click on the lower right date to start the survey

Section 1. Personal information (optional)

Notice: All information provided will be anonymised for analysis, and will be used exclusively for the purposes of this research. The information will not be shared with third parties, and its use follows strict guidelines on ethics and confidentiality.

We would use your email to contact you for a possible interview, but participating in this is also optional.

1. Please provide the following information.

- Name (s): ___________
- Last names: ___________
- Email: ___________
- Country of residence: ___________

Section 2. PhD and funding

2. Have you completed your doctoral studies?

   ○ Yes

   ○ No

3. Year of start and completion of the PhD:

   ○ Start year ( )

   ○ Year of completion ( )

4. At the time you applied to your current doctoral programme, did you apply to other universities?

   ○ Yes

   ○ NO
      - Plese, mention the name of the other universities you applied to.

5. Were you a recipient of Conacyt funding during your PhD education?

   ○ Yes (fully-funded)
      - Please mention the main reasons why you applied to the Conacyt scholarship. __________
      - In the hypothetical situation where your application to Conacyt Scholarship Programme had not been successful, what other sources of funds would you have consider? Check all the options that apply to your case.
         - ☐ Apply for external funding sources
         - ☐ Apply for national funding sources (for instance: Fiderh, Educafin)
         - ☐ Use personal resources (for instance: family loans, personal savings)
         - ☐ Apply to a fully-funded foreign doctoral programme
         - ☐Apply to a national doctoral programme national
         - ☐ Do not pursuit a doctorate
         - ☐ Other options, mention all those that you'd have considered

   ○ Yes, (partially-funded)
      - Please mention the main reasons why you applied to Conacyt scholarship Programme. __________
      - What other sources of financial support did you have? __________
      - In the hypothetical situation where your application to Conacyt Scholarship Programme had not been successful, what other sources of funds would you have consider? Check all the options that apply to your case.
         - ☐ Apply for external funding sources
         - ☐ Apply for national funding sources (for instance: Fiderh, Educafin)

▢ Use personal resources (for instance: family loans, personal savings)
▢ Apply to a fully-funded foreign doctoral programme
▢Apply to a national doctoral programme national
▢ Do not pursuit a doctorate
▢ Other options, mention all those that you'd have considered

◯ No
- How did you funded your studies? __________
- Did you apply to Conacyt Scholarship Programme and/or other funding options (national and/or international)
- Please mention the reasons why you applied to those funding options. Example: I applied to Conacyt scholarship Programme because (mention your motivations). Also, I applied to programme X because (mention your motivations)_________________________

6. Country in which your PhD degree was undertaken/completed: __________
7. Name of the institution in which you undertook/completed your PhD : __________
8. Name of department, group, centre or institute: __________
9. Please indicate in order of importance the reasons why you chose this institution to complete your doctorate. Please select 1 for the most important reason and 6 for the least important. Add some other factor that you consider important and does not appear here.

   ______The quality of the doctoral programme

   ______The reputation of the host institution

   ______The reputation of the academic supervisor and the research group

   ______Guided by Conacyt's list of recommended universities

   ______Guided by the suggestion of academic supervisors from my previous training

   ______Other, please specify __________
10. Research field that best describes your research (select form the following options):

◯ Physics

◯ Chemistry

◯ Biology

- ○ Mathematics
- ○ Computer sciences
- ○ Material sciences
- ○ Other, please specify: __________

11. Please briefly describe the lines of research you have engaged with during your doctoral studies (max 300 characters): __________
12. Does your doctoral thesis have any direct practical application or was this theoretical?

- ○ Theoretical work/addressed a fundamental problem
- ○ Made an improvement in a process or technique in my field
- ○ Provided a solution to an industry
- ○ Other, please specify __________

13. Please, indicate your doctoral thesis title:
14. Your doctoral research project was defined by:

- ○ Your supervisor (you came to work on a project that your advisor already had
- ○ For you (from the beginning you proposed your project)
- ○ It is a joint project in which you designed your project based on a problem given by your advisor
- ○ Other, please specify __________

15. Is (was) your doctoral work linked to any industry or other sector project?

- ○ Linked to a project of a company or industry (mention if possible the company and/or industry) __________
- ○ Linked to a project in the public sector (health, education, energy) __________
- ○ Not linked to any sector

Section 3. Studies abroad: motivations and plans for return

16. What benefits (added-value) does pursuing doctoral education abroad bring to your research training? Which of the following aspects do you consider are also offered in the doctoral programmes in Mexico? Please, indicate those that your consider apply best to your situation and add those aspects that you consider relevant and do not appear here.

Aspects	Displayed options

○ Learn and develop new techniques ○ Access and use of equipment and infrastructure ○ Access to border knowledge ○ Development of ideas, products or processes based on research and placed on the market ○ Independence in the development of the thesis work ○ Know how the labour market operates ○ Formulate and apply knowledge to real problems ○ Flexibility to respond quickly and adapt to new conditions ○ Create and work in teams and collaborative networks ○ Know the trends of new technologies, their markets and areas of opportunity ○ Engage in research projects with industry ○ Communicate effectively in another language ○ Work on multidisciplinary projects and teams ○ Others, please specify	Only abroad Also available in Mexico but is better abroad Also available in Mexico with similar quality than abroad Does not apply

17. Was your decision for pursuing doctoral training abroad influenced by the possibility of getting a job abroad when completing your studies?

○ Yes

- Can you please elaborate on why were (are) you planning or were (are) you interested in finding a job abroad (max 500 characters)

- ○ No
- ○ In that moment I did not have a plan for after graduation

18. When you decided and planned to study abroad, were you considering returning to Mexico?
    - ○ Yes, I have always considered or considered to return
    - ○ No, my plan is or was, from the beginning and still, not to return
    - ○ Initially, I did plan to return, but now I prefer to stay abroad
    - ○ Initially, I wanted to stay abroad, now I prefer to return
    - ○ Others, please specify __________

19. Has your initial plan for returning to Mexico changed after your experience abroad? Please, tell us how and the reasons why your plan changed (max 500 characters). __________

20. In the present time, or according to your situation, if you have already completed your doctoral programme, which statements best describe your plan to return or not to return to Mexico? Please, chose for each of the following statements that that best describes your situation, and add the ones you consider important.

Statements	Displayed options
○ I want to return and build a stable career in Mexico	Extremely likely Very likely Somewhat likely Not very likely Not likely at all
○ I might return to Mexico, but I will keep looking for a jobs abroad	
○ I will stay abroad for family reasons	
○ I will return to Mexico for family reasons	
○ I will stay abroad because I have permanent job	
○ I will stay abroad and search for work there	

- ○ I will return to Mexico because I already have a job offer
- ○ I will return to Mexico only if I can't find a job abroad after my studies
- ○ I will return to Mexico because I have a commitment with my employer
- ○ I will stay abroad only for a short extended period after my studies, but then I will return to Mexico
- ○ I will stay abroad even if it takes me a long time to find a job
- ○ I will staying abroad because _____ please fill the blank specifying your reasons to remaining abroad
- ○ I will return to Mexico because _____ please fill the blank specifying your reasons for returning
- ○ If you have another statement that is relevant to your, please tell share it with us, and specify the reasons that drive your decisions to either stay abroad or to return mention (max 300 characters) ________

Section 4. Trajectory after studies

21. Current employment status:

- ○ Employed in Mexico (includes postdoctoral positions and short-term contracts)
  - Describe your experience upon returning to Mexico and entering the labour market. ________
  - Please mention the projects you are involved in in your work________

- Please also specify the reasons why you returned________
- Please tell us about your overall experience upon return. This can include challenges and/or facilities that affected your job seeking experience, research activities, etc. Please, provide as much detail as possible (max 1500 characters) ________

○ Employed abroad (includes postdoctoral positions and short-term contracts)
- Please indicate the reasons why you decided not to return to Mexico ________
- Please mention the projects you are involved in in your work________
- Please mention the collaboration projects or informal links you have with Mexico. Please, provide as much detail as possible (max 1500 characters) ________

○ Unemployed in Mexico
- Describe your experience upon returning to Mexico and entering the labour market. ________
- Please also specify the reasons why you returned________
- Please indicate the sectors in which you are seeking employment (for example, higher education, private sector, entrepreneurship)
- Please tell us about your overall experience upon return. This can include challenges and/or facilities that affected your job seeking experience, research activities, etc. Give as much detail as possible (max 1500 characters) ________

○ Unemployed abroad
- Please indicate the reasons why you decided not to return to Mexico ________
- Please indicate the sectors in which you are seeking employment (for example, higher education, private sector, entrepreneurship) ________
- Please mention the collaboration projects or informal links you have with Mexico. Please, provide as much detail as possible (max 1500 characters) ________

○ Self-employment in Mexico
- Describe your experience upon returning to Mexico and entering the labour market. ________
- Please mention the projects you are involved in in your work________
- Please also specify the reasons why you returned________
- Please tell us about your overall experience upon return. This can include challenges and/or facilities that affected your job seeking experience, research activities, etc. Please, provide as much detail as possible (max 1500 characters) ________

○ Self-employment abroad

- Please indicate the reasons why you decided not to return to Mexico ________
- Please mention the projects you are involved in in your work________
- Please mention the collaboration projects or informal links you have with Mexico. Please, provide as much detail as possible (max 1500 characters) ________

○ Still in doctoral studies
- Does your PhD research work is in the fields of nanoscience and/or nanotechnology?
- If Yes, please mention the area of research or field to which it relates, or describe how it relates.
- No

If still in PhD skip to------*skip to if option operating here*------

22 -- If you have any comments that you would like to share regarding your experience studying abroad, whether it is regarding benefits or challenges faced when arriving, during and after finishing your studies, etc., you can freely share it in this section (max 1500 characters) ________
- If your CV is online, I would greatly appreciate if you can share the link in the box below, or send it to mayrismt@gmail.com, or mayra.moralestirado@postgrad.mbs.ac.uk
- Participation in subsequent interviews. Would you be willing to participate in the interviews that I will conduct as part of the second data collection stage in this research? (Yes, No). Please provide an email address.

Thanks again for your participation!!

----------------------------------Survey ends---------------------------------
-

○ Still in Q21 Other, please specify________

----*skip to if option operating here*------

23 If employed, please mention the following information:

○ Name of employer

○ Position

○ Employed since

- ○ Location of employment (city, state, country)

24 Sector of employment:

- ○ Business enterprise sector
- ○ Government sector
- ○ Higher education sector
- ○ Private non-profit sector
- ○ Other, please specify

Section 5. Mobility added-value

Skipped from question 21 if returned to Mexico

25 Mention what skills, abilities and knowledge you learned during your training abroad and that you have been able to capitalise in Mexico. What aspects do you consider to have been difficult to capitalise on or take advantage of upon return and why? (max 1500 characters) ________

Skipped from question 21 if stayed abroad

26 Do you collaborate or have links with Mexico in any of the following ways? Please select all those that apply to your case.

- ○ I participate in networks of nationals living abroad
- ○ I have a network of colleagues in Mexico
- ○ I stay connected with Mexico by visiting universities, providing training workshops, receiving students that want to do their PhD in this (your place of work) university.
- ○ I have business relationships with national companies, people or universities. Please specify the nature of the projects or activities you have collaborated or are collaborating______
- ○ I collaborate in scientific publications with researchers in Mexico
- ○ I collaborate with national associations in projects. Please specify the nature of the projects or activities you have collaborated or are collaborating______
- ○ Other, please specify the nature of the projects or activities you have collaborated or are collaborating______

Section 6. Professional experience

27 How many jobs have you had after your doctoral training? Please, mention the positions you held, as well as the name of the company or institution where you worked.

28 How long did it take you to find your first job or start your business after your doctoral studies?

29 At the time you obtained your current position or when creating your company, did you have other job options?

- ◯ Yes, please mention the type of position or opportunities you had ______________________________
- ◯ No

30 To how many calls or job positions did you apply before having your current job or creating your company?

- Please mention the name of the call or the position you entered, and the name of the institution (s) where you applied.

____

31 Please indicate the aspects that are valued in your position. Please select the aspects that better apply to your situation and / or add those aspects that apply and do not appear here.

Aspects	Displayed options
◯ Conducting basic Scientific Research ◯ Conducting experimental research ◯ Designing and implementing industrial solutions ◯ Collaborating with private companies in research and development projects ◯ Training human resources ◯ Publishing in top journals ◯ Patenting ◯ Commercialisation of research outputs: licensing patents, creation of knowledge-based companies ◯ Having active participation in collaboration networks ◯ Teaching ◯ Designing interdisciplinary projects	Highly valued Moderately valued Not really valued NA

- ○ Creating and developing state-of-the-art research projects
- ○ Creating new products
- ○ Capacity to adapt fast to changes
- ○ Bringing additional financial resources
- ○ Others, please specify_______

32 Elements that best describe your employment / self-employment. Please select the aspects that better apply to your situation and / or add those aspects that apply and do not appear here.

Elements	Displayed options
○ I had a previous academic or work relationship with my current employer ○ The position requires a doctoral training ○ The position is short-term ○ The position is full time ○ The position is a postdoctoral project ○ The position requires working on the project of an established researcher ○ The position requires publications in journals ○ The position involves proposing and developing my own research project ○ The position is the result of a selection process competed by open call ○ The position is the result of public financing (Conacyt Chairs) ○ The position requires being a SNI member	YES NO NA

- ◯ The position involves collaborating with the private sector
- ◯ The position involved the development of new products or technologies
- ◯ The position requires expertise on intellectual property and technology monitoring
- ◯ I apply to this position while in my doctoral studies _______
- ◯ I'm looking for a better job
- ◯ Others, please specify

33 Do you conduct scientific research activities in your current position?

- ◯ Yes, the highest percentage of my workload
- ◯ Yes, but is not my primary activity in my workload
- ◯ No

Section 7. End

34 Did your PhD research work have any relation to nanoscience and/or nanotechnology?

- Yes, please mention the area of research or field to which it relates, or describe how it relates.
- No

35 Do the activities you currently perform have any relation to nanoscience and/or nanotechnology?

- Yes, please mention the area of research or field to which it relates, or describe how it relates.
- No

36 If you have any comments that you would like to share regarding your experience studying abroad, whether it is regarding benefits or challenges faced when arriving, during and after finishing your studies, etc., you can freely share it in this section (max 1500 characters) _________

- If your CV is online, I would greatly appreciate if you can share the link in the box below, or send it to mayrismt@gmail.com, or mayra.moralestirado@postgrad.mbs.ac.uk

- Participation in subsequent interviews. Would you be willing to participate in the interviews that I will conduct as part of the second data collection stage in this research? (Yes, No). Please provide an email address.

Thanks again for your participation!!

----------------------------------Survey ends---------------------------------