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The risk–reward nexus: A qualitative analysis of public–private partnerships for investments in innovation in Brazil

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Thesis submitted in partial fulfilment of the requirements of the University of Sussex for the degree of Doctor of Philosophy in Science and Technology Policy Studies

November 2019

I hereby declare that this thesis has not and will not be submitted in whole or in part to another University for the award of any other degree.

This is a thesis in paper style. Chapter 1 of this thesis is co-authored with my supervisor Prof. Mariana Mazzucato.

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Doctor of Philosophy in Science and Technology Policy Studies

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SUMMARY

Governments throughout the world are confronted with new challenges, in particular having to reconcile economic growth, sustainability and social inclusion. Tackling these issues requires new forms of collaboration between public and private actors. As such, how can public–private partnerships be effective?

This research addresses the emergence of the state’s active role as a risk-taker and co-investor in technological innovation. The analysis undertaken considers policy issues that arise from public–private partnerships, by focusing on how public actors may directly appropriate financial rewards. From a perspective that views innovation policy as creating markets, experimentation is crucial for shaping equitable partnerships and strengthening the entrepreneurial role of the state. Furthermore, purposeful state action can influence the institutional frameworks within which these partnerships unfold, and favour the realisation of socially desirable policy goals. The interplay between the two – experimentation with partnerships and changes in the institutional environment – is investigated in three papers that are presented as chapters within the thesis.

In Chapter 1 a framework for studying public–private partnerships for investments in innovation is developed. By highlighting the legal dimension of the role of the state in institutional change, the framework includes essential tools that public actors could use for negotiating more equitable reward distribution with business. In chapters 2 and 3 concrete attempts to build investment partnerships in Brazil are examined, focusing on the recent revival of active and explicit industrial policies in the country. Chapter 2 is a comparative analysis of two R&D programmes, oriented towards biofuels and health, which leads to an appraisal of their preliminary outcomes, viewed through the risk–reward nexus lens. Chapter 3 comprises an in-depth case study in the qualities (attributes and functions) of the contracts that enable public actors to appropriate financial rewards of high-risk investments.

Viewed as a whole, these three chapters contribute to the understanding of the legitimisation processes that underlie the role of the state as an investor, by offering a nuanced appreciation of the limits, tensions, possibilities and tools for building effective public–private partnerships. The theoretical and practical insights from this thesis should benefit the design, implementation and assessment of innovation policies geared to tackling contemporary challenges in Brazil and elsewhere.

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relevant research while giving me the pleasure of working with, and learning from, inspiring and committed colleagues, in particular Rainer Kattel, Simone Gasparin and Tiziana Masini.

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policymakers, public officials and business representatives, who were open and willing to share their experiences. The richness of their accounts certainly contributed to my own understanding of the technical and political challenges of dealing with uncertainty and conducting innovation policy.

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sustained me through this long period of intense work. Bella, João and Nina cheered me up all the way. I could not have done it without you all.

Preface

This work had rather ambitious origins. I wanted to organise and integrate the scattered and seemingly chaotic knowledge acquired in the fields in which I have previously graduated, conducted research or acted professionally.

I studied law but felt uneasy with what seemed to me a disconnection between the legal formalism on the one hand, and the concrete problems for which the law sought a solution on the other. I approached this issue by trying to diversify my interests and to explore the interface between the law and other disciplines within the social sciences. In particular, I turned to applied research into the economic and policy implications of intellectual property rights and competition law, and the relationship between the two. At the same time, I started working on capacity building and training courses for civil servants who held a wide range of positions in the State Government of São Paulo (Brazil) – an experience that provided me with a more grounded perspective on policy processes. It was only a few years later, when I joined the Innovation and New Technologies Unit at the United Nations Economic Commission for Latin America and the Caribbean and could combine research, engagement and technical assistance activities, that I realised that STI policy could be an interesting field within which to integrate knowledge and practice from different backgrounds.

The desire to establish myself in this field motivated me to seek further education. Despite many doubts about where to go, a mix of pragmatism, personal interests and good luck led me initially to complete an interdisciplinary master's degree in Law, Science and Technology at Stanford Law School (United States). This course, with its emphasis on intellectual property issues, gave me a glimpse into

a rich body of work, but I was limited in what I could achieve in one year; I therefore looked for an opportunity to pursue a PhD in STI policy studies. By then, consultations with academics, and my contact with Professor Mariana Mazzucato, with whose research approach I had an affinity, convinced me that the Science Policy Research Unit at the University of Sussex (England) was just the right environment within which to pursue studies that would be aimed at problem-solving.

At first, I envisaged I would explore issues around the appropriation of the financial results of publicly funded research and development by focusing on models through which public sponsoring institutions manage intellectual property. This would have allowed me to draw upon my earlier training and practical experience. However, one of my supervisors, Professor Mazzucato, challenged me to think about the appropriation of the rewards of public investment in innovation from a much broader perspective. Among other aspects, this exercise highlighted the existence of a wide range of financing and legal instruments that could enable public organisations to both recoup a share of financial resources and shape an institutional environment more favourable to innovation. I decided to take on the challenge, and I now thank Professor Mazzucato for guiding me down such a thought-provoking path.

That said, I also have to acknowledge the numerous difficulties encountered along the way. My change in direction forced me to explore a topic about which there was scant theoretical and empirical work to which I could resort for guidance. Some of the first problems I encountered lay at the theoretical level. How would I develop a consistent approach to dealing with an eminently practical, complex and wide-ranging issue? Also, how would I integrate the contributions of

different kinds of literature, disciplines and traditions? From the outset, I sensed that the positive role that the state could play in legal and institutional design had not been paid enough attention; rather, it was implied under generic terms such as ‘embeddedness’ and ‘regulation’, or boiled down to ‘institutional bypass’. Although these expressions do describe relevant aspects of reality, they seemed to fall short of explaining the circumstances in which legal and institutional forms were purposefully engineered with a view to achieving chosen policy objectives. At the same time, I was uncertain how I would reconcile the idea of developing an approach that was interdisciplinary while simultaneously trying to clarify what is ‘legal’, thus implying the approach would be within the realm of the law as a discipline. Such boundaries are not evident; they are only construed. Even so, I recognised that each of the disciplines of law and economics offered instruments that would be useful in my goal of understanding and analysing property rights and contractual relationships. I explore these dilemmas in the three papers comprising the main body of this thesis, and in drawing upon them as a whole I have sought to develop an argument that has balance, depth and breadth.

Despite these challenges, my examination of a wide range of literature, and approaches towards changing how we think about concrete problems that are confronted by innovation policy practitioners, has led me to develop tools that have proved useful for empirical analysis and offered insights into the quality of public–private partnerships.

As a reflection on my initial aspirations, having now done this piece of work, the only certainty left is that although I have learned a great deal, I have taken but one step down a long road.

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Abbreviations

BNDES: Brazilian Development Bank

BNDES Profarma: The Brazilian Development Bank's Programme to Support the Development of the Pharmaceutical Industrial Chain

BNDESPAR: Investment arm of the Brazilian Development Bank

CONITEC*: National Committee for Technology Incorporation (Ministry of Health)

CSEM: The Swiss Centre for Electronics and Microtechnology

CSEM Brazil: Brazilian subsidiary of the Swiss Centre for Electronics and Microtechnology

DECISS*: Department of Industrial Complex and Health Service (Ministry of Health)

DoE: US Department of Energy

E2G: Second-Generation Biofuels (ethanol)

FINEP: Brazilian Innovation Agency

FNDCT: Brazilian Science and Technology Development Fund

FUNTEC: The Brazilian Development Bank's Technology Fund

GECIS*: Executive Coordination Group (Ministry of Health)

ICT: Information and communications technologies

IPR: Intellectual property rights

LTCC: Low-Temperature Co-Fired Ceramics

MCTIC*: Ministry of Science, Technology and Communications (former MCTI)

MITI: Ministry of International Trade and Industry (Japan)

MS*: Ministry of Health

OPV: Organic photovoltaics (solar cells)

PAISS: BNDES–FINEP Joint Programme for Supporting Industrial Technological Innovation in the Sugar-based Economy and Sugar-Chemicals Sectors

PDPP: Ministry of Health's Production Development Partnerships Programme

PROALCOOL: National Alcohol Programme

R&D: Research and Development

SITRA: Finnish Innovation Fund

SMEs: Small and Medium Enterprises

STI: Science, Technology and Innovation

SUS: Brazilian Universal Healthcare System

THAI: Hybrid Debenture for Innovation Support (BNDES)

Yozma: Israeli Government initiative launched in 1993 aimed at attracting venture capital through public–private partnerships

* Brazilian organisations.

Introduction

This thesis is the outcome of research undertaken on the emergence of an active role of the state as a risk-taker and co-investor in technological innovation. The focus of my analysis has been on policy initiatives aimed at building public–private partnerships that maintain a nexus between the risks taken and potential rewards appropriated by each actor. The risk–reward nexus is a common notion in finance: the higher the risks of an investment, the higher the reward potential. It is therefore expected that in an investment partnership, the parties will share both the risks of losses and the financial gains of any successful initiative.

By ‘rewards’ appropriated by public investors I mean rewards that arise through direct instruments like royalties, equity stakes, pricing caps, or other conditionalities and, hence, beyond those that come from economic growth and increased tax revenue. While some public funding organisations have experimented with direct instruments – remarkably, development banks in Brazil, China and Germany, but also the Israeli government-launched initiative (Yozma) and the Finnish innovation fund (SITRA), among others – it is clear that some attempts have been more successful than others. In this thesis I delve into the stories behind how some of the successes in building equitable public–private partnerships came about.

In a context dominated by the notion that businesses lead innovation and the state only fixes ‘market failures’, the idea of a risk–reward nexus as part of public investment is hardly questioned. From this standpoint, the relevant analytical problem is often posed as one of striking an optimal balance between private incentives, i.e. private profitability, and social returns, i.e. the benefits that accrue

to society (Nelson 1959; Arrow 1962). Although investments in innovation have no guaranteed return, the social benefits in the equation can be embodied in cheaper and better goods available to consumers, new knowledge, positive externalities, job creation and ultimately economic growth. Besides, such increased economic activity may enable the state to re-appropriate financial gains through tax collection from which, in turn, society will again benefit if such funds are used to supply public goods and services, infrastructure and other factors useful to society.

The emphasis on the quantity of public (and private) investments needed to fulfil the potential for an optimal rate of social return, although being important, overshadows the fact that the risk–reward nexus here is only indirect. This has prompted Mazzucato (2013) to pose the question “can an innovation system based on government support be sustainable without a system of rewards?” (p. 166) and to propose tools that could be used to explore it. In my research I have aimed to extend her work by applying these tools to an in-depth analysis of three case studies.

Another fact that has warranted investigation is that, in addition to having pace, innovation can have more or less inclusive trajectories as regards the appropriation of any incomes and benefits generated. The quality of finance and the partnerships that mobilise the finance are key factors that influence these paths.

Given that governments throughout the world are now confronted with major challenges such as income inequality and climate change, some may argue that the state *should* play a proactive role in solving them, in particular using mission-

oriented policies (Mazzucato 2018). ‘Mission-oriented’ is the term used to describe innovation policies with a broad-based and problem-solving approach, which were implicit in the behaviour of government agencies that had backed important disruptive innovations in the past (Ergas 1986; Foray et al. 2012). While many examples originate from military agencies, such as the internet, cell phones, and satellites, health is another area in which a mission-oriented approach has developed (Sampat 2012). For the purpose of this thesis, it is worth noting that mission-oriented policies can be regarded as an example of a more general policy approach characterised by the pursuit of creating new markets in different directions from those that already exist (Kattel et al. 2018). This type of policy is based on a view of the innovation process as a systemic, rather than linear, phenomenon, and thus involves mobilising actors and resources towards not just basic science but also scaling up and commercialisation throughout the early stages of development. To the extent that public funding moves downstream to the point that the uncertainties gradually give way to risks,¹ there have been calls for public actors to pursue a ‘portfolio’ approach.

In the same way in which large firms diversify their expenditures in research and development (R&D) because they recognise that most of them will fail, public investors would target pre-set problems, seek desirable outcomes and spread risks through different types of R&D collaboration that would be designed to maximise the chances of good outcomes. If such a portfolio were also designed to allow public actors to appropriate any financial gains in case of success, and these gains were used to replenish public funds and for further investment that

¹ In this thesis, I rely on Knight’s distinction between uncertainty and risk: risk is a probabilistic distribution of success or failure, which differs from genuinely uncertain outcomes, where the odds cannot be estimated (Knight 1921).

had a clear public purpose, then hopes for innovation-led and inclusive growth could be realised (Block 2008; Mazzucato 2013; Rodrik 2015). Such an approach implies a direct nexus between risks and rewards (Lazonick & Mazzucato 2013).

Inevitably the dangers of such a course of action do invite caution: public actors may lack implementation know-how; financial appropriation by public actors may attract corruption or disproportionately raise transaction costs and, ultimately, discourage private investment (Windus & Schiffel 1976; Korn & Heinig 2004). In a context in which policymakers are facing increasing pressure to demonstrate performance, all those issues deserve attention and require adequate measures. But the fact is that efforts to build public–private partnerships that are focused on creating new markets and solving concrete economic, environmental and social problems are already being made; some of these initiatives have been quite successful in enabling public actors to share in any earnings through the direct instruments already mentioned.

Because these partnerships materialise in contracts which in turn are an integral part of a broader institutional environment that is largely (but not only) legal, broadening our understanding of how these successes developed in the legal–institutional arena is vital for guiding policy practice. This has motivated my research into the risk–reward nexus. In the three papers that are presented as chapters within this thesis I explore the following overarching question: *How can public–private partnerships be effectively implemented and scaled up to address contemporary societal challenges?*

In the first chapter, co-authored with Professor Mazzucato, we have asked how both the risks of innovation *and* the rewards can be shared between public and

private actors. The discussion and critique of different theoretical approaches have led us to develop a framework that highlights the legal underpinning of the role of the state as an investor. We have also proposed essential tools that public actors can use for structuring financial relationships so as to favour a more direct risk–reward nexus. In the second and third chapters I have examined concrete attempts to implement public–private partnerships, in the context of an emerging economy, where the institutional frameworks for innovation are under construction. In one I have undertaken a comparative analysis of two R&D programmes oriented towards biofuels and health. I have also conducted an appraisal of the preliminary outcomes of these programmes through the lens of the risk–reward nexus. In the other chapter I have explored the qualities (attributes and functions) of the contracts that have enabled public actors to appropriate a direct share of financial rewards in a partnership that was geared towards promoting advanced solar panels.

In what follows, I summarise the issues addressed in the three chapters and draw attention to their main contributions to my thesis.

Socialising the risks *and* rewards of public investments: Economic, policy and legal issues

Concern over contemporary societal challenges has brought renewed interest into the debate about the role of the state in the economy. From a majority view that primarily sees policymaking as limited to correcting market failures arises the need to think about new forms of collaboration between actors in the public and private sectors.

From a 'market-failure' perspective, innovation happens within firms, and the private sector hosts the leading entrepreneurs, given that sector's superiority in organising the production and owning the necessary capital assets. Private entrepreneurs capture value as profits understood as the "rewards for risk-taking" (Samuelson 1997). In contrast, the state plays a secondary role. It only steps in when the idealised market conditions fail, such as in the presence of public goods (e.g. basic research), externalities (e.g. pollution) or asymmetric information (small and medium enterprises – SMEs).

Within this framework, there is little reason for the public sector to worry about the rewards of public investment. So long as public actors stick to a 'fixing' role, and the costs of a government's own failures do not outweigh those of the market (Buchanan 2003), social returns will appear naturally. The assumption is that government funding is rewarded, albeit indirectly, through the natural mechanisms of economic growth, which produces consumer surplus (new, cheaper and better goods), public goods (e.g. new knowledge), spillovers (diffusion), new jobs and, ultimately, increased tax revenues. The tax system is understood as the main route by which the state may recoup any amounts invested and deploy its distributive function.

Whenever the state chooses to go beyond the above instruments of appropriation of social returns – either by changing the baseline within which they operate or by trying to retrieve revenues through alternatives sources to the tax system – it faces high criticism. To understand this, one must grasp the rules underpinning market interactions and the underlying written or implicit contracts on which actors must agree. Contracts "create obligations, allocate risks, and assign ownership rights which relate to the terms and conditions to use an asset, change

its form or substance, and to appropriate the returns arising from it” (Hall 1994, p. 207). From the market-failure perspective, however, the rules under which actors operate are quickly taken for granted (Jensen & Meckling 1976; Williamson 1988a) or seen as constraining their behaviour (North 1990), whereas contracts appear as functional to mitigating the costs of the markets.

The premise that social returns are naturally achieved through economic growth can be questioned not by seeing the problems as aberrations, but rather as direct implications of the limited theoretical framework regarding the role of the state in the economy. Indeed, in her book *The Entrepreneurial State*, Mazzucato (2013) has aimed at debunking the myths behind the dichotomy between the public and private sectors, by uncovering a far more active, dynamic and close engagement of public actors in financing business innovation. The contrast between this hidden reality and the abstract conceptualisation of the role of the state as a ‘fixer’, ‘de-risker’ or ‘facilitator’ (which stems from neoclassical economics) has triggered efforts to develop an alternative framework for policy.

Drawing on studies on mission-oriented R&D, evolutionary theory, the developmental state and the entrepreneurial state, Mazzucato (2016) has contemplated that in circumstances in which the state plays an active role, innovation policies *co-create and shape* markets, besides fixing them. Accordingly, the kinds of markets that emerge can, and should, be the result of conscious actions by policymakers.

In an earlier study, Lazonick and Mazzucato (2013) explained how the neglect of the collective nature of the innovation process, in which the state takes a vital part, has led to a dysfunctional risk–reward nexus. While the risks of investments

are socialised, the rewards are privatised, which contributes to income inequality. On the one hand, in the light of increased deregulation and financialisation, private actors have accumulated powers to successfully lobby for measures that have enabled them to appropriate, in different ways, more value than their contributions could have generated on their own. On the other hand, by widening the market frontiers, the institutional reforms of the 1980s and 1990s have also weakened states' ability to resist.

The focus on the source of the risk–reward breakdown, although essential as a basis for the formulation of policy responses, does not allow us to deepen our understanding of how efforts in the opposite direction – i.e. to socialise both the risks and rewards of innovation – may develop and eventually lead to success. Despite that, the (tacit) recognition that power relations shaping financial appropriation also express themselves in the legal domain leads to an interesting path that deserves exploration. That path is followed in this thesis.

In the first paper (Chapter 1), the question is posed: *How can both the risks of innovation and the rewards be shared between public and private actors?* The issue has been addressed from a theoretical point of view. The review of the different theoretical approaches, their discussion and critique, have led to the formulation of a framework that highlights the legal dimension as a crucial aspect of the analysis of the possibilities for developing effective and equitable public–private partnerships. Building on the market co-creation and shaping framework for policy (Mazzucato 2016), the state emerges as active in this process. At the same time, attention to the legal dimension has allowed us to study how, even in the context of real constraints, the state may be able to fulfil its role of promoting innovation where private actors lack the motivation or tools to do so.

From the angle of legal institutionalism (Deakin et al. 2017) – from which we derive a view of the law as both a concept and an instrument – building a risk–reward nexus in public–private partnerships appears as a rather experimental process. It may very well be that the actors involved do not know what to do from the outset, nor how. And yet by exploration, trial and error, public actors can learn and accumulate the powers needed to negotiate better deals with supported businesses. Without a doubt, the possibility of experimentation also depends on the framework conditions under which the partnerships take place. Nevertheless, these also can be subject to changes and steered towards socially desirable policy goals. Thus, in this regard, our position on how the state shapes the context and outcomes of innovation policy has converged with evolutionary theory (Nelson & Winter 1982) and Rodrik's view on policymaking as a discovery process (Rodrik 2014).

By broadening the view on the role of the state as a contract-maker and enabler of institutional change, the chapter contributes to expanding those studies on innovation policies that rely on public–private investment partnerships. It also promotes the understanding of how public actors might seek to appropriate a share of any rewards of supported innovations, beyond those that come from economic growth and increased tax revenue, for the sake of adding effectiveness and legitimacy to their investments. Furthermore, in the chapter we have highlighted the variety within two sets of legal instruments – profit-sharing and conditionalities – that could assist policymakers in the design, implementation and assessment of a portfolio approach to public investments oriented towards tackling societal challenges.

The market co-creating and shaping role of the state: Insights from the Brazilian experience

In recent years, there has been growing academic interest in examining actual experiences of implementation of mission-oriented policy initiatives. The special issue of *Research Policy* edited by Foray et al. (2012), explicitly concerned with the need to develop new policy instruments, brought contributions from areas as diverse as health (Sampat 2012), renewable energy (Anadón 2012), agriculture (Wright 2012) and defence (Mowery 2012). In general, the few studies that proceed to comparative analysis refer to variations in the goals pursued, governance mechanisms and institutional structures as responsible for differences in the implementation of public–private partnerships (Foray et al. 2012). However, they do not question the quality of the risk–reward nexus, especially regarding the appropriation of potential financial rewards by public actors. As a result, despite an increase in case studies, that concept has yet to be operationalised.

In the second paper of the thesis (Chapter 2) I have sought to address this gap via two routes: (i) an analysis of the implementation of public–private investment partnerships in real R&D programmes, and (ii) an assessment of their preliminary outcomes in the light of the concept of the risk–reward nexus.

With the focus being on one country, it is implicit that the case study is based on the idea that although globalisation has homogenising and pervasive features in several respects, fundamental national differences persist in the forms of organising and governing state–market relations. Indeed, as the literature on varieties of capitalism suggests (Hall & Soskice 2001), wealthy countries in the West can be roughly characterised as liberal markets (such as the USA and the

UK) or coordinated economies (for instance Germany). Nevertheless, elsewhere in emerging and developing economies, it is often the state that takes on the role of driving economic activity (among others, Brazil, China, India and Indonesia), which some have regarded as a state-led type of capitalism (Bremmer 2009). It is plausible to assume that variations in such structural features carry consequences for the challenges and opportunities for experiments in the field of innovation policies. Empirical studies of the incipient steps towards undertaking mission-oriented initiatives in emerging and developing countries – where, as mentioned above, the state explicitly embraces such an active role – although scant, are of particular interest, as these offer opportunities to look more clearly at the economic, political and institutional dynamics.

In this regard, Brazil is a thought-provoking illustration. The import substitution model that led to the industrialisation of the country in the 1970s also imposed significant constraints on domestic capacities to promote technical change. Consequently, a pattern of foreign-owned enterprises and innovations of low level of knowledge intensity – and, thus, involving investments of low or no risk – came to prevail. With the structural reforms and opening of the market in the 1990s, it was expected that companies would change their behaviour and become more entrepreneurial (World Bank 1991). However, that did not happen. Private investments in R&D declined, and the pre-existing pattern was reinforced. The 2000s mark the rise of active policy measures adopted by the federal government, under the idea that the state needs to become an investor and risk-taker so that companies can follow a similar path. This, in turn, required significant efforts in institutional building and legal design. There were attempts to create risk-sharing financing instruments, and parameters for their implementation, as

well as establishing instruments that enabled public actors to share in any rewards achieved because successes were known to be occasional. In short, Brazil illustrates the gradual change from neither the private nor the public sector accepting the risks of innovation, to the rise of partnerships between the two (that do accept the risks), upon the initiative of the state.

The chance to undertake an in-depth study of this process opened up possibilities for me to gain theoretical and practical insights into how mission-oriented innovation policies could develop and spread. The lessons from the Brazilian experience may be useful, in the first place, for those countries where the state explicitly aims to embrace such a strategic stand.

A comprehensive comparative case study was therefore the main analytical tool adopted, and two R&D programmes were examined: (i) the *BNDES–FINEP Joint Programme for Supporting Industrial Technological Innovation in the Sugar-based Economy and Sugar-Chemicals Sectors* (PAISS); and (ii) the *Ministry of Health’s Production Development Partnerships Programme* (PDPP). Interviews with science, technology and innovation (STI) policymakers revealed that these programmes were considered path-breaking in introducing features of mission-driven policies in the country, as well as positive experiences in building public–private partnerships (Mazzucato & Penna 2016a). In addition, these programmes cover areas of high societal benefit potential, including biofuels and health. For these reasons, the programmes were particularly apt for exploring the risk–reward nexus, and the interplay between experimentation with partnerships on the one hand, and changes in the legal and institutional frameworks on the other.

The theoretical approach presented in the first chapter enabled me to develop principles which I could then apply to an empirical investigation of the risk–reward nexus. It gave rise to five categories of analysis, which in turn I have translated into the following guiding questions: *(i) What are the programmes' motivations and aims? (ii) Who takes the lead, the private or public sector? (iii) What legal and institutional changes enable implementation? (iv) How do federal funding agencies seek to increase and manage the risks taken? (v) How is an equitable sharing of rewards pursued?*

The primary data source for study was a set of interviews (51) with a wide range of subjects from the public and private sectors; all interviewees had been involved in projects or situations relevant to the study, and some held leadership positions. The interviews enabled me to understand certain nuances in the policy process and to capture perceptions about the creation of policy instruments that allow for a direct risk–reward nexus. They revealed, for example, that at this point, Brazilian policymakers were more concerned with enabling the state to take risks than with ensuring it could appropriate a financial reward in the event of success.

Furthermore, the results provided empirical support to our initial framework. In particular, the data indicated that public funding actors have: (i) seized mapped opportunities in areas of high social benefit; (ii) taken the leadership; (iii) engaged in risk-sharing and institutional building; (iv) pursued risk diversification and competition to mitigate the risks; and (v) sought an equitable sharing of rewards, through profit-sharing instruments (both programmes resorted to equity stakes in supported companies and new financing instruments) and conditionalities (only in the programme oriented towards the health sector). In contrast, the assessment exercise regarding the risk–reward nexus, based on the preliminary

results of the programmes, showed that while public risk-taking had played a catalytic function, there were limitations in the investment partnerships and in the instruments adopted for sharing the rewards.

My analysis of these experiences in Brazil has enabled me to develop insights into an understudied, but essential, aspect of the implementation of innovation policies in which the state takes on an active role: the risk–reward nexus. Furthermore, as well as corroborating prior theoretical studies, my analysis has also indicated where further research is needed in order to appreciate better those local versus global dynamics that also affect risk–reward distributions.

Public risks rewarded: Lessons from contract design in public investments in innovation

Public–private investment partnerships materialise in contracts that allocate risks and assign rights to the appropriation of any arising rewards. These contracts also provide structure to, and guide, social and economic behaviour, and yet they are rarely the subject of empirical analysis in innovation policy studies. Nonetheless, it is reasonable to assume that actors in the public sector who invest in innovation accumulate experiences in contract-making that will contain useful lessons for others involved in promoting innovation, but if not studied, these experiences will be lost. In the third and final paper of this thesis (Chapter 3) I have attempted to take a step towards filling this void.

With this aim in mind, my starting point was a review of the literature on contracts and insights developed in the first chapter, in which I have focused on the importance of the legal dimension in understanding the dynamics of experimentation with partnerships and institutional change.

In the contract literature (predominantly rooted in neoclassical economic theory), analysis of the structural characteristics of contracts, such as their decision-making mechanisms, compensation and monitoring schemes, is often based on the degree to which these control agency problems (Fama 1990; Kaplan & Strömberg 2004; Cumming 2008). From this perspective, attributes such as predictability, efficiency and security are desirable if contracts are to play their primary function as cost-mitigating devices that ultimately serve the purpose of correcting market failures.

In this chapter, I conjecture that within an alternative framework that rests on a different theoretical background and incorporates the notion that innovation policy co-creates and shapes markets, contracts would have additional characteristics. This gave rise to the following research question: *What attributes and emerging functions of contracts enable a move from a situation where the parties do not share any rewards, to another that facilitates the construction of a balanced risk–reward nexus?*

As this is a first attempt to operationalise the concept of the risk–reward nexus proposed by Lazonick and Mazzucato (2013) in the analysis of contracts, an in-depth case study has been chosen as the main research method.

According to Baldwin and Davis (2003, p. 881), “empirical research in law involves the study, through direct methods rather than secondary sources, of the institutions, rules, procedures, and personnel of the law, with a view to understanding how they operate and what effects they have.” However, legal scholarship shows a preference for conducting close textual analysis of legal material (Genn et al. 2006; Korkea-aho & Leino-Sandberg 2019). Interviews are

rather uncommon in legal research, in contrast to the social sciences, where they are widely employed as an effective data collection technique to elicit information on political and social phenomena (Webley 2010).

Because this thesis builds upon the literature on institutionalism in which the law is viewed within a broad social, political and economic context (Hodgson 2015; Deakin et al. 2017), in this third chapter my methodological approach has been to combine document analysis with interviews. The latter allowed me to take into account the experiences and perceptions of the actors involved in the contracting process.

For the reasons explained above, Brazil seemed to present an interesting geographical focus. Furthermore, the breadth and depth of the interviews conducted during fieldwork pointed to the partnership between the state-owned Brazilian Development Bank (BNDES), and the Brazilian subsidiary of the private, non-profit Swiss Centre for Electronics and Microtechnology (CSEM Brazil), as the only instance known at the federal level to involve the conversion of a non-reimbursable instrument into another that enabled the sharing of financial rewards. Therefore it offered a unique opportunity to move beyond document analysis and gain the insights into the actors involved. Putting this another way, it allowed me to study how the law is 'in action' rather than simply how it is in 'the books' (Halperin 2011). Other than that, two additional facts indicated that the study could promote a better understanding of public-private investment partnerships, which could be useful for guiding future mission-oriented innovation policies. First, the case in question involved investments in renewable energy, namely, second-generation solar panels, and hence was related to environmental challenges. Second, the parties themselves recognised the investment

partnership as being a positive experience. This opened up the possibility of learning about issues around legitimisation. Against this background, the case was selected for in-depth examination.

Through my exploration of the relationship between public–private partnerships and the context in which they take place, I have offered an interpretation of the attributes and functions of contracts from the perspective of public actors who decide to take the risks of innovation and share in the potential rewards. The attributes and functions found distinguish some of the contracts that had been devised to allow a direct nexus to be established between the risks and rewards of public investments: the attributes are flexibility and ambiguity; the functions are leveraging, legitimisation and preservation. Taken together, these features make it possible to identify the experimental nature of contract design and negotiation. However, in the analysis presented in the chapter I also demonstrate that there are significant constraints against a one-off experiment being rolled out into an institutionalised practice. I conclude the study by reflecting on this duality and by drawing out the implications for building effective and legitimate public–private partnerships in which both the risks and rewards are shared.

Overall, the chapter is a useful addition to the literature on the risk–reward nexus because its findings make explicit the relationships between contracts and their context. I have shown some of the challenges and opportunities for enabling an active role of the state to develop; furthermore, I have described the features of contracts underpinning public–private investment partnerships – attributes and functions – found in connection with a rationale for policy concerned with creating and shaping markets. Such features suggest a complementarity with those found under a market-failure framework for policy. The chapter also provides empirical

evidence on the instruments that have been developed to allow the state to appropriate a direct share of financial rewards.

Chapter 1 Socialising the risks and rewards of public investments: Economic, policy and legal issues

Andrea Laplane and Mariana Mazzucato²

Abstract³

In this chapter we develop a framework for analysing the role of public agencies in making high-risk investments along the innovation chain and ask how both the risks of innovation *and* the rewards can be shared between public and private actors. We build on a new approach to innovation policy, which we call *market co-creating and shaping*, in which the state is not only fixing markets but also actively co-creating them. We also look at the legal institutions that influence (and are influenced by) the relationship between public and private actors. Policy measures to institutionalise rewards in a way that promotes more equitable public–private partnerships can be understood as attempts to mediate asymmetric power relations, tensions and conflicting views among multiple stakeholders, as well as building a shared notion of the value and legitimacy of the role of the state. We conclude by outlining analytical and policy implications and identifying avenues for future research.

1.1 Introduction

The last fifty years have witnessed the emergence of several disruptive technological innovations – from information and communication technologies (ICT) to biotech and, more recently, renewable energy – that have involved profound institutional changes and brought unprecedented levels of value creation. In this process, the idea that innovation is led by private entrepreneurs

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³ A slightly modified version of this chapter has been published in the *IIPP Working Paper Series* (cited in chapters 2 and 3 as Laplane and Mazzucato (2019)) and submitted to *Research Policy* in 9 June 2019 (currently under review).

who benefit from publicly funded infrastructure and research due to the presence of ‘market failures’ has prevailed as a guide for innovation policy.⁴

This view has justified the notion that business deserves to capture a large portion of the value of innovation as profits. From a societal standpoint, as long as adequate framework conditions were in place, the advantages of optimal levels of public spending in R&D (i.e. confined to fixing markets) were apparent. This approach would naturally bring about ‘social returns’ such as better quality and cheaper goods and services (‘consumer surplus’), job creation and public goods (such as new knowledge), ultimately resulting in economic growth and positive fiscal impact.

As direct public funding increasingly moves from basic research towards the later stages of R&D and commercialisation – where the risks of technological and commercial failure are high but so are the expected financial rewards in the event of success – it begins to defy the economic rationale underlying private appropriability. Following the 2008 financial bailouts in particular, a key question raised was whether governments would continue socialising the risks of investments, while rewards were privatised (Mazzucato 2013). With the ICT-based technological revolution turning growing income inequality into a significant contemporary challenge (Piketty 2017), the debate on the distribution of rewards of public investments has become all the more urgent.

⁴ We use ‘innovation policy’ broadly to mean policies that have a significant effect on innovation (Edler & Fagerberg 2017). Innovation is defined in Schumpeterian terms as new combinations of existing knowledge, capabilities and resources brought into the market, thus distinguishing them from mere inventions (Schumpeter 1934). Using this definition, innovation policy in some respects overlaps with what may be called ‘technology policy’ or ‘industrial policy’. However, we consider that industrial policy is broader in scope (see, for instance, Andreoni and Chang (2019)).

Meanwhile, fierce competition for budgetary funds and rising pressure on public bodies to be more effective and accountable have led to some rather timid attempts at policy responses. In the United States, the original text of the Bayh-Dole Act from the 1980s established an obligation for companies whose products benefited from the results of publicly funded research to pay back a share of their profits to the Treasury (Herder 2008). While this particular effort did not translate into law, other institutional innovations and new financing instruments enabling public–private partnerships to share both risks and rewards started to appear there and elsewhere.

Attempts to obtain a more equitable agreement between actors in public and private sectors who contribute to the innovation process have coexisted with other initiatives seeking to steer and target more tangible economic and social benefits. Though still incipient, public agencies' efforts to increase the strings attached to the use of public funds, including conditions on accessible prices, R&D collaboration and open science (Mowery 2009), reinvestment in R&D, and local production, reflect an increasing desire for a more concrete social return on investment than that assumed under a market-failure framework.

Nevertheless, only a few authors have examined governments' initiatives to capture a share of both the financial gains and the more compelling benefits to society beyond those that come from growth and hence increased tax revenue (Enke 1967; Windus & Schiffel 1976; Korn & Heinig 2004; Herder 2008; Sampat & Lichtenberg 2011). Most importantly, sporadic attempts to find a coherent economic rationale for government recoupment of financial rewards – as in Windus and Schiffel (1976) – have lacked a framework that acknowledges and

links these problems explicitly. Therefore, up to now policymakers have found only poor or indeed no guidance.

Lazonick and Mazzucato (2013) made an important step towards filling this gap. They offered a comprehensive framework which they named the ‘risk–reward nexus’ for use in investigating the relationship between innovation and inequality. Their main argument was that the collective, cumulative and inherently uncertain nature of innovation processes enables the dissociation between the risks taken and rewards realised by different types of economic actors – workers, citizens (represented by the state) and shareholders. The authors focused on strategies that allow financial actors to position themselves along the innovation chain and extract more value than their contributions could have generated on their own, at the expense of the other actors.

This chapter complements that study by looking at the relationship between the role of the state as an investor and the extent to which public funding agencies attempt to reap a share of financial rewards realised in partnerships with business. This analysis builds on a new framework – market co-creating and shaping – in which the state is a leading actor and entrepreneur working in close collaboration with the private sector and is therefore endogenous to economic processes (Mazzucato 2013; 2016). We adopt a perspective that highlights the constitutive role of the state, in the institutional shaping of market relations, society and the state itself, which some academics have referred to as ‘legal institutionalism’ (Hodgson 2015; Deakin et al. 2017). This approach makes it possible to go beyond the notion of legal rules and contracts as background incentives for profit-maximising agents, and to assess their quality in terms of the potential for shifting the nature, goals or meanings of economic activity and

organisation to deliver increased wellbeing (Stryker 2003). Bringing these economic and legal angles together creates a richer understanding of the complexities, complementarities and tensions underlying the dynamics of public–private partnerships concerning risk-and-reward distributions.

In this chapter, our aims are two-fold. One is to develop analytical tools that help to frame and systematise challenging aspects of contemporary innovation policy related to the risk–reward nexus. By conceptualising the institutionalisation of reward structures as a social, legal and political process – rather than an optimal end-point – the new framework should help researchers and decision-makers identify some of the relevant dilemmas. The second aim is to advance knowledge that can guide better policy practices and tools towards socialising the risks and rewards of public investments, to promote inclusive, innovation-led growth. Hence, this framework operates at the level of a mid-range theory akin to policy guidance, as opposed to abstract or general theory (George & Bennett 2005).

In Section 2.2 we review the market-failure approach to innovation policy and its main shortcomings. In Section 2.3 we introduce three bodies of literature that lay the foundations for a new approach, these being (i) the developmental state, (ii) legal institutionalism and (iii) the entrepreneurial state. We consider the role of legal institutions underpinning economic structures, showing that legal and economic action and institutional design are interdependent. New functions of legal rules and contractual relationships become apparent in the co-creation and shaping of markets and the underlying power relations. In Section 2.4 we ask how the state can capture a share of the rewards, on behalf of citizens, that better reflects its lead role as a risk-taker. In Section 2.5 we conclude by outlining analytical and policy implications, and areas for future research.

1.2 The market-failure approach to innovation policy and its main shortcomings

Within the neoclassical economic framework, innovation policy is viewed as fit for correcting market failures, stemming from the notion that ‘free’ market interactions play a prominent role in the economy. The production function is the conceptual model of value creation within firms, wherein the use of labour and capital inputs produces new products and services. As the primary organiser of production and owner of the capital assets involved, the private sector is the leading entrepreneur. Government’s role is to guarantee the necessary conditions for markets to operate and to intervene in the economy to correct ‘market failures’.

Regarding innovation, market failures involve under- or over-investment by business. A classic example refers to the ‘public good’ nature of basic research, which offers insufficient incentives for firms to invest given the high spillover effects, making it difficult to appropriate returns (Nelson 1959; Arrow 1962). There is also asymmetric or incomplete information in the financial markets, which increases the cost for firms – especially SMEs – to finance R&D (Hall & Lerner 2010). Eventually, investments in certain areas exceed desirable levels, for instance, when negative externalities take place – such as those created by patent races, pollution or traffic congestion (Stiglitz 2000). The government’s direct financing has a limited role in fixing those problems and should focus on scientific research and SMEs. As public funding moves downstream, it receives more criticism, because, in theory, late spillover effects are not as significant as those that occur early on, and companies are in a better position to capture returns.

The expectation of achieving high rewards through public funding is vital for legitimising innovation policy. However, the accepted instruments for the state to appropriate rewards tend to be limited. The assumption is that government's role in fixing markets naturally generates a return through welfare increases and economic growth. As a result, the benefits to society – the 'social returns' – are new and better goods at reduced prices for consumers, 'public good' provision, knowledge spillovers and new jobs. Also, these benefits reflect a positive fiscal position. Supposing that supported companies and individuals pay their due taxes, then increased economic activity contributes to increased tax collection (one of the primary mechanisms through which the state recoups a financial gain). While imperfections may block or reduce the optimal social rate of return, these are, again, just imperfections for government to fix. In short, because this approach is based upon the perception that public funding is a passive tool for boosting private entrepreneurship, governments tend to pay insufficient attention to how to appropriate the rewards of public investment.

Implicit here is also a limited view on the role of the state regarding the rules underpinning market interactions and the underlying written or informal contracts on which actors must agree. These rules and contracts are crucial, however, as they ultimately define reward distributions between public and private actors. Assuming that economic exchanges only happen among private owners, the state appears as an external entity responsible for the rule of law. It helps the market system operate at its best by ensuring robust and stable institutions through well-defined property rights and rigorous contract enforcement (Posner 2014).

Accepting that only one set of rules maximises economic welfare – by definition these are ‘the best’ – (Coase 1960), economic analyses of contractual relationships have mostly taken the underlying rules as given. Consequently, according to the literature on new institutional economics, the role of government, operating through courts, is at best limited to seeking efficient or aligned incentive structures that enable shareholder maximisation and transaction cost mitigation (Jensen & Meckling 1976). At worst, the state is almost irrelevant and ineffective in filling gaps, correcting contractual errors or settling any arising disputes (Williamson 1988a). Even when the rules of the game are admittedly endogenous, the political, economic and social contexts reduce manoeuvring room (North 1990). Therefore, any policy guidance that is derived from this approach will deal with removing legal barriers and strengthening the incentives for profit-maximising entrepreneurs.

The market-failure framework for innovation policy has attracted significant criticism. The ‘systems of innovation’ literature qualifies that while substantial innovations happen within firms, they depend on a complex network of actors, institutions and interactions that influence the rate and pattern of knowledge creation and diffusion across the economy (Lundvall 1992; Freeman 1995). Neo-Schumpeterian and evolutionary theory has highlighted what is omitted from neoclassical economics. Neoclassical economics examines existing landscapes (markets, sectors or technologies) and existing trajectories (whether firms are investing too little or too much in a given area), thus overlooking the dynamic and cumulative process through which new landscapes and trajectories come about (Dosi 1982). It also neglects the range of actors and particularly the role of state-

owned financial institutions that contribute to changing them, and this is an area which has been receiving increased attention (Mazzucato & Penna 2016b).

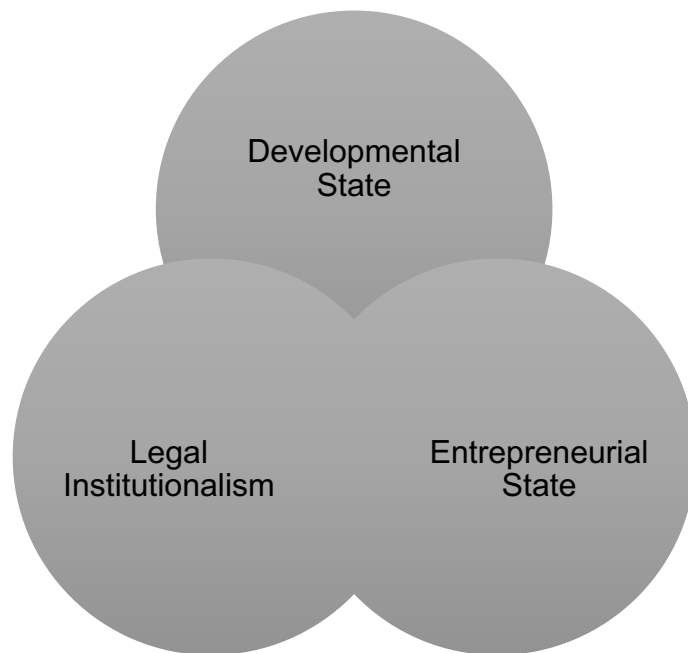
A significant shortcoming of the market-failure approach, in the context of the present chapter, is the passive role attributed to public finance (Perez 2003; Mazzucato 2013). This has meant that the approach does not include the possibility of having an array of mechanisms, beyond taxation, that public agencies may deploy in order to recoup a direct share of financial rewards of investments downstream. Examples include royalties on intellectual property rights (IPR) or sales and equity stakes on supported firms. A related problem is the neglect of the state's influence on the rules and contracts that underpin public–private partnerships, through legislators, regulators, courts (Pistor 2009; Hodgson 2015; Deakin et al. 2017) and funding agencies themselves (Mowery 2009; Mazzucato 2013; Hockett & Omarova 2014). These shortcomings suggest the need for a new conceptual framework for innovation policy that extends the justification for public funding. Such a framework must take into account the risks taken by state actors, the legal grounds and procedures for them, and the legal instruments adopted for capturing rewards.

1.3 Towards a new framework: market co-creating and shaping

Three bodies of literature lay the foundations for a new approach for policy. These are on (i) the developmental state, (ii) legal institutionalism and (iii) the entrepreneurial state (Figure 1.1): the first draws on Karl Polanyi's insights on the nature of markets as socially embedded, stressing the active and endogenous role of the state in economic transformations (Polanyi 1944); the second disentangles the collective processes through which legal arrangements frame,

influence and sustain the organisation of the economy and the state; the third sheds light on the risk-taking role of public actors as a driver of the rate and direction of innovation.

Figure 1.1 *The building blocks of the market co-creating and shaping framework*



Source: Own elaboration

Bridging these complementary and sometimes overlapping bodies of literature allows for a richer understanding of the complexities, complementarities, tensions and power relations underlying the dynamics of public–private interactions in innovation. On this basis, the market itself becomes an outcome to which the state, operating through multiple actors, makes a vital contribution (Mazzucato 2016).

1.3.1 The developmental state

In his description of the emergence of capitalism, Polanyi emphasises that policies are not 'interventions', and that markets are embedded in social and political institutions, and largely influenced by them (Polanyi 1944; Evans 1995). Studies on the developmental state have conceptualised and documented such an intrinsic and active state leading profound transformations, such as those involved in the development of emerging East Asian economies (see Johnson (1982), Amsden (1989), Wade (1990), Woo-Cumings (1999) and Chang (1999)).

The concept of the developmental state was pioneered by Johnson in his book on the 'Japanese miracle' (Johnson 1982) in which he characterised the role the state played in fostering the high growth of the Japanese economy in the twentieth century. His central argument was that the successful economic performance of Japan owed a great deal to conscious and persistent government policies focused on economic development. This 'visible hand' acted as a capital provider and coordinator of industrialisation and technical change processes.

Johnson's book was followed by other studies in which analysis of the developmental state was extended to different Asian contexts: for example, Amsden (1989) investigated the case of South Korea; Wade (1990) examined the case of Taiwan; and Weiss and Hobson (1995) conducted a comparative analysis of Japan, Korea and Taiwan. This body of work has served to emphasise that the success of policy implementation in the countries studied can be largely attributed to the institutionalised structures that allowed for continuous dialogue and exchange of information between their governments and their business sectors.

On this subject, Evans (1995) put forward the concept of ‘embedded autonomy’, explaining that in order to accomplish its developmental mission a government needs to maintain both roots in society (i.e. remain accountable) and some degree of autonomy (i.e. be able to impose its own will against vested interests). This idea, coupled with a theoretical understanding that state capabilities to govern industrial transformation vary (Weiss 1998), remains valid in the most recent studies on the developmental state.

This literature has expanded into the concept of a developmental network state, exposing the often hidden activity of public agencies that also governs change in advanced economies (Ó Riain 2004; Block 2008; Block & Keller 2011). While past industrialisation experiences were about imitation and adaptation of existing technologies, the contemporary model puts innovation – R&D and commercialisation – at the centre of competitive strategies. High-tech booms in countries like Israel, Taiwan, Ireland and the United States exemplify policies encouraging activities that were not being done at all, working as devices to revitalise the economy.

Another distinctive feature refers to the decentralised, ‘networked’ and flexible structures on which government relies (Ó Riain 2004), rather than the top-down, centralised organisation exemplified by the Ministry of International Trade and Industry (MITI) in Japan. Various types of public agencies operate by engaging in direct and close partnerships with businesses (Block & Keller 2011). Public officials who have a problem-solving focus perform a range of activities that do not fit under the market-failure framework: targeting resources in promising areas; opening windows that enable support for other innovations; brokerage; and facilitation (such as providing infrastructure and standards). Such proactive

stances can enable the creation of new networks of collaboration, or stimulate those that already exist. Hence, they are key to the accumulation and diffusion of knowledge that drives technological change (Block 2008, pp. 172–179).

1.3.2 Legal institutionalism

Drawing on various traditions,⁵ emerging studies serve to restore the view on legal institutions – including the state – as playing a central, constitutive role in capitalist societies and as a source of power (Hodgson 2015). The term ‘legal institutionalism’ has been used to refer to this approach, which is still dispersed in the literature and does not yet incorporate a fully structured theory (Deakin et al. 2017), but it does offer useful insights on the interrelations between legal and economic processes, policy and social change, otherwise obscured under the notion of ‘embeddedness.’

From this perspective, legal arrangements that structure markets and other institutions are outcomes rather than natural circumstances. The interactions of legislators, courts and policymakers with a broader group of actors, including firms and civil society, are indispensable for sustaining legal rights and obligations. This is partly because the effectiveness of those arrangements also lies in shared norms and values informing perceptions regarding their reasonableness, fairness and compliance with established rules (Commons 1959). Enabling participation is important for legitimation in democratic environments. Legal institutionalism emphasises that this interplay between state-dependent and spontaneous legal developments (contingent on private

⁵ The sources of inspiration range from legally grounded institutional analyses e.g. Commons (1959) and Samuels (1989) – see Deakin et al. (2017) – to contemporary institutional political economy studies e.g. Chang (2002) and Chang and Evans (2005) – see Coutinho (2017).

interactions, culture and custom) underpins essential institutions within capitalism, such as property, money, contracts, corporations and markets (Hodgson 2015). If law plays an integral part in capitalist societies, the potential for shifting the nature, goals or meanings of economic activity, and achieving enhanced equality, also have an expression in the legal sphere (Stryker 2003).

This view implies a crucial conceptual distinction. Law is part of institutionalised power structures, but it is also an instrument for the exercise of power and an expression of power itself (Deakin et al. 2017); it is not just the mirror image of pre-existing power relations. The state's power is manifested through the actions of public officials in the executive, legislative and judicial branches, which, under well-grounded rules of their time, make decisions that define policies and assign legal rights (Commons 1959).

Similarly, the process of setting up systems of substantive rules, contracts, procedures, routines and practices institutionalises policy goals. However, formalisation is imperfect because there are always gaps between written rules, their interpretation and practice. The outcomes of state policy and legal choices are not neutral; they fit different purposes, benefit particular interests, and frame which economic (among other) performances are to be pursued (Samuels 1989).⁶ Consequently, legal processes themselves become the arena of conflict and power relations, unravelling through negotiation, bargaining and compromising (Pistor 2009).

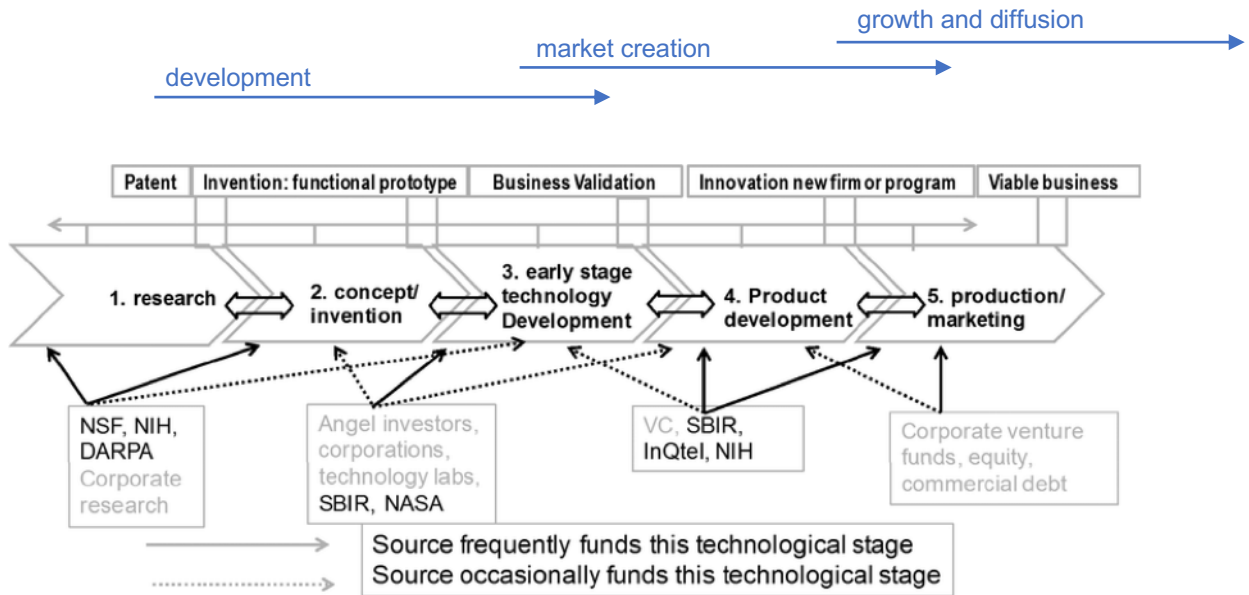
⁶ In this regard, legal institutionalism is consistent with the political economists' remarks that the promotion of economic development requires institutions to fulfil specific functions, which are better served by certain institutional forms (Andreoni & Chang 2019).

A central contribution of legal institutionalism is to conceive of the opportunities for advancing policy agendas as associated with participation in law-making, regulation and contracts. This is a view in which it is claimed that law can (and must) be subject to intentional operationalisation geared towards framing adequate and legitimate institutional arrangements in public policies (Coutinho 2017). It follows that the scope for shifting power relations in the economy largely depends on (public) actors discovering how to effectively use the law to advance their goals (Deakin et al. 2017). Therefore, successful policies are also contingent upon experimentation in the legal domain.

1.3.3 The entrepreneurial state

Research on the entrepreneurial state challenges the received wisdom that business is the only risk-taker (Mazzucato 2013). It builds on scholarship on industry dynamics, which offers a more refined view of entrepreneurial phenomena, distinguishing progressive and regressive characteristics affecting the entry of new firms to industry and performance (Vivarelli 2013). Firms act as profit-seekers driven by expectations about future opportunities that become clearer as the innovation process unfolds (O'Sullivan 2006). Recognising that public investments are a trigger for economic and technological opportunities, Mazzucato (2013; 2016) has drawn attention to the roles that different types of public actors and public finance may play in the risk landscape (Figure 1.2).

Figure 1.2 Sources of public and private finance along the innovation chain (United States)



Source: Authors adaptation of underlying figure by Auerswald and Brascomb (2003). NSF, National Science Foundation; NIH, National Institutes of Health; DARPA, Defence Advanced Research Projects Agency; SBIR, Small Business Innovation Research Programme; NASA, National Aeronautics and Space Administration; InQtel (venture capital firm funded by the CIA Central Intelligence Agency).

The concept of ‘entrepreneurial state’ refers to the public sector’s “willingness to invest in, and sometimes imagine from the beginning, new high-risk areas before the private sector does” (Mazzucato 2016, p. 149). It supports an interpretation of the history of most of the important contemporary technological breakthroughs, by showing that strategic public investments often arrive early, absorbing major uncertainties and long-term risks. They ultimately enable new industries to be taken over by business only once profits are apparent. Examples include the ICT revolution (Block & Keller 2011), the biotech industry (Lazonick & Tulum 2011; Vallas et al. 2011), and emerging renewable energy technologies (Mazzucato & Semieniuk 2017).

As far back as the 1930s, Schumpeter (1934) considered that new markets created through innovation depended on inventiveness (creating ‘new

combinations'), entrepreneurship (envisioning business opportunities and bringing inventions to market) and capital (providing finance so entrepreneurs could control the production factors needed). Noting that these roles may not necessarily be conflated in the same individual or entity, Schumpeter made it clear that financiers are those who put their capital at risk, not entrepreneurs as such.⁷ Therefore, in Schumpeterian terms, especially in the initial capital-intensive stages of technology development, the state is a leading financier in contemporary market economies, acting both as a capitalist (who is a risk-taker) and an entrepreneur (who is opportunity-driven). In light of this, Mazzucato (2016) has argued that the role of the state is better understood as co-creating and shaping markets, and not only fixing them.

Further insights derived from mission-oriented R&D literature indicate that public risk-taking has a pervasive space dimension. Public funding spans the entire innovation chain, reaching both the supply-side – from fundamental to applied research and early-stage financing of companies downstream – and the demand-side (Mowery 2009; Foray et al. 2012). Public resources operated in this way may play a catalytic role if, beyond direct funding, policymakers embrace a systemic approach that includes complementary measures such as regulation and taxes (Ergas 1986).

Analysis of the entrepreneurial state leads to the argument that neglect of the nature of public investments has created a pattern of socialising risks while privatising rewards, preventing innovation policy from realising its full potential (Lazonick & Mazzucato 2013). In turn, acknowledging state risk-taking implies

⁷ As Schumpeter (1934) stressed, even when entrepreneurs invest their own resources in R&D, they absorb the risks of failure in the capacity of financiers, not entrepreneurs.

accepting that most attempts to create new businesses are likely to fail. Occasional successes come through trial and error. As a result, academics have pointed to the advantages of conceiving a portfolio of long-term public investments so the state can also benefit from the potential financial rewards (Stiglitz & Wallsten 1999; Block 2008; Mazzucato 2013; Rodrik 2015), recover from losses and continue to fund further rounds.

1.3.4 The legal–institutional dimension of market co-creating and shaping

Attention to the institutional and legal foundations of markets can reveal an essential dimension of policymaking, implementation and assessment. Legal institutionalism sheds light on state agencies' ability to create, change, use and sustain legal rules, procedures and contracts that contribute to socially desirable and democratically legitimised innovation policy objectives. Admitting that institutionalisation is the product not only of state design, but also of shared norms and values at a point in time, this approach makes it possible to consider those legitimisation processes that underlie a risk-taking state. Thus, the conditions for enabling adequate institutional alternatives and consensus-building become more important than determining the constraints on market creation and shaping.

Consistent with the above, a dynamic and context-dependent analysis of the different forms and functions of legal and institutional arrangements takes priority over a static comparison with the best set of rules for optimal markets. Such analysis provides for a more nuanced appreciation of the limits, tensions and possibilities of public and private collaboration throughout the innovation and policy processes. Integrating these ideas into this new framework opens the way for new analytical tools that can be used to deal with real-world policy challenges,

such as the potential mismatches between the risks taken and rewards realised by actors participating in public–private partnerships.

1.4 Socialising the risks and rewards of public investment: elements for a portfolio approach

The allocation of risks and rewards in public–private partnerships offers a unique lens through which to observe the division of innovative labour, perceptions about the ‘failure’ and ‘success’ of public investments, and expected returns. It makes it possible to look into actual mechanisms whereby the state, on behalf of citizens, seeks to reap a share of the financial rewards and use other instruments to appropriate returns that go beyond the prescriptions of market-failure theory. Nevertheless, certain limitations need to be recognised, given that public and private contributions are closely intertwined (Nelson 2005).

Because innovation is inherently uncertain, and investments have no guaranteed return, enhancing public control over any arising rewards is a necessary condition for legitimising the state’s role in creating and shaping markets. Within a framework that sees public agencies as capable of absorbing high technological and market risks, there is a valid expectation that the fruits of successful public finance will serve the taxpayer and therefore provide a rationale for also socialising the financial rewards achieved (Lazonick & Mazzucato 2013).

Market-failure theory assumes that the state already recoups rewards via job creation, knowledge spillovers, increased living standards and tax revenues. However, it ignores concrete limitations in those mechanisms. Patents granted broadly and upstream end up blocking or slowing down knowledge spillovers, either of which can harm follow-up innovations (Mazzoleni & Nelson 1998).

Similarly, when companies avoid or evade tax payment, the state is unlikely to reap enough fiscal surplus to enable its redistributive function. Furthermore, the mainstream approach has no explanation for a variety of instruments that public agencies eventually consider in seeking to link risks and financial rewards. A market co-creating and shaping approach incorporates the view that these government initiatives are an intrinsic dimension of the investment process and strategy.

As this framework focuses on innovation policy that is oriented towards critical societal needs, the socialisation of rewards can be understood as an attempt to balance financial returns and broader economic and social benefits. Thus, the framework enables a distinction to be made between two sets of complementary, yet sometimes conflicting, practical measures: profit-sharing and conditionalities.

1.4.1 Profit-sharing policy instruments

In neoclassical economics, business profits often mean the “rewards for innovation and risk-taking” (Samuelson 1997). Conversely, if the state plays a lead entrepreneurial (investor-of-first-resort) role, it would be reasonable for public agencies to share in the profits. Claiming a share of the financial gains of public investments, beyond taxation, makes it possible to compensate for the inevitable losses (given the high uncertainties involved) and continue to invest in future innovation. Therefore, it could help to create a revolving fund, as in the case of private venture capital portfolios.

One advantage of profit-sharing mechanisms over taxation concerns the potential for attaining a more stable source of public funding and having a higher impact on the direction of innovation. A revolving fund allows public agencies to enhance

their discretion over, and independence from, highly competitive budget funds. Another advantage is that governments can design and manage the recoupment of revenues more flexibly than they could through taxes. Besides being essential for the alignment of private and public actors' interests, flexibility prevents harm being done to supported firms (Enke 1967). Moreover, having the state retain a share of business profits arising from successful innovations is an essential instrument for building consensus around the public sector's role and performance (Windus & Schiffel 1976). As a public portfolio leaves a traceable record of supported projects and firms, and gains and losses, it also offers an objective measure of success against which public managers can be held to account (Mazzucato 2016).

Failure of public funding, for any reason, is often considered indicative of an inability to 'pick winners' or 'distortion' of (otherwise optimal) markets (Owen 2012). Yet many of the successes go unnoticed and even result in public rewards being privatised. The US Department of Energy (DoE) attracted criticism for providing a guaranteed loan of \$528 million to the solar-power start-up company Solyndra, which went bankrupt once the price of silicon chips fell dramatically, leaving taxpayers to pick up the bill (Wood 2012). However, few critics acknowledged that a similar guaranteed loan (\$465 million) supported Tesla for the development of the Model S electric car, which led to success; even fewer have ever questioned why the government accepted early payment of the underlying loan (earning \$12 million back) instead of negotiating stock options that could have been worth almost \$1.4 billion, according to some estimates (Woolley 2013). Had the DoE chosen the stock options, the royalties retained could have not only covered the Solyndra losses many times over but also been

used to continue to fund promising ventures (Mazzucato 2013), signalling the importance of the government's high-risk funding for achieving renewable energy technologies.

The above example also exposes the set of strategic decisions that policymakers face regarding the selection of profit-sharing mechanisms suitable for each context. Table 1.1 illustrates how the design of financing instruments for supporting innovation downstream (first and second columns) entails choices regarding how and to what extent public investors may be able to capture financial rewards (third and fourth columns).

Table 1.1 Existing policy instruments for financing innovation that allow for profit-sharing (selected examples)

Financing instruments	Types	Key features	Returns to funding agency	Some country examples
Debt financing	Repayable grants/ Advances	Repayment required, partial or total; could be granted on the basis of private co-funding	Royalties of IP licensing or levy on sales	Repayment grants for start-ups from 2014 to 2016 (New Zealand)
Debt/equity financing	Mezzanine funding	Combination of several financing instruments that incorporate elements of debt and equity in a single investment vehicle	Interest rates plus spread	Credit line mezzanine financing (Portugal)
Equity financing	Venture capital funds and fund of funds ⁸	Funds provided by institutional investors (e.g. banks, pension funds) to be invested in firms at early-to-expansion stages; referred to as patient capital, due to lengthy time span for exiting (10 to 12 years)	Equity stakes	Innpulsa (Colombia), National Innovation Fund – Venture Capital Fund (Czech Rep.), Corporate Venture Programme (France), Yozma Fund (Israel), Scottish Co-Investment Fund (UK)
Public procurement for R&D and innovation		Demand for technologies or services that do not exist yet; or purchase of R&D services (pre-commercial procurement of R&D)	IPR of research results; agency can opt to shift ownership to contractors and establish licensing conditions	Entrepreneur Growth Strategy (Estonia), Strategy for Public Procurement (Sweden), Small Business Innovation Research (SBIR) Program (US) and SBIR-type of programmes (UK)

Source: Authors' adaptation of OECD (2014; 2016)

⁸ Fund of funds – also known as ‘multi-manager’ funds – are those comprising investments in a range of other funds controlled by different asset managers. Financial Times Lexicon, retrieved from: http://markets.ft.com/research/Lexicon/Term?term=multi_manager-fund. Last accessed on 9 November 2019.

Profit-sharing mechanisms may include: repayable grants with profit-sharing via royalties on sales or equity stakes; public venture capital funds enabling royalties on equity; debt financing convertible into equity; and other sorts of fund-mixing elements of equity and debt (OECD 2014). Hence, besides the timing for the public sector to reap any rewards, a critical distinction concerns the revenue basis upon which public and private actors agree to share, ranging from a low-value basis (IPR) to high-value (capital gains), as the Solyndra versus Tesla case illustrates.

Although state-owned banks adopt many of these instruments, the market-failure approach often takes them as distortions. From a market co-creating and shaping perspective, public financial institutions are authentic mechanisms for socialising the risks and rewards of investments (Mazzucato 2013). By definition, banks are structured to operate with an expectation of return and to manage their investments through a portfolio approach. They retain equity when running venture capital support while eventually benefiting from windfall gains, as corroborated by evidence on state-owned banks in Brazil, China and Germany (Mazzucato & Penna 2016b). Alternatively, even less risky investments ensure a reward; for example, when involving loans or corporate bonds. Furthermore, for state-owned banks typically operating a wide range of financing instruments, it is plausible to assume that they are also in a privileged position to innovate in the design of those instruments so as to compensate for the risks absorbed, with proportional financial rewards. Using a market co-creating and shaping framework ensures that questions are asked about what lessons can be drawn from development banks to help the broader range of public agencies that fund innovation to develop a coherent portfolio approach.

A related concern is the types of structures of the state apparatus and governance schemes that are appropriate for delivering desirable outcomes. While there are analytical gains in assessing the risk–reward nexus in public–private partnerships, further thinking is required on the possible safeguards to mitigate policy risks. One key issue in this regard is how to ensure a recouping state does not shy away from reinvesting with a clear public purpose.

1.4.2 Policy instruments involving conditionalities

Recognising the importance of balancing risks and financial rewards does not mean neglecting the core objective of innovation policy, which is to generate tangible economic and social benefits. A market co-creating and shaping framework departs from the premise that social returns will naturally emerge and shed new light on actual institutional designs, policies and practices that contribute to a productive environment for innovation. In this context, typical industrial policy measures such as conditionalities tied to the allocation of public funds can be understood as active attempts to enable innovation to flourish while steering benefits directly to society. Examples of such conditionalities are the pricing of final goods and services, knowledge governance and reinvestment in innovation and local production, and these are discussed below.

Pricing. Supported innovations, especially essential public goods and services, must be affordable and accessible to fulfil an investor-of-first-resort role for the state. Otherwise, taxpayers may end up paying the taxes that enable public investment in R&D and infrastructure, and again for high prices when these downplay the state’s contribution to the former (Alperovitz & Daly 2009). Pricing regulations for monopolistic industries of the kind enacted as a law in the United

States, but not yet implemented, can mitigate this problem. The 1980 Bayh-Dole Act includes a pricing cap provision named ‘march-in rights.’⁹ This rule provides public agencies that supported an invention with powers to license it to a third party if, among other causes, the patent-holder does not take steps to achieve practical use. An example of the rule in action is that the requirement on the practical application of research results regarding new drugs that benefited from public funding demands ‘reasonable’ (accessible and affordable) prices (Davis & Arno 2001).

Knowledge governance. The term ‘knowledge governance’ has been used to describe the coordination of policy mechanisms into a broader strategic goal of positively influencing the rates and directions of knowledge accumulation (Burlamaqui 2012; Burlamaqui & Cimoli 2014). This approach finds support in the history of mission-driven public finance, which shows that the creation and diffusion of knowledge in priority areas were not spontaneous, but heavily reliant on the decisions of public funding agencies. The US military sector illustrates that the use of public procurement can furnish the government with leverage that enables it to steer the development of strategic technologies under an open science and collaborative environment (Mowery 2009). Ensuring that information was available and accessible, procurement stimulated dynamic and persistent exchanges among and within multiple organisations, favouring learning and high spillover effects. In any case, the scope for positive spillover depends on the stage of technology development – declining as technologies mature – and the

⁹ 35 US Code § 203 (‘March-in rights’).

design of missions and projects in question: the more sectors involved, the higher the synergies (Mazzucato 2018).

Reinvestment. Instead of assuming that economic growth and job creation will ensue, a market co-creating and shaping approach sees the materialisation of those expectations as associated with the sustainability of investments in innovation and local production. If business profits are hoarded or mainly used for short-term, low-risk and high-return financialisation purposes, the expected effect on employment will be reduced. This interpretation offers a foundation for steering business investments into productive economic activities. A real alternative is to enforce regulations establishing obligations for firms to reinvest in innovation. Since the late 1990s, Brazil has implemented legislation mandating public and private companies in previously privatised sectors to reinvest a share of their profits into public R&D funds.¹⁰ A similar obligation gave rise to Bell Labs when US antitrust authorities ordered AT&T to invest in R&D in order to continue benefiting from a telephone industry monopoly. There is also plentiful evidence of governments taking a more active stance towards local manufacturing, which was closely linked to the opportunities for job creation. Furthermore, the Bayh-Dole Act brought a requirement for products embodying the results of publicly funded R&D to be manufactured substantially in the United States.¹¹

Other conditions. Baumol's (1990) work on the different types of entrepreneurship showed that encouraging 'productive' activities may not be

¹⁰ Law 11540/07 enacted the National Science and Technology Development Fund (FNDCT) and sectoral R&D funds while establishing a mandatory requirement for profit reinvestment in R&D in selected areas.

¹¹ 35 US Code § 204 ('Preference for United States industry').

enough to deter or block those that are 'destructive'. In this regard, recognising that the state can act as a leading investor gives new meaning to initiatives to protect and manage its (capital and intangible) assets; however, such initiatives do not fit in a market-failure framework. Managers of public venture capital funds, like their private counterparts, contemplate the option of upholding preferred stocks or golden shares in individual firms as a way of protecting state-owned capital assets. Preferred stocks ensure priority in the receipt of dividends, high rates and warrants, whereas a golden share empowers the vetoing of key corporate events (mergers, liquidations, asset sales, etc.) when these are deemed detrimental to society. The UK government has widely adopted both types of measures to avoid hostile takeovers of privatised firms and foreign companies gaining full control (Jones et al. 1999). However, in the context of active entrepreneurial states, such measures have received renewed attention, as has the protection and management of intangible assets held in the public sector. Because of the UK government's industrial strategy, the Treasury has published a report on this matter (HM Treasury 2018).

As the literature on the entrepreneurial state and various academics propose, the mix of profit-sharing policy instruments and those involving conditionalities can be re-interpreted as incipient, often ad hoc attempts to fulfil the reward function of a portfolio approach to public funding. By analogy with business management practices, seeing public investments as a bundle, instead of individual units, means spreading the risk across individual programmes, R&D projects, directions of search and types of firms, enabling exploration of multiple pathways while enhancing the chances of success (Stiglitz & Wallsten 1999; Mazzucato 2013). Our framework highlights the importance of diversifying not just risks, but also

reward mechanisms, thus moving beyond the market-failure approach and providing decision-makers with core elements with which to devise a portfolio strategy. This makes it possible to assess these practices more systematically and derive lessons that are relevant to developing better policies.

1.4.3 The legal and institutional foundations of symbiotic ecosystems

So far, the analysis has indicated economic reasons for balancing risks and rewards of public investments, showing that they involve, among other factors, the mobilisation of resources in the legal domain, for example, through attempted changes in legal rules and contracts. At this point, it is useful to widen the view of the role of legal institutions in the economy and society. The fact that their development is dependent on state powers adds to the explanation of how and to what extent the socialisation of risks and rewards will occur.

One consequence of the market co-creating and shaping framework is that attention on exchanges among private owners shifts to market interactions, especially public–private partnerships for financing innovation. Accordingly, the relevant analytical and policy problem regarding the functions of underlying contracts and rules is the extent to which an institutional environment favours and sustains widespread collaboration, dynamism and market creation. The equity of the distribution of rewards of public–private partnerships and the rules that fit that purpose are essential dimensions of that process.

Research on developmental states and legal institutionalism points towards the risk–reward nexus being a social, political and legal construction, whereby the state plays an active and constitutive role (Polanyi 1944; Evans 1995; Deakin et al. 2017). The framework makes it possible to locate the decisions regarding the

adoption of profit-sharing policy instruments and conditionalities in the dynamics and tensions among state powers, within and across public organisations, and, in between these, the private sector and citizens. In this way, the framework goes beyond emphasising the importance of stability, clarity and predictability of the rules underpinning economic activity as devices for mitigating uncertainties: it indicates that signalling values such as trust and fairness are functions that the law should undertake. Therefore, an institutional environment only supports the risk–reward nexus of public–private partnerships when the key stakeholders perceive it as such.

Rather than natural or neutral, as construed in neoclassical economics, legal and institutional frameworks mediate private and public appropriation of rewards. In this sense, the ‘winner takes all’ mindset results from political and legal choices, as illustrated by high-tech industries in the United States. Besides the changes in IPR legislation, the emergence of a special court to handle patent appeals meant that courts could play an active role. However, it is debatable whether expanding patent subject matters into living organisms was necessary for attracting business into biotech (Eisenberg 2006). In ICT, judges and regulators loosened copyrights and privacy regulations – justified by freedom of speech but resulting in a *de facto* industrial policy (Chander 2013). Similarly, publicly funded activities in defence and aerospace, such as those targeting low-Earth orbit, seem to be moving towards expanded private appropriability (Mazzucato & Robinson 2018), along with efforts to create more equitable public–private partnerships.

To the extent that financial relations involve power, the outcomes depend on the unfolding of negotiations, bargaining and compromising (Pistor 2009). The Bayh-

Dole Act originally contained a provision that entitled the US Treasury to recoup a share of the profits realised upon publicly funded research, but only above a certain threshold. Nevertheless, this provision was removed due to the economic downturn, political reasons and concerns regarding the bureaucratic costs of implementation (Herder 2008). In contrast, Israel exemplifies an investor-of-first-resort state that co-evolves with legal and institutional structures that enable public rewards to be enhanced. The Innovation Law of 1984 requires successfully supported projects to repay royalties on sales to the Innovation Authority. Israel is also famous for the positive experience of the government's performance as a venture capitalist through the Yozma Fund, which yielded returns via equity (Avnimelech 2009). These various arrangements across and within countries reinforce the need to deepen the knowledge on the instruments appropriate for each context which can then be applied to support strategic decision-making.

While one could interpret some of these policies using market-failure theory (for example, asymmetric information causing incomplete contracts among private actors), it is hard to justify the bureaucratic burden of profit-sharing contracts involving venture capital or royalties purely on those grounds. The function-based approach to systems of innovation offers a more useful explanation, underscoring legitimisation processes as a prerequisite for the emergence of new technology innovation systems (Bergek et al. 2008). However, the focus on individual technologies, and on the premise that business drives innovation offers a limited opportunity for analysis of the challenges for leading public agencies to shape how their role as investors can be legitimated. A market-co-creating and shaping framework sheds light on the development of this role, because within it is the

concept that governments' efforts to build more equitable public–private partnerships are an integral part of legitimacy-building.

Mazzucato (2013) has distinguished between two ideal types of innovation ecosystems – symbiotic and parasitic. Derived from a comparison to biological communities, the term 'innovation ecosystem' is used to describe the functionality of the economic dynamics of the network of relationships between the multiple actors and institutions collaborating for the purposes of R&D and innovation. The term complements the notion of 'systems of innovation' by highlighting the nature of those relationships. An innovation ecosystem is symbiotic if it is rooted in mutually beneficial legal relationships, in which increased profits accruing from innovation enable public and private investors to replenish funds and continue to invest in new rounds (Mazzucato 2013). A crucial ingredient is the perception that the environment at stake is virtuous and equitable. A parasitic ecosystem is rooted in legal relationships in which one actor benefits at the expense of the others. It tends to expand the private appropriability of financial gains obtained with public support, thus favouring 'winner takes all'. The symbiotic/parasitic dichotomy is useful in any analysis of current systems and for informing the direction of change.

Table 1.2 summarises the features of formal rules and contracts sustaining symbiotic and parasitic ecosystems. While the contrast suggests two opposite poles, the reality is more complicated. Between the two, there is a continuum of hybrid ecosystems rooted in public–private contractual relationships that combine the two types. Hence, one can consider a hypothetical spectrum of change between the two extremes.

Table 1.2 Features of the legal underpinning of the distribution of rewards in public–private partnerships: parasitic versus symbiotic ecosystems (selected examples of how public actors can capture rewards)

	Parasitic	Symbiotic
Risk–reward nexus	Imbalanced Favouring private appropriability	Balanced Favouring public appropriability
Private appropriation	Rewards captured as profits and capital gains (increase in asset value), but they lead to ‘winner takes all’	Profits and capital gains still relevant, but shared more equitably among actors who contributed to the innovation process
Public appropriation	Passive	Active
Via conditionalities (legal measures to ensure tangible benefits to society)	<p>Rewards are natural, spontaneous and gradually accrued from competition through:</p> <ul style="list-style-type: none"> ▪ Improved living standards for consumers; ▪ Diffused benefits of ‘public good’ provision and positive externalities; ▪ Knowledge creation and spillovers; ▪ Job creation 	<p>Rewards targeted, steered and sustained through conditionalities on:</p> <ul style="list-style-type: none"> ▪ Pricing controls for public goods/services (access and affordability to all); ▪ Targeted, mission-driven benefits (qualitative requirements for ‘public good’ provision); ▪ Knowledge governance (access to and diffusion of the crucial knowledge for tackling societal challenges); ▪ Local manufacturing to stimulate productive entrepreneurship and job creation within the country/region; ▪ Profit reinvestment on R&D to continuously stimulate productive investments and virtuous ecosystems; ▪ Avoidance or blocking of dilution/liquidation of state-owned capital assets (preferred stocks, golden shares etc.)

	Parasitic	Symbiotic
<i>Via profit-sharing</i> (legal measures to enhance financial rewards to the state)	Limited to the taxation of profits or capital gains	Beyond taxation, financial rewards recouped via: <ul style="list-style-type: none"> ▪ Reimbursement of public funds (partial or total); ▪ Public sharing of profits (e.g. royalties, levies on sales); ▪ Public sharing of capital gains (e.g. equity convertible bonds or hybrid financing instruments mixing equity and debt)
Legal framework	Allows public funding and assumes recoupment will follow	<ul style="list-style-type: none"> ▪ Allows public funding plus recoupment (via conditionalities and profit-sharing); ▪ Allows public funding and makes recoupment mandatory

Source: Own elaboration

The concrete examples in this section indicate limits and possibilities for state action institutionalising, through the law, more equitable reward structures. Such examples are a start towards identifying the conditions that encourage symbiotic ecosystems. Analysis of these and other experiences could lead to useful lessons for public agencies in how to design new policy instruments and shape symbiotic relationships. After all, experimentation is crucial to the accumulation of the powers to do this effectively.

1.5 Conclusion, main implications and areas for future research

In this chapter we have presented a new approach to innovation policy that complements the market-failure rationale. Public investments are at the centre of the innovation process because of their role in co-creating and shaping markets with businesses. Also, legal rules, procedures and contracts play a constitutive role and the state's action is strategic for steering the institutional environment in those directions that allow for the realisation of socially desirable policy goals. By making explicit the leading role of the state as an investor and enabler of institutional change, this approach allows public funding agencies to be conceived of as actors entitled to seek to appropriate a share of the rewards of the innovations to which they contribute. In other words, it becomes possible to understand and analyse how governments, when acting along the innovation chain, may attempt to socialise both the risks and rewards of public investments – a question that has been only narrowly considered under a market-failure framework. The analytical and policy implications suggest interesting avenues for future research.

Recognition of the risk-taking entrepreneurial role of the state provides initial justification for public funding agencies' attempts to recoup some of the financial rewards realised, beyond taxation. Sharing rewards with private actors enables a more 'portfolio' mindset – where the upside is used to cover the downside – and more stable funding to serve citizens' needs. Furthermore, emphasis on the legal–institutional dimension sheds light on additional functions for measures such as royalties, equity stakes, pricing-capping mechanisms or other conditionalities, that remain invisible in the mainstream approach. In democratic societies, these can be understood as a means of attempting to balance asymmetric power relations, tensions and conflicting views among multiple stakeholders, while building a shared notion of the value and legitimacy of the state. On the basis of this conception, in this chapter we have refined the notion of innovation ecosystems in terms of the risk–reward nexus in public–private partnerships. While accepted equitable agreements lay the foundations for symbiotic ecosystems, those that are parasitic encourage 'winner takes all' at the expense of society.

We have identified two sets of legal measures through which public agencies could seek an adequate return on investment. Profit-sharing enables recoupment of potential financial gains in proportion to the risks undertaken. Conditionalities target tangible benefits to society regarding the pricing of essential goods and services, access to and diffusion of new knowledge, job creation, etc. Although not meant to be exhaustive, this distinction reveals several legal instruments and practices fitting the two broad types of measures, instead of a 'one-size-fits-all' approach. This aspect highlights an opportunity for further thinking on new instruments – and corresponding governance schemes – capable of ensuring

that the state, representing the public, has the possibility of capturing a fair share of rewards. Pursuing a better understanding of the functioning of and interactions between those measures in governments' policy mixes may also be worthwhile.

The legal–political processes that influence the institutionalisation of initiatives to socialise rewards offer another way of grasping the complexity behind risk-and-reward distributions. Recognising that these processes are intertwined, and that the state power is intrinsic to them, uncovers key challenges. Consensus-building takes time and effort, as it involves multiple actors, asymmetric powers, different interests and actors operating under various rules etc. Potential solutions will not always work: they reflect the possible agreement. Thus, experimentation, learning and flexibility are critical for institutional and legal design.

The benefits of advancing a market co-creating and shaping framework for innovation policy seem clear in the face of contemporary societal challenges. While empirical studies could help to enrich and expand the analytical tools discussed in this chapter, this new approach also offers guiding principles for policy design, implementation and evaluation.

First, our analysis suggests the importance of improving the targets of public investments so as to develop a clear public purpose and to state expected benefits to society through defining missions, goals and measures of progress. Extending the use of mission-oriented initiatives, and nurturing the capabilities to do so, are important for legitimising a risk-taking state; however, also required are adequate institutional mechanisms to enable open and broad participation in deliberations regarding the directions of change (Stirling 2008).

Second, the framework indicates the advantages of pursuing a portfolio approach to structure long-term public investments, as it allows public agencies to spread the risks while ensuring an upside in the event of success that could provide for a continuous funding source. A direct nexus between risks and rewards is instrumental in forming and managing a portfolio. Thus, policymakers should aim to develop a strategy for achieving a risk–reward nexus, which defines priorities and brings coherence to the measures to recoup rewards while keeping in view their public missions.

Third, the framework emphasises the importance of contemplating the design of legal and institutional structures that underpin an equitable sharing of rewards between actors in the public and private sectors, as part of the process of market creation and shaping. Public agencies should be allowed to come close to the private sector and explore the different legal instruments available, in order to identify which are more appropriate for building symbiotic partnerships. As well as encouraging creativity, this may involve raising awareness of, and negotiating with, actors in the state legal apparatus, such as legislators, regulators, judges and auditing bodies.

Together, the above-mentioned aspects suggest the need to promote the development and accumulation of capabilities in the public sector. Empowering governments to design, implement and assess practices for dealing with the risk–reward nexus is the key to shifting the contemporary pattern of socialising the risks while privatising the rewards. Only appropriate capacity building can invigorate hopes for inclusive, innovation-led growth.

One avenue for future research is to explore relevant criteria for taking forward the taxonomy of the risk–reward nexus in innovation ecosystems. Also, undertaking case studies and in-depth empirical research could help illuminate market co-creating and shaping initiatives, and whether and how these co-evolve with the construction of virtuous ecosystems. Such research could also help explain the situations in which legal structures and framings enable equitable public–private partnerships. Drawing the relevant lessons from existing experiences should contribute towards building a richer evidence base which can then be used to inform decision-making and better practices.

Chapter 2 The market co-creating and shaping role of the state: Insights from the Brazilian experience

Abstract¹²

This chapter documents the incipient emergence of an active role of the state in Brazil that has been oriented towards creating and shaping markets through strategic investments in innovation. It draws on a comparative analysis of two case studies of federal funding programmes: the *BNDES–FINEP Joint Programme for Supporting Industrial Technological Innovation in the Sugar-based Economy and Sugar-Chemicals Sectors* (PAISS), and the *Ministry of Health’s Production Development Partnerships Programme* (PDPP). The study finds evidence of the programmes of five dimensions of effective public–private partnerships, these being that public funding agencies (i) seized mapped opportunities; (ii) took the lead; (iii) engaged in risk-sharing and institutional building; (iv) pursued risk diversification and competition; and (v) sought an equitable sharing of rewards. While public risk-taking has played a catalytic function, its limitations and those regarding the appropriation of rewards became apparent. After discussing the main policy implications I reflect on the specific challenges for building equitable public–private partnerships in the light of the increasingly competitive and global scope of the economy.

2.1 Introduction

Governments around the world are confronted with new challenges, in particular having to reconcile economic growth, sustainability and inclusion. In this context, and markedly since the 2008 financial crisis, they have increasingly turned to innovation policies in response. Innovation policies, as an integral part of industrial policies, have historically been the subject of heated discussion about the positive and negative aspects of the active role of the state in the economy.

¹² I would like to thank the two anonymous referees of the *SPRU Working Paper Series* and Manuel Gonzalo (National University of General Sarmiento, Argentina) for constructive comments on earlier drafts.

Although there are different views in this debate, one of the practical ways being sought to steer the directions of innovation has been through mission-oriented policies (EC 2018).

A mission-oriented approach can be associated with those initiatives that in the past have mobilised actors and sectors across the economy around the attainment of specific objectives – typically in the defence sector, but not limited to it (Ergas 1986). Since then, important lessons from the accumulated experience have been drawn (Foray et al. 2012; Mowery 2012; Mazzucato 2018). Also, there have been efforts to build up and systematise an evidence base and integrate it into theory, the objective being that these activities would lead to effective guidance for policymaking.

In this regard, Mazzucato (2016) has argued that contemporary missions call for a new framework capable of offering policy tools for “co-creating and shaping markets”, besides “fixing” them. This perspective transcends the polarity between the public and private sectors and turns to the possibility of fruitful collaborations led by entrepreneurial public institutions (Mazzucato 2013). However, it acknowledges that there can also be problems if only the risks of investments are socialised, while the rewards are privatised – what Lazonick and Mazzucato (2013) have referred to as a dysfunctional “risk–reward nexus”.

This issue has been examined in detail in the first chapter of this thesis, where particular attention was paid to the legal and institutional frameworks that also influence public–private relationships (Laplane & Mazzucato 2019). We have identified some instruments that can be used to allow the state to reap a fair share of rewards and hence help remedy imbalances in the risk–reward nexus.

Examples include royalties, equity stakes, price-capping mechanisms and other conditionalities. Nevertheless, analyses of this nexus in concrete cases and the implementation of these policy tools are still missing.

Empirical studies focusing on emerging and developing countries are of particular interest because the economic, political and institutional challenges – as well as the conflicts over distribution – appear more clearly. This, in turn, offers opportunities for developing further theoretical and practical insights into the design, implementation and assessment of public–private partnerships for investments in innovation.

This chapter is an attempt to contribute to the above line of study and has two main aims:

- a) to analyse, in real R&D programmes, some of the key issues that decision-makers and practitioners will need to address in order to make public–private partnerships more mission-oriented and effective; and
- b) to assess the preliminary outcomes of these programmes in the light of the concept of the risk–reward nexus.

To these ends, a literature search has been conducted with the aim of identifying some of the critical (political, economic, legal and institutional) issues that drive successful mission-oriented innovation policies. This exercise enabled the foundations to be laid for an analytical framework that was used to study the implementation of public–private partnerships. In the analysis, the following are considered: (i) the objectives of the programmes; (ii) the role of public funding agencies; (iii) the legal and institutional changes enabling public–private

partnerships; (iv) the measures to increase and manage the risks taken; and (v) the measures adopted so the state can also reap an equitable share of rewards in case of success.

This framework has then been adopted for use in a comparative analysis of two federal R&D programmes in Brazil, an emerging economy that has recently experienced a brief revival of active and explicit industrial policies (2003–2016). The two case studies are: (i) the *BNDES–FINEP Joint Programme for Supporting Industrial Technological Innovation in the Sugar-based Economy and Sugar-Chemicals Sectors* (PAISS); and (ii) the *Ministry of Health’s Production Development Partnerships Programme* (PDPP). These programmes are interesting because they pioneered features of mission-orientation in Brazil and were considered symbolic of virtuous public–private collaborations by the local STI community in terms of the quality of resources mobilised and arrangements concerning reward distribution (Mazzucato & Penna 2016a). By including an examination of these experiences, the study promotes an understanding of some of the critical issues that arise in the implementation of programmes that rely on the state’s role as a risk-taker. The cases illustrate the process of developing the instruments that are designed to allow for a direct risk–reward nexus.

I present a literature review and proposals for an analytical framework to operationalise the concept of the risk–reward nexus in Section 2.2. The methodology follows in Section 2.3. In Section 2.4 I outline the recent evolution of innovation policy in Brazil, and set the stage for comparing the case studies, according to the five key elements of the framework (Section 2.5). In Section 2.6 I conduct a preliminary appraisal of the outcomes of those programmes through the lens of the risk–reward nexus. I discuss policy implications in Section 2.7, and

then conclude the chapter by reflecting on both the challenges for building effective public–private partnerships in the face of a global economy, and on the implications of the research findings.

2.2 The market co-creating and shaping policy framework

The concerns with contemporary challenges such as slow economic growth, rising inequality and environmental issues, have opened a new agenda for innovation policy studies. This has sparked critical analyses of both the purely theoretical position that is focused on the correction of market failures and the rationale for policy based on systems of innovation. Some critiques have put forward proposals for alternative approaches that have been developed from different perspectives, see, for instance, Schot and Steinmueller (2018) and Mowery et al. (2010).

In this context where interest in active mission-oriented policies resurfaces, Mazzucato (2016) has argued for a new framework in which the justification for the role of the state in innovation is concerned with the co-creation and shaping of markets. The underlying premise is that if the problems in need of solution come from the market, they cannot and will not be addressed by the market alone. Recognising that innovation crucially depends on the quality of the network of relationships between a variety of actors including firms, research institutions, financing bodies, regulators, users and others (Lundvall 1992; Freeman 1995), Mazzucato draws attention to the importance of different types of actors – especially those in the public sector.

Accordingly, Mazzucato (2013) has put forward the notion that the ‘entrepreneurial state’ should become the cornerstone of an argument that

governments can, and should, play a more active role as investors in innovation – which is very different from maintaining the overall assumption that governments only fix failures. Entrepreneurial states are driven by a clear purpose and vision of economic and technological opportunities. As public finance arrives before technologies are mature enough for a business to be willing or able to invest, public agencies feature as lead risk-takers, rather than mere de-riskers (Mazzucato 2013). They operate through a commonly hidden, decentralised, coordinated and networked governance structure, rather than one that is centralised and top-down (Block 2008; Block & Keller 2011). History shows that this course of action – which goes well beyond funding basic science to reach the entire innovation chain, including the deployment and diffusion phases through supply-and-demand-side policies – enables the strategic mobilisation of different types of public (and private) finance (Mowery 2009; Foray et al. 2012).

This broader perspective on the role of the state in which direct public funding increasingly moves downstream means that public agencies work in close collaboration with business and become more exposed to failures, particularly given the inherent uncertainties of the innovation process. That is why the question arises whether, in the exceptional cases of success, the nexus will be kept between those who take the risks of investing and those who will reap the rewards – since the sharing of rewards among those who have shared the risks is a fundamental principle of investment partnerships (Lazonick & Mazzucato 2013). In this regard, some academics have been defending a position that public investments should be treated as a portfolio that contains diversified assets, which will mitigate the risks, while ensuring public agencies have the right to

recoup any financial gains that can be later reinvested into innovation (Block 2008; Mazzucato 2013, 2016; Lazonick & Mazzucato 2013; Rodrik, 2015).

In Chapter 1, we reviewed the literature on legal institutionalism (Hodgson 2015; Deakin et al. 2017) in an attempt to develop a deeper understanding of how the risk–reward nexus varies in response to changes in social shaping processes. From this viewpoint, the legal sphere is an expression of the state’s powers and, thus, a space for contestation, negotiation and experimentation that not only enables institutional change, but also constrains it. On this basis, and recognising that public–private partnerships will be legitimate if perceived as reasonable and fair (Commons 1959), we have identified two sets of measures that could help public agencies have a share in any rewards. These are profit-sharing (involving financial gains to the state) and conditionalities (for more significant economic, social and environmental benefits).

To sum up, the aspects highlighted so far point to the theoretical possibility of building virtuous public–private collaborations based upon the risk–reward relationship. However, success will depend on a sequential path of action being taken; identifying this path provides the basic building blocks for an initial analytical framework which can be used to study concrete R&D programmes (Figure 2.1). The first step along the path is the identification of clear opportunities related to overcoming societal challenges. In the second step, public actors are required to mobilise resources, taking and sharing risks to attract private partners. This, in turn, compels them to engage in legal and institutional experimentation and change (the third step), and to move towards a portfolio approach to manage the risks taken (the fourth step). Moving to the final (fifth) step entails devising measures for ensuring that public agencies are able to recover a portion of the

amounts invested, in the event of success, and which may allow the process to be repeated. Naturally, this is a simplification for analytical use, as in reality, the process is often non-linear and less clear-cut.

Figure 2.1 Framework operationalisation



Source: Own elaboration

From this analytical framework, five main guiding questions for the case studies were derived: (i) What motivations and aims lie behind the programmes? (ii) Who takes the lead, the private or public sector? (iii) What legal and institutional changes enable implementation? (iv) How do federal funding agencies seek to increase and manage the risks taken? (v) How is an equitable sharing of rewards pursued?

2.3 Methodology

To investigate these five questions, a comparative case study was adopted. Qualitative case studies can be a rich source of data and thereby can enhance the understanding of a particular problem or phenomenon (George & Bennett

2005; Stake 2005; Yin 2009). Because it was recognised that legal and institutional specificities have a significant effect on policymaking, the study focused on a single country, Brazil; however, cross-country analysis is the next logical area of research.

According to Stake (2005), case studies that have the potential to reveal information relevant to a particular research problem are the most worthwhile – hence my choice of two R&D programmes in the biofuels and health sectors (covering the period between 2008 and 2016). These programmes were unique in advancing a broad-based and challenge-oriented approach to innovation policies, in a period of time that followed the government's stated goal of enhancing investments in innovation and improving the underlying legal framework (more details are given in Section 2.4). As such, they were well suited for studying public–private investment partnerships and how the risk–reward nexus could be achieved. By following a comparative approach, it was possible to gain insights into the differences in how public actors engaged with business and responded to the need of risk- and reward-sharing.

A variety of data sources were used for the analysis. First, a review of the literature and documentary material on public agencies' activities, policy reports, and scientific and popular journals, provided an initial account of the goals and characteristics of the programmes, actors involved, challenges for implementation, and preliminary outcomes. Second, interviews with the key stakeholders allowed for a more nuanced understanding of their experiences with or perceptions about innovation policies, while enabling exploration of the notion of a risk–reward nexus.

Fieldwork took place between May and August 2016 and comprised in-depth semi-structured interviews with 51 subjects, representing different types of actors and organisations in the public and private sectors (Table 2.1). Given the research interest in identifying critical issues for successful policy implementation, priority was given to respondents in the public sector (41 in total). Selection of the interviewees relied on purposeful sampling and the snowballing technique (Atkinson & Flint 2004). To increase the robustness of the analysis while mitigating bias, I selected interviewees from various positions (leadership, technical and academic), who had been active during the period under study (Table 2.2). Respondents were contacted by email, following a standardised protocol in accordance with ethical guidelines. Each person was interviewed once and the interviews had an average duration of one hour. This process ended at the saturation point (Bryman 2016).

The interviews were recorded and their contents transcribed. A deductive approach was then adopted, in which the interviews were analysed and manually coded (Kvale 1996) in the five steps outlined in the operational framework set out in Figure 2.1. First, I observed how policymakers identified an investment opportunity related to overcoming a societal challenge and coded the perceptions of interviewees in terms of both the benefit and risk potential involved. Second, I looked at the specific measures that enabled public funding agencies to perform a leading role and take on such risks, including those measures that the interviewees regarded as limited in scope, and coded for these measures and their limitations. Third, I identified the changes (i.e. experimentation) in legal rules and institutions at various levels (e.g. legislation, organisations' operational guidelines, etc.) that allowed the implementation of the programmes, and also

coded for these changes. Fourth, I examined the specific measures through which public agencies managed the risks undertaken, and categorised these into three streams (new financing instruments, risk diversification, and competitive funding application processes). Fifth, I considered whether public funding agencies resorted to any additional measures aimed at ensuring they could appropriate a share of potential rewards. This coding and analysis were based on Laplane and Mazzucato's (2019) framing of policy instruments for sharing both risks and rewards, which allows a distinction to be made between two sets of policy instruments: profit-sharing and conditionalities.

Based on this framework, the empirical analysis in section 2.5 has been structured around five themes: (i) opportunity-driven risk-taking; (ii) public sector leadership; (iii) incremental legal and institutional innovations; (iv) new financing instruments, risk diversification and competition; and (v) profit-sharing and conditionalities balancing the risks and rewards of investing.

Table 2.1 # Interviewees by organisation and sector¹³

Organisation	# Interviewees	Sector
Brazilian Centre for Research in Energy and Materials – CNPEM	1	Public
Brazilian Company of Research and Industrial Innovation – EMBRAPA (public non-profit)	2	Public
Centre for Strategic Studies and Management in STI – CGEE (non-profit)	1	Public
Development Bank – BNDES	18	Public
Health Regulatory Agency – ANVISA	1	Public
Innovation Agency – FINEP	6	Public
Ministry of Defence	1	Public
National Agency for Petroleum, Natural Gas and Biofuels – ANP	1	Public
Oswaldo Cruz Foundation – FIOCRUZ Research Foundation linked to the Ministry of Health	3	Public
Public universities – UFRJ, Unicamp and USP	5	Public
Sao Paulo Research Foundation – FAPESP	1	Public
State-owned oil enterprise – PETROBRAS	1	Public
	41	Total public
Brazilian Association of Fine Chemical Industries, Biotechnology and its specialties (non-profit)	1	Private
National Oil Industry Association (private non-profit)	1	Private
Grupo FarmaBrasil (private non-profit)	1	Private
Business enterprises (Bionovis, BG, Cristalia, Grambio, Orygen and Recepta)	7	Private
	10	Total private
Total	51	

Source: Own elaboration

¹³ Data in the table refer to the year in which the interviews took place (2016), which means that interviewees may have previously worked in different organisations and sectors.

Table 2.2 Interviewees' profile

Type of organisation	Chief executive	Position							Total
		Senior executive or civil servant	Higher executive officer	Executive officer	Legal officer	Founder	CEO	R&D manager	
Ministry		1							1
Development bank		3	7	6	2				18
Innovation agency		2	1	1	2				6
Research institute	1								1
Research foundation	1	3							4
University	1	4							5
Regulatory agency			2						2
State-owned enterprise								1	1
Private enterprise						1	5	1	7
Non-profit	4	2							6
Total	7	15	10	7	4	1	5	2	51

Source: Own elaboration

During the interviews, the following themes were addressed (further details are in the Interview guide, see Appendix): (i) the context and roles of public and private actors; (ii) characteristics of public support; (iii) legal and institutional issues affecting public–private partnerships; and (iv) the risk–reward relationship.

Data analysis proceeded through three main phases; in each, the results of the interviews were triangulated with those obtained from other data sources to ensure robustness (Mabry 2008). In phase one, the secondary data regarding the programmes were summarised in chronological order. This was useful for understanding the backgrounds, goals, evolution and results of the programmes. In phase two, repeated comparisons were made between the data and the theoretical framework, the outcome of which enabled the five guiding questions to be addressed. The interviews were key for identifying the specific roles of the different public and private actors, given that their contributions were intertwined (Nelson 2005). It was also possible to characterise the processes and instruments for building the risk–reward nexus, on the basis of the features of the financial instruments deployed and the actors' perceptions and narratives. In phase three, an attempt was made to link the data on the outcomes of the programmes with the pattern deducted from theory (Yin 2009). The relationship between the risks and rewards of public and those of private co-investors could then be established.

Before proceeding to the case studies, it is important to note the political, economic and institutional developments that allowed for active innovation policies to emerge in Brazil.

2.4 The recent evolution of innovation policy in Brazil

The evolution of innovation policy in Brazil is still recent, which is reflection of the country's late industrialisation and the continuous changes in the role of the state in the economy. It was not until the late 1990s that the Ministry of Science and Technology¹⁴ (MCTIC) took incipient steps to restore and sustain STI funding – through the National Science and Technology Development Fund (FNDCT) – and propose legislation to allow public–private partnerships (the Innovation Law). However, since those initiatives took place amid neoliberal reforms and a conservative macroeconomic administration, it has not proved possible to reach the synergies needed, within and across the government, to integrate innovation into actual policy.

The election of President Lula da Silva, in 2002, inaugurated the gradual shift towards a more favourable political, legal and economic landscape for advancing the role of the state through policy experimentation. In May 2003, the government affirmed its commitment to long-term, environmentally sustainable, and inclusive growth, recognising the importance of the state as a driving force (MPOG 2003). The revival of industrial policies would then place innovation at the centre of the development strategy for the first time, evolving through three successive plans (MDIC 2003, 2008, 2011).

To this end, the legal and institutional frameworks had to undergo change. Among this was the passing into law of the innovation bill (Law 10973/04), enabling the government to offer direct financial support to the business sector. This laid the

¹⁴ It originated as the Ministry of Science and Technology; in the 2000s, it became the Ministry of STI and recently it has been merged with communications to become MCTIC.

foundations for the Brazilian Innovation Agency (FINEP) to start a Subvention Programme in 2006. The legislation also permitted the use of other policy instruments, including on public procurement. Enacted in 2007, the Law of Good (Law 11196/05) similarly regulated tax incentives for R&D. There were also institutional changes at the level of public funding agencies themselves. For instance, under new directorship, the state-owned development bank (BNDES) gradually resumed its role as the chief financier of development strategy. New operational norms ensued, which prioritised support to investments in innovation with longer-term horizons, broader access, subsidised credit, and the waiving of risk premium, thus signalling the bank's willingness to take risks. Furthermore, in 2007, BNDES intensified its operations in venture capital, indicating the rise of public institutions acting as venture capitalists (Schapiro 2012).

Despite these changes, the initial move towards increasing investments in innovation was modest, in part because, up to that point, the political and legal environment had been extremely inflexible about the use of public funds directed to R&D. In the absence of an explicit and active innovation policy, a legal vacuum persisted, and there was little innovation culture in the private or public sectors. As private finance for innovation had historically been missing (Melo & Rapini 2014), the lack of public funding meant that business remained risk-averse. The enactment of the Innovation Law and other pieces of legislation had only begun to change actors' practices and mindsets. Nevertheless, effective implementation would require learning, further adjustment and time.¹⁵ Another critical factor was

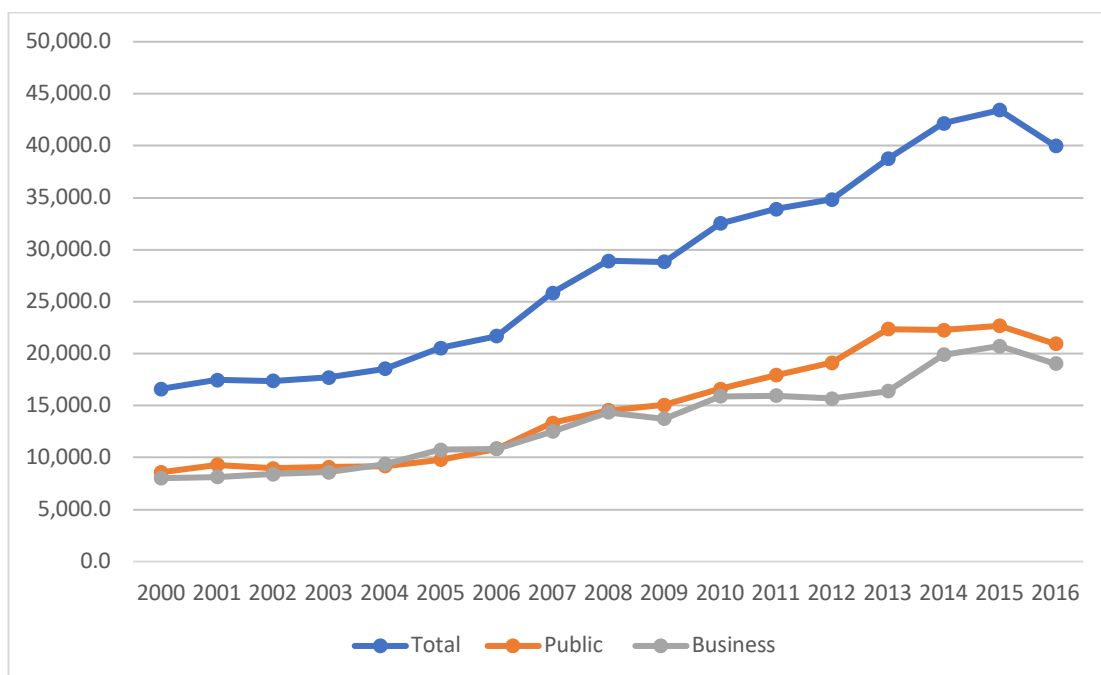
¹⁵ In 2015, a constitutional amendment (n. 85/2015) made explicit the public sector's role in stimulating innovation in the private and public sectors and promoting interactions between the two. Early in 2016, the enactment of the 'New STI Legal Framework' (Law n. 13243/2016) clarified some procedures, the aim being to bridge the gap concerning auditing controls.

the continuity of a misaligned macroeconomic policy approach. As the government maintained high interest rates while withholding public funds, the stifling of private investments was not surprising.

President Lula's second term (2008–2011) opened a period of progressive reorientation towards an active role for public investment. Following the eruption of the financial crisis, countercyclical measures such as the Investment Support Plan (PSI: 2009–2013) provided BNDES and FINEP with additional resources. From 2010 onwards, the Treasury also (temporarily) ceased the systematic retention of FNDCT funds. In that propitious context, the Government Blue Book stated the need to break new ground in terms of the legal framework, and quantity and quality of public support to innovation (MCT/CGEE 2010).

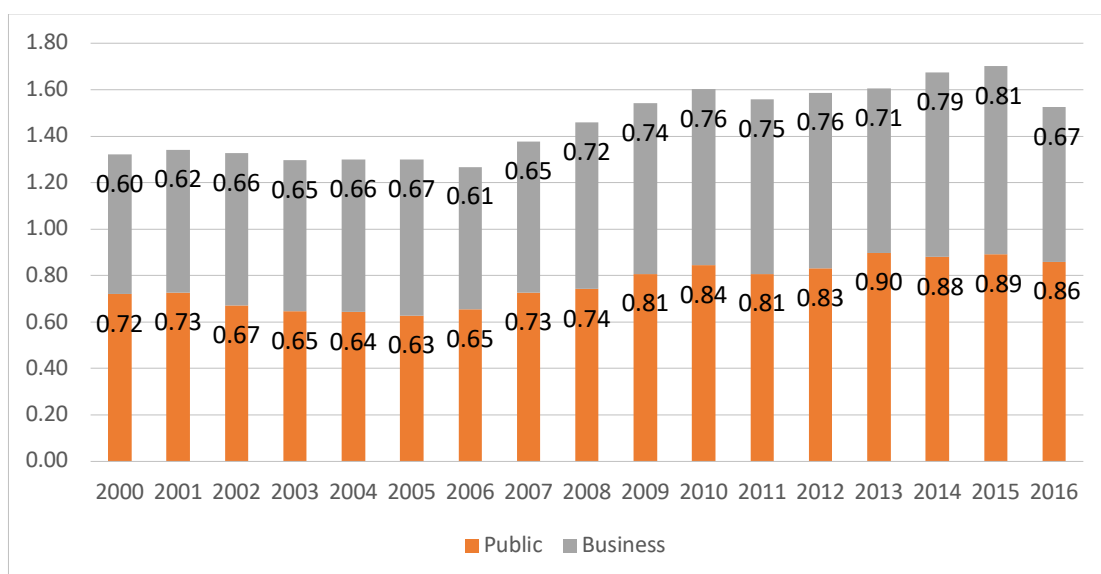
Over the next few years, federal public funding achieved new breadth; one can also observe a correlation between it and growth in business expenditure in R&D (Figures 2.2 and 2.3). Led by executives invested with autonomy and resources, and committed to encouraging risk-taking, public agencies experienced a thriving period of experimentation and learning. Meanwhile, advances in the coordination mechanisms within government, and between it and the private sector ensued, culminating in the growing ambition of the national STI strategy (MCTI 2012). Among the highlights were new programmes with features of mission-orientation such as the Inova Empresa Plan (Mazzucato & Penna 2016a). Notwithstanding such positive developments, again the mismatched macroeconomic policy, and the worsening of international conditions, gradually led to a major political, institutional and economic crossroads, interrupting Brazil's promising developmental path.

Figure 2.2 National R&D expenditure by sector, Brazil (PPP\$ millions)



Source: MCTIC

Figure 2.3 National S&T expenditure as % GDP by sector, Brazil



Source: MCTIC

The two programmes selected as case studies were pioneering in that they embodied incipient features of mission-orientation, i.e. innovative activities were not an end in themselves, but to some extent were part of a strategy to address mapped problems (Gadelha 2016). They represent clear departures from the previous status quo, whereby neither the public nor the private sectors took the high risks of investing in R&D. As well as being relatively successful in stimulating risk-taking, interview data shows that the programmes were considered positive examples of public–private partnerships in Brazil (Mazzucato & Penna 2016a). In this sense, the programmes paralleled each other sufficiently to merit study using a compare-and-contrast approach.

2.5 Two case studies on the market co-creating and shaping role of the state

In this section, two programmes are described that were initiated by the federal government to encourage R&D and innovation: the *BNDES–FINEP Joint Programme for Supporting Industrial Technological Innovation in the Sugar-based Economy and Sugar-Chemicals Sectors (PAISS)* and the *Ministry of Health’s Public–Private Production Development Partnerships (PPDP)*. PAISS is a supply-side stimulus aimed at tackling the key challenges that advanced technologies impose in order to maintain the country’s world leadership in sugarcane-based biofuels. It offers direct financial support to business, structured across the whole innovation cycle. PPDP is a demand-side policy geared towards building capabilities and catching, up mainly in biotechnologies applied to pharmaceuticals. In coordination with supply-side funding, it deploys public procurement to support partnerships for the local development, transfer and absorption of strategic health technologies.

Both programmes represent a positive turn in the historical record of policies oriented towards the sectors in question. The Brazilian pioneering production and use of vehicular biofuels based on sugarcane that dates back to the 1970s have benefited from active government support primarily through the mandatory blending of ethanol in gasoline – especially under the National Alcohol Programme created in 1975 (PROALCOOL). Conversely, the Brazilian pharmaceutical sector, which experienced a setback following the sudden liberalisation of markets in the 1990s, has enjoyed the government’s proactive engagement in rebuilding the industry. Key measures were the adoption of generic drugs legislation (1999) and the supply of subsidised credit under the BNDES Programme to Support the Development of the Pharmaceutical Industrial Chain (BNDES Profarma¹⁶) created in 2004. Therefore, it is only after these cumulative efforts in biofuels and pharmaceuticals that PAISS and PDPP could embrace a more systemic, purposefully driven view of innovation.

2.5.1 Opportunity-driven risk-taking

Both programmes aimed to stimulate high-risk private investments in R&D and innovation, following the perception of new opportunities. In the case of PAISS – the joint initiative by BNDES and FINEP launched in 2011, new technologies for the processing of sugar-based biomass brought the potential for breaking new ground in productivity gains for the biofuel agroindustry. The frontier has been moving from traditional fermentation techniques (first-generation biofuels) to more efficient models based on biochemical or thermochemical processes – the

¹⁶ According to Gomes et al. (2014), the successful implementation of Profarma involved three distinct phases: in Phase I (2004–2007) the focus was on production capabilities; in Phase II (2008–2012) there was a move towards incremental innovations (mainly generic drugs); and in Phase III (2013 onwards) the emphasis shifted to biosimilar drugs and biotechnology.

second-generation (E2G) or advanced biofuels. Thus, there were advantages regarding environmental sustainability and energy efficiency, in particular because these new processes represented a promising alternative to fossil fuels. In turn, the Ministry of Health's (MS) PPDP released in 2009, came in response to the awareness that biotechnology could help to reposition the national pharmaceutical industry in the world. The imminent expiry of patents (held by global players) for drugs that represented a heavy burden on the public healthcare system's (SUS) budget opened a window of opportunity for steering private investment in directions that ensured access to medicines. Besides potentially having high spillover effects, the programme represented a systemic view in which innovation was integrated into economic and social development perspectives (Gadelha 2003; 2009). Therefore, PAISS and PDPP were both oriented towards seizing the opportunities that increased risk-taking could offer, including high economic, environmental and social benefits.

Favourable supply- and demand conditions were in place that suggested that Brazil could succeed if the government acted. PAISS qualified, having natural resources, a competitive industry, and potential demand due to the prevalence of vehicles that could operate on different types of fuel ('flex-fuel vehicles') (Nyko et al. 2010). Scientific and technological capabilities in ethanol,¹⁷ and public funding sources of sufficient scale to support internationalisation strategies (BNDES), were also essential. PDPP had a mature generic drugs industry and the demand of one of the largest healthcare systems in the world. Public laboratories with some experience of biotechnology, a science base and growing STI infrastructure

¹⁷ For a historical analysis of the Brazilian sugarcane innovation system and its dynamics see Furtado et al. (2011).

were also relevant. Hence, in both cases, the combination of supply- and demand-side factors, STI base and public finance constituted drivers of change in the ambitions of policymakers.

However, the challenges were enormous. In PAISS, adopting technologies under test required investors to bear inevitable failures. A viable cost of production has yet to be reached, and the high productivity levels of the first-generation biofuels set a benchmark that was difficult to overcome. There was also the risk of international players arriving first and foreclosing the window of opportunity. Similarly, PDPP faced vulnerabilities such as a poorly integrated supply chain – including small and fragmented biotech firms. Given the high technological complexity of the products targeted for development through tech transfers, the risks were high and dependent on the accumulation of capabilities and infrastructure. Moreover, as public demand alone could not ensure a viable rate of return for supported companies, market risks remained high. Thus, the two cases dealt with technological challenges that required long-term, high-risk and capital-intensive investments that the private sector could not meet on its own. PAISS and PDPP appeared in response, as possibilities for public–private partnerships: the former focused on direct supply-push mechanisms, the later on demand-pull.

2.5.2 Public sector leadership

The leading role of state actors in mapping the technological, economic and institutional challenges, engaging with business, and devising solutions was vital. In the case of PAISS, public officials from BNDES started investigating the reasons behind the stagnation of the Brazilian ethanol agroindustry early in 2010.

Back then, confronted with a complex R&D project, BNDES and FINEP were grappling with the problem of improving coordination and the structure of funding. This situation prompted ideas on how public support could be best employed (see, Nyko et al. 2010)).¹⁸ Early communications with business, signalling a willingness to share the risks of investments, would also prove strategic:

We noticed that whoever managed to solve these technological bottlenecks would establish this industry...we offered financial support with a view on this future... Once we had a diagnosis, we devised a strategy and engaged with the business sector (Interviewee 9, PublMa).

In turn, PDPP stemmed from the gradual alignment of industrial, STI and health policy agendas. In 2004, the formulation of a National Policy for Science, Technology, and Innovation in Health (MS 2008) was a milestone in building a shared vision among stakeholders in the public and private sectors and organised civil society.¹⁹ While public officials operating the BNDES Profarma engaged in diagnosis and prognosis (see Reis et al. (2009, 2010, 2011)), the MS was taking the first steps towards using strategic procurement. The approximation between them facilitated coordination. Therefore, the proactive and future-looking attitudes of public officials in decentralised agencies triggered PAISS, and both bottom-up and top-down pressures contributed to PDPP.

Indeed, the public sector's leadership in PDPP went far beyond stimulating private investment, as BNDES was playing an active role in articulating existing national players under a more competitive structure. Moreover, the successful experience of engaging a public laboratory in tech transfer from a pharmaceutical

¹⁸ This background is recalled by Nyko et al. (2013).

¹⁹ For a detailed account on the consensus-building process driven by the Ministry of Health, see Guimarães et al. (2006).

company and local production in 2007,²⁰ offered a template upon which to structure the procurement programme. Hence, in addition to the public sector's leadership in terms of financing and coordination, one can observe a process of growing confidence to deal with business:

What is it that allows us to be so bold? It's that Brazil has a large market. With... 200 million people, you can ask for certain responses (Interviewee 33, PublMa).

The mobilising feature of the state's risk-taking is apparent. PAISS made it possible to increase the scale of public support and combine the financing instruments of BNDES and FINEP. Before PAISS (2010), public investment amounted R\$ 415 million (\$ 250 million²¹); from 2011 to 2015, it reached R\$ 5 billion (\$ 2.3 billion) (Nyko et al. 2013). FINEP non-refundable grants targeted the early stages of R&D, whereas BNDES credit and equity were key for reaching the higher-risk and capital-intensive stages of industrial plants. Likewise, federal investment in health R&D gradually moved from R\$ 600 million (\$ 433 million) in 2004 to R\$ 1.7 billion (\$ 907 million) in 2013.²² The coordinated efforts within the government enabled a systemic policy approach to PDPP, having public actors who would fund R&D directly, perform it, or manufacture/buy the resulting products.

2.5.3 Incremental legal and institutional innovations

The move towards public–private partnerships had incremental legal and institutional transformations as vehicles. PAISS's approach to attracting private

²⁰ On that occasion, the MS had issued a compulsory licence for the drug Efavirenz which is used for HIV treatment.

²¹ Hereafter, conversion from Brazilian R\$ into US dollars adopted the Purchasing Power Parity Exchange Rate of the corresponding year (www.ipeadata.gov.br). Accessed on 9 October 2018.

²² <http://www.mcti.gov.br/index.php/content/view/29534.html>. Accessed on 5 May 2018.

investments involved opening calls for funding applications and experimentation with priority setting. The first edition (2011–2014) targeted the development of 2EG and renewable chemical technologies, whereas the second (2014–2018) targeted agricultural bioenergy. Another novelty was the structuring of the bidding process around business plans instead of R&D projects, signalling a preference for investments with high commercial potential. In PDPP, converting an early attempt at priority setting (Portaria n. 978/2008) into a systematic practice within the MS demanded new governance structures. The Executive Coordination Group (GECIS) has representatives of ministries and public agencies, including BNDES and FINEP. It is responsible for publicising the list of strategic products, which triggers procurement and guides investment decisions of both public and private actors. Another example is the National Committee for Technology Incorporation (CONITEC). With civil society participation, CONITEC defines the criteria for investment and disinvestment in technologies for the healthcare system.

Public agencies' attempts to guide the directions of innovation involved conditionalities but maintained degrees of flexibility. BNDES and FINEP included commercial application, production, and collaboration with other firms and/or research institutions as qualifying criteria for PAISS²³ while ensuring freedom for companies to choose technological paths and partners. In PDPP, the government required the involvement of public laboratories in the partnerships, quality standards and gradual price reductions of the products that, if met, would benefit

²³ Annex I to the Cooperation Agreement between BNDES and FINEP: <https://www.bndes.gov.br/wps/portal/site/home/financiamento/plano-inova-empresa/plano-conjunto-bndes-finep-apoio-inovacao-tecnologica-industrial-setores-sucroenergetico-sucroquimico-paiss/plano-conjunto-bndes-finep-apoio-inovacao-tecnologica-industrial-setores-sucroenergetico-sucroquimico-paiss>. Accessed on 10 May 2018.

from public demand over the following ten years. Public laboratories featured as mediators of the relationships between the MS and firms – de facto price regulators – and internalisers of technological and production capabilities through transfers. This institutional design illustrates the bold attitude of the state, and reveals the legal and political–economic nature of the challenges confronted:

Because [public] labs are subject to bidding exemption [under the procurement legislation], they have been chosen to stand as ‘sellers’ of health goods to the MS...they are [also] in a better position to resist dumping (Interviewee 36, CivSoc);

and

Multinationals cannot acquire public labs, so technology knowledge can remain in Brazil (Interviewee 40, PrivMa).

Incremental institutional changes happened at various levels to enable implementation. PDPP demanded extensive regulations beyond the Innovation Law’s general provisions. Law 12349/10 amended the procurement legislation, establishing preferential margins for the health sector and additional margins for products developed locally. Similarly, the regulatory framework for biological products had to be built (RDCs 55 and 49). Furthermore, a conditioning factor was that the choice of standards compatible with those of European and US agencies allowed for the mitigation of market risks.

Increased institutionalisation, capacity building and adjustments were important ingredients that enabled the programmes to operate and the inevitable failures to be borne. Indeed, public officials at BNDES and FINEP described PAISS as an innovation itself, a process of “learning by doing” (Nyko et al. 2013, p. 60). One could say the same about PDPP. It started with a few partnerships (around 25)

and soon scaled up to over a hundred. As the programme evolved, the rules that defined procedures for, obligations on and responsibilities for public and private actors went through a revision (in 2014), later obtaining clearance from the auditing bodies. Thus, public risk-taking came hand-in-hand with efforts to strengthen the legal and institutional frameworks.

Public organisations themselves had to adapt in order to embrace active policies. Under PAISS, the provision of structured support changed the dynamics of financial design in that businesses would no longer apply for specific types of support for individual R&D projects. Instead, public agencies were put in charge of selecting the financing tools that best suited the different stages of business R&D plans (Nyko et al. 2013). BNDES' institutional set-up regarding PDPP, in turn, exemplifies more profound changes associated with a new mindset. In 2016, the department that was in charge of promoting the pharmaceutical industry became the Department of Industrial Complex and Health Service (DECISS), reflecting a move beyond the sectoral level consistent with the national policy perspective. Hence, both programmes were implemented within evolving legal and institutional frameworks.

2.5.4 New financing instruments, risk diversification and competition

The quest to promote investments of higher technological risk also prompted attempts to devise new financing instruments that allowed public agencies to increase their risk appetite. In 2016, while targeting the scaling-up phase that is critical in the case of biofuels, BNDES introduced the Hybrid Debenture for

Innovation Support (THAI).²⁴ While the aim was to encourage disruptive innovations in large companies, in practice, design and implementation proved to be challenging, not only for legal and technical reasons, but also due to internal tensions:

We noticed that the DoE (US Department of Energy) concentrated the bulk of non-refundable grants on few and not small companies, yet by law, BNDES cannot operate non-refundable...The challenge was to design a financial instrument with features of equity but linked to the innovation project...Internally...the biggest...resistance referred to the withdrawal of collateral guarantees...It is an extremely complex product, which took us almost a year to develop, following failed attempts in the past (Interviewee 18, PublMa).

Earlier, in the context of financial support to pharmaceuticals, BNDES had also experimented with another financing instrument – the Future Revenue-Sharing Risk Contract (BNDES 2010). However, operational difficulties and the lack of demand for this kind of support led to it being withdrawn from use:

It was difficult to assess revenues and to define clear milestones for firms. Finally, it ended up not generating returns (Interviewee 11, PublMa).

In the interviews, public officials showed they had been mindful of the importance of increasing their risk-taking, for which ensuring an equitable sharing of any potential rewards in case of success would serve as an enabler.

In order to manage the risks taken, indications suggest that public agencies have pursued a sensitive portfolio approach. PAISS funds were spread across many types of firms and industries such as national start-ups, medium-sized and larger

²⁴ <https://www.bndes.gov.br/wps/portal/site/home/financiamento/produto/bndes-thai>. Accessed on 1 June 2018.

firms related to the sugar and ethanol industry (GranBio, CTC S.A. and Raízen S.A.) along with larger international groups in the biotech (Amyris, Novozymes and Mascoma), chemicals (Dow and Dupont) and oil sectors (Oliveira Filho & Consoni 2016). While part of the public support covered investments in R&D such as laboratory facilities and pilot plants, others entailed demonstration and commercial facilities. Moreover, to the extent that companies were left to choose their preferred technological solutions, PAISS financing also allowed variety and exploration of technological paths. By doing so, besides mitigating the blame-game regarding inevitable losses, this financing also increased the chances of success. In contrast, PDPP took an important step towards developing a portfolio approach when, following an initial period in which the MS commissioned a sole partnership for each product, it introduced competition. While advancing risk-mitigation practices helped to alleviate accusations of ‘picking winners’, it would not prevent failures – more than 25 partnerships have been dissolved along the way.

2.5.5 Profit-sharing and conditionalities balancing the risks and rewards of investing

In both programmes, concrete mechanisms were adopted to ensure that the state could benefit from the upside in case of success and compensate for the likely setbacks. In the context of PAISS, until the creation of THAI, equity was the main instrument that the public sector could employ for that purpose, and it is what we have referred to in Chapter 1 as a ‘profit-sharing policy instrument’. Indeed, BNDES played an active role in seeking minority shareholder participation in national players such as Granbio and the Sugar Cane Technology Centre, thus acting as a venture capitalist. There were advantages for both the public and

private sides of the partnership. Within structured support that combines several financing instruments, shareholding activity reduces the risks on BNDES' lending by helping national firms to build muscle. Moreover, if the investment thrives, the bank can recoup a share of rewards that it can channel into further investments:

We enter these equity partnerships due to the technological risks involved and the expected returns. If [it] works, we can have a [financial] return that can fund future initiatives. At this stage, however, we are not making any money...it could even be that firms other than the ones on which we've bet might win the race (Interviewee 9, PublMa).

The use of this type of financing instrument has also aimed to fulfil the strategic purpose of keeping national (as opposed to foreign) control over supported companies. An interviewee in the private sector made it clear:

If there weren't public support, probably the company wouldn't be Brazilian and investments would have taken longer to happen (Interviewee 10, PrivMa).

It is worth noting that neither BNDES nor FINEP retains IPR on the exploitation of research results. Public officials at both agencies reported having discarded this option as a more general policy stance, due (among other reasons) to the high bureaucratic costs and potential for driving private investment away.

In contrast, since PDPP's anchor is public procurement, the conditionality on pricing is the primary mechanism through which the government recoups any financial rewards. Here, aside from the impact on national savings, price regulation has a concrete meaning linked to access to medicines. The starting point is the obligation for firms to incur some price reduction, not necessarily initially, but along the learning curve and throughout the product cycle. Even

though price stability is expected, renegotiation is also possible in the case of supervening circumstances. Therefore, the evidence suggests that risk-and-reward sharing serves multiple and strategic purposes, but that implementation invites caution and flexibility. Public agencies' ability to negotiate and compromise is key because it is what allows the creation and development of a common path with the business sector (Chapter 1):

We are flexible and offer opportunities for [companies] to defer payment [via equity] (Interviewee 19, PublMa);

and

The guarantee of [public procurement] will lower industry costs with marketing and commercialisation, which are up to 40% of pharmaceuticals value. Can I ask for a 40% price reduction? ... What is the price? It's the price of common sense! That's why it's so complex and risky (Interviewee 33, PublMa).

Just as important as the government's predisposition to have dialogue and to negotiate with the private sector, is that of reaching agreement across public agencies. In particular, in the context of a systemic policy like PDPP, overcoming the inherent tensions between different players' rationales, interests and return expectations – for instance, between public financiers and public purchasers – is challenging but possible through coordination. Another critical issue concerns negotiating with auditing bodies, if possible *ex ante*, over assessment criteria beyond the standard cost-benefit analysis:

In technology procurement I can't be opening a bid to obtain the lowest price every year... [on the other hand], whoever takes a picture...[now] will forget that in the first year I [have obtained] a 40% price reduction...there must be a reasonable way in which this can be done (Interviewee 33, PublMa).

In order to mitigate accountability risks for public managers, which negatively affect private investments, building consensus regarding the appropriate metrics to deal with the dynamic and uncertain nature of the innovation process is critical.

Table 2.3 includes a summary of the results of the comparative analysis of the two programmes.

Table 2.3 A comparison between PAISS and PDPP through a market co-creating and shaping lens

Guiding questions	PAISS (supply-push)	PDPP (demand-pull)
What are the programmes' motivations and aims ?	2 nd generation biofuels, sustainability and competitiveness	Biopharmaceuticals, access to medicines and competitiveness
Who takes the lead , the private or public sector?	Forward-looking public officials	Top-down and bottom-up pressures
What legal and institutional changes enable implementation?	Conditionalities and flexibilities	New governance structures, regulation and routines
How do federal funding agencies seek to increase and manage the risks taken?	New financing instruments, risk diversification and competition	
How is an equitable sharing of rewards pursued?	Profit-sharing (equity)	Profit-sharing (equity) and conditionality (pricing)

Source: Own elaboration

2.6. Outcomes, risks and rewards: a preliminary appraisal

It is beyond the scope of this research to include an evaluation of the impact of the programmes and, in any case, it would be premature to do so as they are ongoing. However, some results are already visible and help to illuminate the risk–reward dynamics in the public–private partnerships in question. Below, the results have been pulled together under three categories: public risk-taking

boosting private risk-taking; limitations in public risk-taking mirrored in private risk-taking; and links between public and private rewards.

Public risk-taking boosting private risk-taking. Once the public sector was willing to take risks, it managed to attract private investment and stimulate collaboration. During PAISS's first phase, the announcement of R\$ 1 billion of public funds prompted 39 business plans (35 selected) involving potential investments of nearly R\$ 6 billion linked to 25 firms, 7 business consortia, and 10 university–industry partnerships. In response, public funding increased to around R\$ 3 billion, indicating the public sector's disposition to undertake higher risks. Subsequently (2015), two commercial plants were under operation, one under construction, and one demonstration plant was operating. Brazil now hosts 12% of the world's installed capacity for 2EG production, following the United States, Europe and China (UNCTAD 2016). Furthermore, two of the three companies closer to reaching economic viability, GranBio and Raízen S.A. (Marques 2018), have remained under national capital control.

PDPP achieved similar outcomes. In parallel with their production of generic drugs, local companies embraced the biotech endeavour. From 2009 to 2014, 105 partnerships obtained approval, involving 50 private and 19 public laboratories, covering 61 drugs, 6 vaccines, 19 health products and 5 devices (Vargas et al. 2016). According to the same source, by the end of 2014, procurement linked to the programme amounted to R\$ 2.7 billion (US\$ 1.3 billion), generating R\$ 1.8 billion (US\$ 880 million) savings for SUS and over R\$ 9.1 billion (US\$ 4.4 billion) of revenue for public producers. Furthermore, building work started on two new manufacturing plants for biopharmaceuticals.

Limitations in public risk-taking mirrored in private risk-taking. As public agencies were able to take some risks – albeit while maintaining caution in several domains – business responded accordingly. In PAISS, public officials noticed that the early stages of technology development, which typically had been supported by grants, suffered from an insufficient scale (Milanez et al. 2015). Out of the R\$ 5 billion of public funds mobilised, only R\$ 250 million were non-refundable. FINEP's capacity in this realm has improved but is still deficient. Thus, with few exceptions, most companies opted for technologies developed abroad, not daring to try local alternatives during the more embryonic stages (Milanez et al. 2015). The lack of specific demand-side policies²⁵ and other incentives left the acceleration of 2EG diffusion vulnerable:

Establishing a new industry...depends on more than finance (...) regulation..., tax incentives and... support on collateral guarantees [are also important], ...[but] here we only have finance (Interviewee 9, PublMa).

One can observe an analogous dynamic in PDPP. Despite growing its ambition, the government remained limited in its ability to do more. Auditing and judicial bodies still consider the lowest price to be the guiding principle for procurement, regardless of the written rule including qualitative criteria. The cautious pace at which institutional building aligns with policy agenda somehow stifles the process, exposing public and private actors to additional risks:

The regulatory framework is not ready for innovation. Pioneer companies are paying the price of arriving first: there isn't institutional hostility, government agencies are proactive and engaged in seeking solutions, but it isn't simple, and it takes time (Interviewee 41, PrivMa);

²⁵ Since the 1930s, the government determined the mandatory blending of ethanol in gasoline (5%). In 1975, it raised it to 20% and stimulated ethanol production and use. To date, the stimulus maintains similar levels but has no specific reference to 2EG.

and

[Because] there is legal and institutional instability to deal with the risks of innovation (...) public managers are scared. [Being fearful makes it unlikely that they will engage in any innovation] (Interviewee 33, PublMa).

The lack of a stable legal framework increased the uncertainties, especially following the economic and political turmoil that ensued in 2015, contributing to some firms downsizing their original plans (Fontes 2016).

PDPP provides yet another clear indication of the link between the public and private sectors' risk-taking. Policymakers envisioned that public laboratories would gradually move from being knowledge-transfer recipients and manufacturers to being R&D providers, and procurement would enable the development of technologies new to the world. Nevertheless, conciliating the goals and rewards expectations of public and private actors regarding future technologies has proved to be more difficult than anticipated. Consequently, as yet, local companies are not necessarily betting in directions that meet public health priorities.

Links between public and private rewards. Public agencies sought mechanisms that enabled an equitable sharing of rewards, which favoured a balanced risk–reward nexus. Both cases showed how state action towards enabling such a nexus appeared as an evolving process. Indeed, in the context of the incipient emergence of the role of the state as an investor in Brazil, it was possible to observe that public actors have exercised caution about rewards. Within PAISS, a public official recalled that the possibility of retaining a golden share in individual companies had been discussed but not implemented:

Sometimes we support university start-ups that may end [up being] sold to foreign companies and the state receives nothing in exchange...Golden shares... can be designed... [so] the company needs to compensate the state or give it priority to buy [it] (Interviewee 9, PublMa).

Although golden shares could have enhanced public appropriability, it is not clear whether they would have been endorsed by business partners.

Nevertheless, the unveiling of policymakers' concerns with keeping national versus foreign ownership of capital investments indicates another way in which the disconnection between those who bear the risks and those who reap the rewards might occur. The economic openness that could serve as a catalyst to innovation has given way to the aggressive strategies of global players, resulting in increased risks of losing national ownership. In contrast, PDPP dealt with this by building a complex institutional arrangement anchored in public laboratories. Therefore, the cases show that the efforts to create an explicit link between risks and rewards in public–private partnerships led stakeholders to different contextual solutions that, albeit imperfect, have been negotiated and accepted.

2.7 Key issues for policy and practice

In this chapter the aim has been to analyse critical issues in the implementation of public–private investment partnership programmes, and explore the risk–reward nexus. To this end, an analytical framework has been proposed – called the market co-creating and shaping framework – which has been used in an empirical analysis of recent innovation policies in Brazil that can be seen as the government taking small steps towards mission-oriented initiatives. The case studies offer evidence confirming that the framework is a useful analytical tool

and that it is relevant to actual experiences. The studies also highlighted some complexities which need to be taken into account in the design, implementation and evaluation of this policy approach. Hence, there are lessons drawn from the Brazilian experience that can serve as guidance for other government initiatives. In the following sub-sections, these lessons have been assembled under four headings: carving out a suitable policy space; making entrepreneurial public finance effective; building legal foundations for symbiotic public–private partnerships; and nurturing institutional learning and capability accumulation.

2.7.1 Carving out a suitable policy space

As anticipated in Section 2.3, a change of vision from the top by which the government commits to promoting development policies, though a necessary foundation, is not enough. Equally important is the state's convening power. It must be able to create the synergies needed, within and across ministries and agencies, to harmonise macro- and micro-economics with social policy goals. Achieving this, however, first requires a change to the rationale that sees the space for policymaking as limited to fixing market failures. A fundamental shift in mindset, capable of countering the stigma attached to state 'intervention', while increasing public agencies' stamina to act as key drivers of economic and social change is, thus, critical for the development of virtuous public–private partnerships. The Brazilian cases illustrate that such a shift is possible even after a long period of neoliberal administrations. Still, it tends to be gradual and concentrated in a few 'islands of excellence'.

The process of legitimacy-building goes over and above the structural economic conditions preceding a given policy. It features as strategic throughout the policy

process, even more so in young democracies like Brazil. On the one hand, the creation of a shared vision that guides large-scale initiatives must already be present when the programme is formulated. In PAISS, whose design involved mainly BNDES and FINEP, public officials perceived that engaging more actors at that stage would have helped to strengthen public support. On the other hand, a policy like PDPP was part of a more articulated strategy for the health sector, engaging a wide range of actors such as civil society, public agencies and business. This suggests that expanding participation in the formulation of the policy – that is, combining both top-down and bottom-up approaches – is essential for legitimation and increases the likelihood of sustaining the policy's effects in the long-run; it is also in line with the considerations that have been highlighted in studies on the need for democratising decisions about the directions of innovation (Stirling 2008, 2009).

Following on from the above, the specification of the intended policy outcomes in terms of environmental, social and economic benefits – on which the two programmes relied – also plays a role in constructing a favourable political environment for targeted initiatives. However, it is not sufficient. The value of an open-ended interaction, not just across public agencies but also between them and business and civil society, also became apparent. While an intergovernmental body that helped to bring coherence to public (and private) actions were missing in PAISS, it and other participatory institutions were present in PDPP, contributing to the latter's systemic approach and stronger support. In any case, the starting point for any such policy must be a predisposition of public and private actors to collaborate with one another so as to promote the socio-economic goal in question.

2.7.2 Making entrepreneurial public finance effective

The change in the government's strategy must translate into real financial risk-taking and sharing capacities that enable the state to become entrepreneurial in the first place. While this is an aspect that might have been overlooked in studies focusing on contexts where the public sector had been playing a leading role for a long time, in the Brazilian cases, its relevance emerges clearly. Once federal agencies came under active, and forward-looking directorships – aligned with the administration's vision, vested with autonomy and funding – proactive and innovative attitudes flourished in the bureaucracy. It then became possible to improve both the quantity and quality of public finance.

The gains in scale and scope of public support, spread across the innovation chain while reaching the supply and demand sides through a wide range of instruments, are core ingredients for stimulating high-risk private investments. In the case of PAISS, collaboration between the funding agencies was intended to achieve greater breadth of support which was then expected to enhance their performance. There was an acknowledgement that the absence of specific measures to stimulate the demand and supply sides were shortcomings that the creation of a new market (ideally) would need to overcome. A similar and yet more comprehensive mix of policy instruments was deployed in PDPP, linking up the supply and demand sides to tackle the transformation of an existing market. This is consistent with what other comparative studies on mission-oriented R&D have found (e.g. Foray et al. (2012)) regarding the importance of systemic policies in positively affecting the rate and direction of private investment.

Increasing the impetus of strategic public finance further involves assigning it properties such as patience, timely investment and some flexibility. It is worth recalling that the point of departure was a change in public funding agencies' operational policies, indicating their willingness to take risks (Section 2.3). In the case studies, the initiative to advance entrepreneurship first came from the public sector. The interview data also supports the interpretation that companies recognised that the state took the lead, arriving before the private sector and accelerating investments that otherwise would have taken longer (if ever) to happen. Besides, public support was well timed as it tackled challenges that benefited from windows of opportunity.

Similarly, there is evidence pointing to a nexus between the risk appetite of public and private actors which showed that public officials were aware of the importance of playing an active role; for example, there was the realisation that less ambitious business behaviour mirrors cautious attitudes in the public sector (e.g. the insufficient scale of grants allocated within PAISS) and there were attempts to innovate around financial instruments (in both cases). Although the evidence presented here is limited to two case studies, which involved some constraints in terms of the scale of resources mobilised and other factors, it does provide elements relevant to the Entrepreneurial State hypothesis as put forward by Mazzucato (2013). However, there is one aspect of the evidence that contradicts that hypothesis.

Public–private partnerships can, and must, occur in explicit ways. The analysis has drawn attention to instances in which risk-sharing was considered vital, and stakeholders were outspoken about what was being agreed upon, notwithstanding the uncertainties involved. This means that some common

understanding regarding risk allocation had been achieved. Thus, the rise of the new 'Developmental and Entrepreneurial State' does not depend on implementation through implicit policies (Block 2008; Mazzucato 2013). If risk-sharing occurs consciously and openly, it is more likely to allow openness about the distribution of rewards.

2.7.3 Building the legal foundations for symbiotic public–private partnerships

Besides having the political will and availability of resources to invest, solid legal bases are needed that enable the state to engage effectively in collaboration with business. The Brazilian experience is again revealing in this respect. The case studies illustrate that the incipient rise of public entrepreneurial finance requires the breaking of new ground in terms of legal and institutional building. They also showed that this process evolves incrementally, and can take some time to mature. Filling the gap between the adoption of a broad legal framework for innovation, and implementation, often involves further amendments in legislation, new administrative procedures, regulations, financing instruments allowing for risk-and-reward sharing, contract designs, etc.

A crucial focus of tension that needs to be overcome consists of defining the boundaries within which public funds can be put at risk. This is apparent in the case of PDPP, in which interviewees stressed that public–private partnerships faced additional uncertainties due to the legal framework being under construction. Needless to say, to welcome long-term investment requires stability of governing rules, predictability and guarantees that contracts agreed upon will be honoured. Also important are high levels of institutionalisation of selection and decision-making processes within public agencies, along with robust internal and

external controls as safeguards against arbitrariness, capture and corruption. However, equally imperative is that the legal environment develops tolerance to (1) recognise that some margin of discretion is inherent to any investment, policy and legal process; and (2) protect public officials in case of losses owing to market or technological risks.

Otherwise, irrespective of how technically sound public investments may be in terms of their compliance with standards of good practice and prudence, the entire premise behind a policy driven by public sector entrepreneurship falls flat. While the evidence indicated the constitutive features of legal institutions in defining the room for public risk-taking (Laplane & Mazzucato 2019), there is more to be understood about how to shape the legal foundations that allow entrepreneurial states to emerge and become acceptable.

Statutory laws that incorporate the notion that innovation has social value, and subsequent formal rules that operationalise this notion, may trigger the legal design chain, yet effectivity also lies in those norms being perceived as fair and interpreted as such by judges, auditing bodies and citizens. The evidence on the difficulties of obtaining a common view about the metrics for policy evaluation underscores that this might become an obstacle, suggesting that policymakers' disposition to take part in dialogue and to compromise may be a valuable (Pistor 2009), if not essential, requirement for promoting awareness of the inherent risks of innovation. Since building consensus around public risk-taking is so urgent and complex, the legal framework must also ensure the negotiation of an equitable deal regarding the appropriation of any arising rewards. The case studies unveiled that such negotiation was an enabling device for raising the stakes of public–private partnerships which motivated innovations around financing

instruments. In this sense, the social – and importantly legal – construction that allows both the risks and rewards of public investments to become socialised become palpable. Thus, the evidence presented supports an interpretation that sees a rationale for policy design to include mechanisms that enable the state to capture a share of financial rewards of publicly financed innovations (Lazonick & Mazzucato 2013; Laplane & Mazzucato 2019).

Although the primary policy objective is to promote innovations that tackle relevant societal problems, a secondary policy objective is to build an environment within which actors can feasibly reach an agreement concerning the potential rewards. The empirical analysis showed the importance of operating under a legal framework that is flexible enough to allow supported companies' financial positions to be considered before the imposition of a distribution of profits that could harm them. This aspect is even more relevant for developing and emerging economies, which usually lack robust technology-based firms. A sensible approach seems critical, especially given public officials' references to the difficulties of overcoming resistance to having flexible collateral guarantees – and their observations suggest they also faced pressures to generate returns for their organisations. Therefore, elaborating adequate safeguards to restrain short-termism and profit-seeking within public agencies themselves is also important to ensure adherence to the main policy objective of promoting innovations that tackle relevant societal problems. Omission of this aspect would also result in the breaking down of the expected symbiosis in public–private partnerships that justifies their existence in the first place.

While policymakers can draw on a variety of financing instruments that make it possible to share the risks and rewards of innovation, the identification and

selection of those that are fit for each context is another issue that deserves attention. Because public agencies considered and eventually discarded alternatives like IPR or golden shares, advancing knowledge on individual instruments may help to illuminate which types of deals are feasible in different settings so as to overcome constraints imposed by the legal framework and actors' capabilities. If increasing the array of reward-generating mechanisms allows for better adjustment to contextual circumstances, linking them up through a portfolio approach that diversifies risks while ensuring recoupment in the upside is just as suitable for legitimization purposes.

2.7.4 Nurturing institutional learning and capability accumulation

Instead of focusing on whether public and private actors know how to establish symbiotic public–private partnerships, a more pressing issue to consider is whether these actors can develop the capabilities to learn how to do so and improve their partnerships over time. In Section 2.3 favourable conditions were presented that allow for changes in institutions and practices, as well as in the mindset of the various actors, to occur while the cases illustrated the importance of competent and highly motivated bureaucracies with problem-solving attitudes. Nevertheless, key challenges persist.

Equipping state agencies with institutional structures and technical and policy capacities that enable them to be nimble is a conditioning factor for entering the risk–reward game. The interview data highlighted that public officials face difficulties in operating instruments such as non-refundable grants and strategic procurement, at least in part because of legal and institutional rigidities. Also, there were references to the complexity of financial instruments, R&D projects

and business plans themselves, highlighting the centrality of developing the required expertise in risk assessment, valuation and the measurements on which to retrieve expected rewards (Windus & Schiffel 1976). Devising adequate mechanisms within the state that allow for the constant monitoring and identification of investment opportunities and future needs is also important. PDPP contemplated this with CONITEC, but the fact that such a structure was absent in the case of PAISS suggests that in some innovation systems this remains as a rather ad hoc practice. Surely there are opportunities for public organisations to review, simplify and improve their procedures so that they can effectively speed up their operational capacities. There is, however, a trade-off between fast-tracking proceedings, and the quality of negotiations with business, especially when more substantial changes in industrial strategies are at stake. Indeed, one of the lessons from PAISS is that accelerating procedures can be vain and even counterproductive, considering that strategic decision-making in the corporate sphere may need time (Nyko et al. 2013). Therefore, institutional and capacity building is also a matter of learning by doing.

The advancement of risk–reward management strategies and practices is another critical factor for spurring policy and institutional learning. Both cases offered evidence showing that public agencies took essential steps in the direction of a portfolio approach – including flexibility for companies to choose technological paths and R&D collaborators, risk diversification and competitive bids. There were perceptions that these contributed to mitigating the blame-game and the problem of picking winners. The empirical analysis also illustrated the experimental nature of government efforts to design and oversee their investment portfolios, from opening calls for funding applications to negotiating the contracts

with business. The analysis also made clear an additional advantage of a portfolio, concerned with allowing the eventual recoupment of financial returns, which is useful for recovering from losses and replenishing public funds that could sustain investments in the long-run. In any case, a crucial factor of success in portfolio management is that public and private actors get to learn from experience (Sabel 2004; Rodrik 2014; Karo & Kattel 2016), including from the failures in handling either the down- or upsides of the investment process (Laplane & Mazzucato 2019). Ultimately, building an institutional setting that nurtures exploration, trial and error, and learning, albeit challenging, is also a precondition for strengthening the state powers needed for addressing the directionality of innovation and negotiating more equitable partnerships.

2.8 Conclusion

The incipient emergence of a strategic role of the state co-creating and shaping markets in Brazil has been examined in this chapter. The findings come out of a comparative case study of two federal R&D programmes which had some features of mission-orientation. The starting point was a framework in which the state is viewed as a lead investor in innovation and promoter of legal and institutional changes capable of favouring symbiotic public–private collaborations. Evidence was presented which supported this view through the entrepreneurial way (i.e. that was opportunity-driven, proactive, problem-solving, and constructive) in which public funding agencies interacted with businesses and sought to achieve an explicit link between the risks and rewards of public investments.

The preliminary results of the programmes also made it possible to observe more closely the risk–reward dynamics in public–private partnerships. While public risk-taking has played a catalytic function, contributing to a virtuous ecosystem, its limitations and those of the mechanisms agreed upon regarding the appropriation of rewards became apparent. This finding indicates that the construction of a balanced risk–reward nexus, within an evolving legal–institutional framework, is an outcome that reflects the possible agreement obtained between multiple stakeholders. This nexus is then contingent upon tensions, power and learning relations between all those involved.

Some of the questions that the implementation of the market co-creating and shaping policy framework raises have been discussed (Section 2.7), although it should be noted that the case studies uncovered an additional complexity: how should the link between the risks taken and the rewards appropriated by public investors be sustained? Policymakers’ concern about the risk of denationalisation of businesses that benefited from public support deserves more attention and offers opportunities for future theoretical and practical developments. Not only do tech-based companies enjoy greater mobility than other types of business, but also they may be more vulnerable to takeovers by powerful global players. These trends are salient features of the increasingly integrated world economy and also reflect changes in the strategies of multinational corporations.

A critical issue is the asymmetries in states’ powers and capabilities to formulate and sustain policies that confront the interests of powerful corporations. This problem – although particularly sensitive in the case of emerging and developing economies, where institutional vulnerabilities are usual features – is also experienced in other economies. Thus, expanding the framework to enable a

fuller understanding of the challenges and opportunities for devising responses at the local and national levels appears to be a worthwhile activity. Moving in this direction should enhance the explanatory power of the framework and contribute to making it an even more useful guide for policy.

Lastly, the research findings raise some important lessons: in cases of emerging and middle-income economies that have accumulated some experience, they indicate that under certain circumstances, it is possible to create the spaces for active and broad-based innovation policies while exploring pathways for sustainability and inclusive development. Nevertheless, the challenges for institutional building and implementation must be noted. In the case of Brazil, the hope is that this early experience of engaging in market creation and shaping will help to illuminate present and future innovation policy. Because this positive agenda is vital for breaking out of the current economic, political and institutional crisis, it is one that the country cannot afford to give up.

Chapter 3 Public risks rewarded: Lessons from contract design in public investments in innovation

Abstract²⁶

In this chapter the features of contracts designed by public funding institutions that have explicitly embraced an active entrepreneurial role are explored. Particular attention is given to those features associated with the possibility of equitable sharing of financial rewards arising from public–private investment partnerships. The analysis proceeds through the case study of the partnership between the Brazilian Development Bank (BNDES) and the research centre CSEM Brazil, which involved amendments in the contracts that led to a shift from non-refundable grants to reward-sharing. The main attributes and functions of those contracts were identified from open-ended semi-structured interviews with public officials and document analysis. The attributes comprise flexibility and ambiguity; the functions comprise leveraging, legitimation and preservation. Such features transcend the common view of contracts as cost-mitigating devices and highlight their appropriateness as tools for strengthening the entrepreneurial role of the state. Lessons are drawn from contract design, and guidelines are developed for policies aimed at a balanced risk–reward nexus.

3.1 Introduction

It is by means of institutions that policies for supporting innovation in business can be designed, conducted and enforced (Andreoni & Chang 2019). Contracts, written or implicit, are institutions that structure relationships between two or more actors, create obligations, allocate risks and ultimately assign rights over any accruing rewards (Hall 1994). Policy experiences show a variety of possible contracting strategies and forms both in public procurement (Kalvet & Lember

²⁶ I would like to thank my colleagues Pavel Corilloclla (SPRU) and Manuel Gonzalo (National University of General Sarmiento, Argentina) for their very helpful comments on earlier drafts.

2010; Georghiou et al. 2014) and in financing innovation (e.g. Kerr and Nanda (2014)). They may also vary in the degree to which they succeed in fulfilling the functions for which they were originally created. Nevertheless, governments can learn from examining different institutional and, thus, contractual alternatives “and their distinctive features” that are associated with the achievement of certain policy objectives (Andreoni & Chang 2019, p. 9).

With the growing interest in the role of the state as an investor, however, there does not seem to be a commensurate emphasis on contract design. Governments are urged to move beyond their role of “fixing market failures” and to welcome the high risks at the early stage of technology development that no private investor or industry would be able to bear alone (Mazzucato 2013, 2016). Yet the move towards active entrepreneurial states is a challenge in itself (Martin 2016) and one closely related to contractual issues.

First, policymakers are confronted with the need to develop tools for enabling the state to mobilise a large scale of financial resources. In this regard, there have been calls for public institutions to seek a balanced risk–reward nexus (Lazonick & Mazzucato 2013). By not only taking the risks of investing, but also appropriating financial rewards directly in case of success, the public sector could support the creation of a sort of revolving innovation fund, whereby the wins would cover the losses (Mazzucato 2013; Rodrik, 2015). This would mean abandoning the idea of public funding as a subsidy, which is implied in the use of traditional instruments such as non-repayable grants. In this fashion, contract design is what enables any such change towards public–private sharing of risks and rewards.

Second, governments are required to overcome the institutional obstacles that prevent the stimulation of symbiotic innovation ecosystems – i.e. those in which mutually beneficial interactions among various types of actors result in an uninterrupted flow of investments in innovation in areas of high social benefit (Mazzucato 2013). However, the effectiveness of measures taken in this direction also depends on whether the purposes and forms of collaborations pursued, as well as the results achieved, are perceived as virtuous (Laplane & Mazzucato 2019). The problem is that innovation is inherently uncertain; measuring it and distinguishing failure and success is an extremely complex task. As policymakers face tight budgets and high demands to demonstrate impact, the potential for misalignments between their own perceptions of successful performance and that of auditing bodies increases. This is the context in which the concerns for building more equitable public–private partnerships must be understood. Still, it is through shifts in the reward structures defined in contracts, once again, that the hopes for symbiotic relationships may be fulfilled.

In practice, there have been incipient changes allowing recoupment by public funding institutions and, thus, management of the risk–reward nexus (Laplane & Mazzucato 2019 and Chapter 2 in this thesis). Financing instruments already used that serve this function, to varying degrees, include repayable grants, loans with reduced interest, venture capital, private equity and mezzanine funding (combining elements of debt and equity) (OECD 2014, 2016).

Although studies on these policy tools exist, the framings of the contracts that underpin them have rarely been the focus of empirical analysis. Despite that, following Andreoni and Chang’s (2019) line of reasoning, one would expect that some contract designs and features are best for promoting the equity of risk–

reward relationships. Therefore, analysing amendments to contracts made for this purpose, in connection with their key characteristics, could help to generate lessons for public institutions on how they may positively affect innovation policy processes and outcomes.

In the present chapter, the amendments in and features of financial contracts that allow a shift from non-refundable grants to reward-sharing between actors in the public and business sectors are explored. The research question posed is: *What attributes and emerging functions of contracts enable a move from a situation where the parties do not share any rewards, to another that facilitates the construction of a balanced risk–reward nexus?*

To address this question, the analysis proceeds through a case study of the partnership between the (state-owned) Brazilian Development Bank (BNDES) and the (private, non-profit) research centre CSEM Brazil. This case involves amendments in contracts designed in 2011 and 2013, and implemented shortly after, that represent a departure from the then standard practices at BNDES concerning the supply of non-refundable grants. For the first time, the bank introduced a condition making possible its participation in any economic results. Eventually, this right was exercised by retaining equity stakes in the spin-off company Sunew which was devoted to manufacturing and commercialising organic solar panels (OPV). Since both parties share in the risks and potential rewards of innovation, and publicise it as a successful case,²⁷ it can be considered an exemplary attempt to build a symbiotic partnership. This makes it

²⁷ According to CSEM Brazil's website: <https://csembrasil.com.br/en/project/sunew-opv/> (Accessed on 3 June 2019), BNDES (2018) and interviews with public officials (1, 6, 12, 14 and 20).

a suitable case to illustrate the engineering of an instrument that directly influences the risk–reward nexus.

By illustrating a success story, the analysis in this chapter does not ignore the high exposure to failures that this type of policy implies. Rather, the point is to begin to identify the institutional features, focusing on the contractual attributes and functions, associated with a rationale for policy in which the state co-creates and shapes markets (Mazzucato 2013, 2016). The study also contributes empirical data to this area of research, by combining document analysis and semi-structured interviews with the public actors involved in decision-making. The rich body of data collected provides the basis for detecting the particularities of the contracts and deriving the key lessons from financial contract design.

Section 3.2 comprises a review of the literature on contracts and contains my proposals for a complementary approach to market-failure theory. Section 3.3 covers the methodology. Section 3.4 contains background information on the case study of BNDES providing funding to CSEM. Here I use the study as an illustration of an attempt to structure an equitable partnership. In Section 3.5 I identify the features of the contracts used in the process of shifting from non-repayable grants to reward-sharing, and distil the main lessons. I have emphasised the interplay between experimentation with financial contracts and the context in which they unfold. In Section 3.6 I present some conclusions.

3.2 From contracts for market fixing to contracts for market creating and shaping

Contracts can be seen to be much more than just a formal link between two or more parties. Important to this study are the notions of contracts as technologies,

organisations and cost-mitigating devices. If technologies are taken to mean “useful knowledge about how to produce things at low cost”, contracts meet such criteria in that they entail knowledge embodied in “documents that serve as blueprints for collaboration” (Davis 2013, p. 85). Alternatively, assuming organisations follow specific objectives and develop fairly formal rules to regulate their internal relations and those with external actors, contracts can also qualify as forms of organisations themselves (Smith & King 2009). In their review of empirical research, however, Smith and King (2009) have found that the focus on the role of contracts as cost-mitigating devices prevails. This latter conception stems from economic thinking rooted in market-failure theory.²⁸

Economic theories have made important contributions towards the understanding of contract relationships under uncertainty; they have highlighted the fact that the specific characteristics of market failures concerning innovation – mostly unclear boundaries of property rights or incomplete contracts – can give rise to many costs. These may comprise externality (Demsetz 1967), transaction (Williamson 1981) and agency costs (Jensen & Meckling 1976), which in turn offer one possible explanation of existing forms of economic organisation and the associated allocation of risks and rewards between collaborating entities.

Transaction cost economics posits that the specificities of the object of contracts for innovation, which comprise a heterogeneous, often indivisible knowledge base that cannot be used to safeguard any transaction, lead to uncertain and

²⁸ In this regard, Eggleston et al. (2000) argue that there are two streams in the economic literature on contracting. One is Law and Economics, in which the economic effects of legal rules are sought, the aim being the development of guidance for public (executive, legislative and judicial) institutions. The other is Economics of Contracting (or incomplete contract theory), which focuses instead on the relationships between private actors, using the assumption that the rules are given within which actors operate. For reasons of space, this section prioritises the latter stream.

high-risk outcomes for which few buyers may exist (Williamson 1988a, 1988b). These features cause entrepreneurs to have better information on innovation projects than external capital providers, making it difficult for these to define ownership rights, negotiate equal shares of returns, and avoid selecting projects with higher chances of failure (Stiglitz & Weiss 1981; Williamson 1988a). Given the assumption that actors behave opportunistically, it suggests a strong likelihood that incomplete contracting will result in unfair agreements. The main implication is that the choice of contract design and underlying reward structures work as a governance mechanism to mitigate transaction costs, especially those involving monitoring, renegotiating the initial agreement in response to contingencies (so-called 'private ordering'), resolving disputes and enforcing sanctions *ex post*.

The principal-agent theory points to the dilemma that the separation between ownership and management within corporate structures, and between external investors and entrepreneurs, may raise for striking complete contracts for financing innovation (Jensen & Meckling 1976). Managers (agent) are often more risk-averse than shareholders (principal) and may prefer short-term, low-risk investments rather than those that are long term and uncertain, which may nonetheless yield higher returns. Consequently, in order to maximise their rewards, managers have strong incentives to act against the interests of the firm, enhancing the costs of defining adequate ownership rights, negotiating commensurate shares of returns and avoiding moral hazards. It follows that the choice of contract design and underlying reward distributions emerges as an incentive-alignment device. The main purpose it serves is the mitigation of such

costs that are most significant before the parties reach an agreement, which may lead to investment strategies that do not maximise shareholder value.

In line with these economic theories, attributes such as predictability, efficiency and security are desirable if contracts are to play their primary function of cost mitigation. Regarding the risk–reward nexus, one can notice some of the main options that innovative firms and (assumed to be private) investors might have under the market-failure approach (Table 3.1). Beyond grants, which rarely entail an expectation of reward-sharing, financing instruments can take the form of equity (common or preferred stocks), loans or bonds (corporate bonds or convertible debt) (Wang & Thornhill 2010). The associated reward schemes are, respectively, dividends, payment of the loan, and periodical payment of interest rates, which can eventually be converted into returns on equity (Stiglitz 1991). As the last two columns of the table illustrate, equity and convertible bonds offer strong alignment between risks and financial rewards and are linked with no ‘appropriation discrepancy’ for investors (Wang & Thornhill, 2010). In turn, loans and corporate bonds are less suitable for that purpose, as investors earn returns irrespective of the supported innovation’s success.

Table 3.1 Financial instruments, contract designs, risks and rewards

Financial instrument	Parties relationship	Governance mechanism	Risk-reward nexus	Returns to investors
Equity				
Common stock	Integration between investor and firm (long-term relationships)	Investor seeks information to select most promising rate of returns and continues to monitor execution through participation in the Board of Directors	Risk-reward sharing	Residual value of the firm in the form of dividends (no appropriation discrepancy); preferential stocks get priority in receiving dividends
Preferred stock		Investor monitors through participation in shareholder meetings though not necessarily holds voting rights (minority shareholders)		
Loan ('Bank finance')	Separation between investor and firm (short- or long-term relationships)	Investor monitors that funds are executed in the way promised by the borrower, and that the borrower, in responding to contingencies, takes into account the interests of the capital providers	<i>Ex ante</i> and reciprocal allocation of risks and rewards	Payment secured through collateral assets (isolated from shareholders residual value)
Bond				
Corporate bonds ('Market finance' or 'Relational debt')	Separation between investor and firm (long-term relationships)	In principle investor cannot intervene in firm management	No risk-sharing	Periodical payment of predetermined interest rates - fixed or variable (isolated from shareholders residual value)
Convertible debt	Initial separation with option for investor to hold common stocks	Investor cannot participate in firm's Board of Directors until opting to become shareholder	Risk-reward sharing	Returns indirectly aligned with the firm's residual value, as conversion to hold common shares enables investor to benefit from upside (low level of appropriation discrepancy)

Source: Own elaboration based on Williamson (1988a); Stiglitz (1991); Wang and Thornhill (2010)

Despite being useful for identifying issues that under certain situations can be relevant in public–private partnerships, market-failure theory remains a narrow lens through which to observe the features of contracts in circumstances where the state plays a leading role as a risk-taker (Mazzucato 2013). Besides assuming economic actors are homogeneous and profit-maximisers, a market-failure approach is based on the assumption that markets, technologies and overall rules are given. In so doing, it hinders the possibility of analysing the political processes through which existing institutional and legal alternatives came into being and evolved towards the achievement of broader policy goals (Nelson & Winter 1982; Hodgson 1999; Perez 2003; Pistor 2009). In contrast, a perspective that considers the state as a powerful driver of transformation in the patterns of interactions underpinning innovation ecosystems calls for new analytical tools that acknowledge actors' diversity and contextual variables.

To account for the attributions and functions that distinguish public investors from those in the private sector, and the two-way interplay between financial contracts and the context in which they come about, this chapter builds upon the approach set out in an earlier study (Laplane & Mazzucato 2019). The rationale for innovation policy is therefore viewed as co-creating and shaping markets, rather than simply fixing them. Legal institutions play a constitutive – enabling, as much as constraining – role in these processes, which are permeated by power relations (Hodgson 2005, 2015; Deakin et al. 2017). Accordingly, the state's ability to alter the balance of power in part depends on whether it explores and learns to use the legal tools – i.e. contracts – that best serve socially desirable policy goals (Deakin et al. 2017). In a nutshell, directing innovation towards

pathways that enable a more equitable distribution of rewards is also a matter of legal and contract design.

Under a market co-creating and shaping approach, the hypothesis could be raised that public–private contracts embody features that transcend those associated with cost mitigation (assumed under a market-failure approach). In particular, some attributes and emerging functions would be most appropriate for meeting a balanced risk–reward nexus. But which ones? This is an empirical question that I aim to explore in this chapter. To do this, in addition to using the institutional literature mentioned above, in my analysis I draw insight from legal scholarship on corporate governance and finance, in particular, Gilson et al. (2009, 2010); Pistor (2013); Hockett and Omarova (2014).

3.3 Methodology

Financing contracts between actors in the public and private sectors depend on established rules and values that are historically and socially contingent. These vary according to context and time. The Brazilian setting, where between 2003 and 2016 there was an incipient shift in the role of the state towards promoting risk- and reward-sharing through public–private partnerships (Chapter 2), enables in-depth analysis of the instruments developed in this process. Case studies are well suited for examining contemporary and complex problems at length and within their real-life context (Yin 2009). They can help to illuminate a particular issue or illustrate theoretical insights about it (Miles & Huberman 1994; Stake 2005).

Formalised in 2011, the collaboration between BNDES, a public financial institution, and CSEM Brazil, a non-profit research centre, involved public support

in the form of grants, the result of which was the creation of a spin-off company. The novelty of the contract design, consisting of moving from a non-refundable grant to a scheme in which the rewards could be shared, had been brought to my attention during fieldwork in 2016. The specific characteristics of the contract, embedded in its context, invited a detailed case study. Apart from being unique in Brazil, this case illustrates a strategic behaviour of the public financier in supporting the early stages of technology development that would normally benefit from non-refundable resources. By assessing the dynamic links among public and private actors, policy goals, tools and outcomes, this study highlights contractual amendments made by the state in the attempt to achieve equitable relationships as it begins to perform as a risk-taker.

Empirical legal studies tend to rely on close textual analysis of legal documents as primary sources (Genn et al. 2006; Korkea-aho & Leino-Sandberg 2019). In contrast, in the social sciences, interviews are frequently deployed and viewed as helpful for eliciting information on political and social behaviour. This method, however, is rarely used in legal research (Webley 2010).

Consistent with our view of the law being embedded in the broader social, political and economic context (Laplane & Mazzucato 2019), in this particular study I adopted a methodological approach of combining document analysis with interviews. These sources of data were appropriate to my interest in learning from the insights, experiences and perceptions of the public actors involved in the contracting process.

Data collection through interviews took place in two stages. From the total of 51 interviews conducted during fieldwork (Chapter 2), on the basis of the purposeful

sampling and snowballing technique (Atkinson & Flint 2004), those with subjects who worked at BNDES were initially selected (18 in total). The targeted public officials included key individuals who had been involved in decision-making in different ways. To avoid bias, interviewees were selected to ensure the inclusion of people occupying a wide range of positions (leadership, managerial and legal services). Next, of these 18 interviewees, a stratified sample of 5 – all those who had mentioned the CSEM partnership (interviewees 1, 6, 12, 14 and 20) – were investigated. This process allowed me to gain valuable insights from those who had been active during the inception and development of the BNDES–CSEM partnership (Table 3.2).

Table 3.2 Interviewees' profile²⁹

Position	Gender		Total
	Female	Male	
Senior civil servant		1	1
Higher executive officer	1	1	2
Executive officer	1	1	2
Total	2	3	5

Source: Own elaboration

The interviews followed an open-ended semi-structured questionnaire, which made it possible to add specific questions and probes about the partnership, when the first accounts of this case started to appear. Respondents were asked about (i) the amendments in the contract design that enabled public recoupment; (ii) the conditioning factors affecting implementation; and (iii) their overall

²⁹ This takes the year in which the interviews took place (2016) as reference, but some of the interviewees had previously held leadership positions.

perceptions about the risk–reward nexus (Interview guide, Appendix). All interviews were recorded, transcribed, coded and contrasted with notes taken on site (Kvale 1996).

The interview data was later cross-checked with the written contracts and secondary data sources to enrich and corroborate the analysis. Copies of the contracts in digital format have been obtained upon formal request from the BNDES Citizens' Enquiry Service.

Directed content analysis was used to examine both the interview and document data (Hsieh & Shannon 2005). This approach is based on the use of an initial theoretical framework in which thematic categories are prioritised and tools provided for establishing relationships between the two types of data. The continuous analytical process of contrasting data and theory allowed for findings that validated and qualified Laplane & Mazzucato's (2019) framework, while providing the means for drawing up lessons for policymakers.

3.4 A case study of the partnership between BNDES and CSEM Brazil

In this section I present the case study of the partnership between BNDES and CSEM Brazil, which involved changes in the use of non-refundable grants and resulted in the creation of the solar panel company Sunew, of which BNDES became an equity partner. The account is focused on two broad aspects. One is the division of labour: How has BNDES taken the risks of investing? For what reason? The other is the contract design: What were the reasons for changing the standard practice concerning non-refundable grants and moving into a reward-sharing scheme? What were the alternatives considered regarding the

modes of public recoupment of rewards, and the corresponding challenges involved? Before addressing these issues, some contextualisation is necessary.

3.4.1 Background

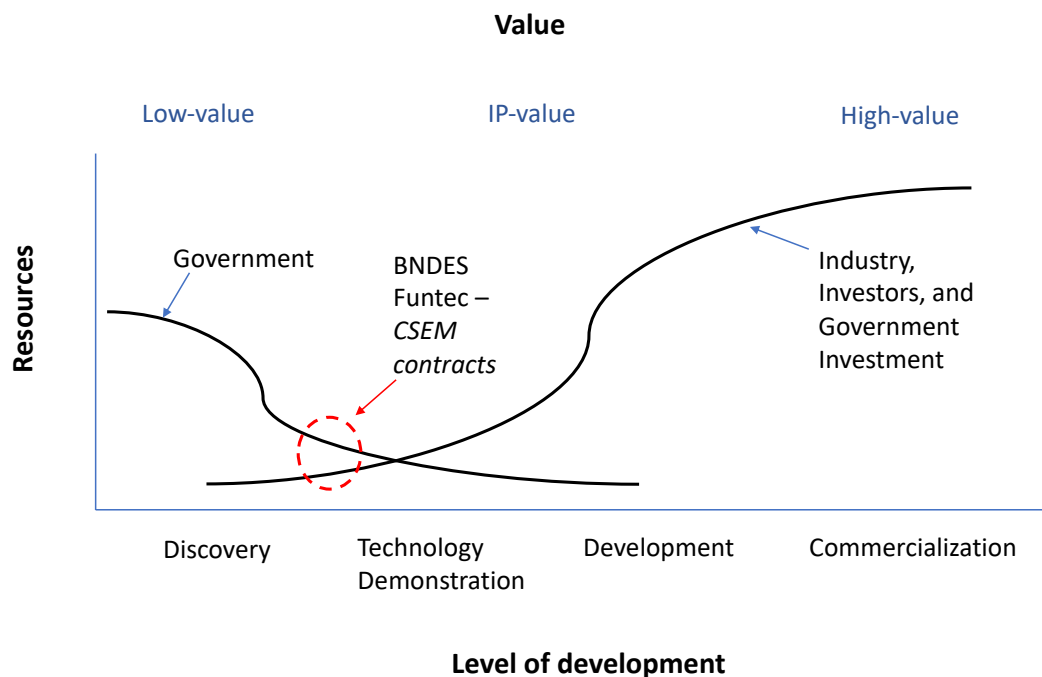
An overview of the initial situation in Brazil in the early 2000s has already been presented (Chapter 2). Essentially, the resumption of active industrial policies meant that the state placed innovation at the centre stage of its development strategy and, through BNDES, assumed the leading role as coordinator, financier and inducer of economic behaviour. In this respect, several changes in the legal and institutional frameworks ensued, which, among other things, enabled the diversification of the state's policy mix. By the end of 2016, the following financing tools were available: non-refundable grants, loans with reduced interest, capital investment (venture capital, private equity and a new hybrid instrument), besides procurement. There were also significant developments relating to the federal sponsoring public institutions.

BNDES' trajectory in development finance, in particular, and the fact that it is the main operator of capital investments in the country, make it an interesting illustration of the rise of entrepreneurial public actors. After the experience accumulated in financing the industrialisation process and in divestment during the privatisations that followed in the 1990s, the bank regained a prominent role in the 2000s, when it incorporated the promotion of business innovation into its mission. From 2007 onwards in particular, the bank's investment arm BNDESPAR became crucial to the (early) development of the entrepreneurial finance landscape in the country. Although acting on a scale that was still

insufficient, the bank supported the creation of venture capital funds and became a minority equity partner in ground-breaking SMEs that had high growth potential.

Against this background, and considering the underlying institutional structure – banks operate in the expectation of achieving a monetary return – BNDES took part in the only known case in Brazil of the conversion of a non-refundable grant into a reward-sharing agreement (Figure 3.1). Since the partnership targeted the early stage of technology development in a sector with high potential for social benefit (renewable energy), it offers an appropriate setting for looking into public institutions' contractual practices and attitudes towards the risk–reward nexus.

Figure 3.1 *The BNDES–CSEM partnership in the innovation funding landscape*



Source: Own elaboration based on Jackson (2011)

In the context of this study, a key institutional innovation was the recovery of BNDES Technology Fund (FUNTEC) in 2006, which had been established in

1964 but discontinued shortly after. Originating from a share of BNDESPAR profits and replenished annually, the fund now supports R&D collaboration between research institutions and business, involving early-stage and potentially disruptive innovations. Besides being the only source of non-refundable grants that BNDES operates, a distinctive feature is that the money cannot be supplied to companies directly. Statutory rules only authorise it to be applied to scientific and technological institutions (Decree n. 4418, 11 October 2002. Art. 9, IV). The Innovation Law (Law n. 10973, 2 December 2004) also restricts this type of support to the mandatory sharing of IPR between collaborating entities. Despite these requirements, and given that the bank has greater independence over the use of FUNTEC money than it has in relation to other sources, it was possible to gradually accumulate experience in mobilising resources in selected directions. Priority has been given to those projects that tackle issues such as aging populations, smart cities, urban mobility and renewable energy (Souza et al. 2016). The partnership between BNDES and CSEM fits in with the bank's efforts to meet this latter challenge.

3.4.2 BNDES as a risk-taker

Solar power, as a clean and renewable source of energy, is considered one of the alternatives that can be used to mitigate the environmental harm caused by greenhouse gas emissions. Although solar panel technologies have matured in the past years, allowing for large-scale production, their widespread use has yet to be achieved. The obstacles for diffusion stem from certain attributes of traditional technologies – both physical (such as their weight, rigidity and opacity) and economic (related to their limited applicability and high costs). Therefore,

overcoming these hurdles opened opportunities for breaking new ground in energy solutions.

Created in 2006, CSEM Brazil is a private non-profit centre for applied research modelled after a similar institution already in place in Switzerland – the Swiss Centre for Electronics and Microtechnology (CSEM). In 2010, with support of public and private funding sources, CSEM Brazil started research on organic printed electronics, with a view to developing organic solar panels (OPV). Because these panels bring together qualities such as flexibility, lightness and transparency that will enable them to be used in smart buildings, urban furniture, mobility aids and many other new applications, they are deemed to be the next generation of solar panel technologies. However, developing the capabilities and infrastructure needed to confront the challenges inherent to the incipient stages of any technology, and its production processes, were key obstacles that had to be overcome before OPV could be brought to market.³⁰

Examining the prospects for OPV in Brazil, BNDES' public officials noted that although the country had positive enabling conditions, there were some weaknesses (Rivera & Teixeira 2014). The strengths included a promising R&D base (CSEM Brazil worked with a highly skilled team and networks worldwide), access to high solar incidence, potential demand from local industries, and (mostly public) funding sources for R&D. That said, no doubt the risks of investing in OPV were high: the technology might not mature; OPV competitors might advance faster; or local companies might not meet the scale needed to compete globally. On the other hand, interviewees were mindful that if BNDES did not take

³⁰ CSEM Brazil. <http://csembrasil.com.br/> (Accessed on 3 June 2019).

the chance, it could not enjoy the potentially huge successes either (Mazzucato 2013). The achievement of such a cutting-edge technology represented an opportunity to fuel sustainable and long-term growth:

There [were] huge technological risks (...) but at the same time [the research results] could be highly valuable...Who was making [that undertaking] possible was the state. If there weren't the support from BNDES, this initiative wouldn't consolidate (Interviewee 20, PublMa).

Considering this, when CSEM Brazil's investors reached out to BNDES prior to starting OPV research, late in the 2000s, the bank was willing and able to accept the risks. The bank granted support through FUNTEC in two occasions, nearly R\$ 45 million (or \$ 25 million) in total, becoming the main sponsor of the initiative. According to one of the research centre's creators, BNDES "was the only place in the country in which they found people who understood their project" (BNDES 2018). Thus, by acting as the main financial actor to put its capital at risk for the development of a cutting-edge technology with promising (but uncertain) commercial prospects, once again BNDES revealed its role as a lead investor, risk-taker and entrepreneur (Chapter 2).

3.4.3 An imbalance in the risk–reward nexus as an obstacle

The partnership between BNDES and CSEM was already innovative in the structure of the financial contract design. As noted in Section 3.4.1, by law, the bank's use of non-refundable grants was typically conditioned to: (i) the presence of a company collaborating with the supported research institution; and (ii) IP sharing between the two. The former was aimed at stimulating linkages in the innovation system. The latter, according to interviewees, indicated an implicit understanding regarding the public appropriation of potential rewards in the

sense that it would occur mainly through positive externalities (e.g. spillover effects, job creation and economic growth):

ICTs (research institutions) can use and license the same technology to different companies, which increases the chances of generating spillovers, further innovations, economic growth, and job creation (Interviewee 1, PublMa);

and

The concept was (...) to maximise [positive] externalities to society. This was [a] sufficient [mechanism of public appropriability] in most cases (Interviewee 14, PublMa).

In practice, this materialised in the contractual requirement for research institutions to retain the IPR and know-how developed, which could exceptionally be negotiated and take the form of a temporary exclusive licence for cooperating firms. As a result, BNDES tended to be rewarded rather indirectly, meaning that it would not retrieve any financial gains from FUNTEC resources.

Nevertheless, the operational model of CSEM did not fit this scheme. CSEM worked under three main scenarios for the exploitation of research results: (i) if the technology became viable, it could be developed by the industry upon the payment of royalty fees; (ii) the research centre could opt to develop it by itself; or (iii) it could create a spin-off company for that same effect. In this latter case, besides the equity stake in the start-up in question, CSEM would hold an exclusive technology licence agreement with this company (Arruda et al. 2016). However, if this choice prevailed, it would break down the bank's expectations of achieving indirect returns via spillover effects. This is so because an exclusive IPR licence granted too early in the R&D process may block or slow-down diffusion and follow-up innovations (Mazzoleni & Nelson 1998).

The perception of interviewees supports the interpretation that keeping the contract as it was implied accepting an imbalance in the risk–reward relationship in the public–private partnership. Therefore, in order for the operation to proceed, revising and adapting the standard contractual practice was needed:

As CSEM operated under exclusive technology licences, we supported the creation of technological capabilities but decided that in case of success, we would have the right to become partners of the spin-off company. This is an appropriability mechanism on behalf of the state (Interviewee 14, PublMa).

3.4.4 The contract design: from non-refundable grant to equity stake on spin-off

BNDES went on to pioneer provisions in the contracts signed in 2011 and 2013, which entitled it to capture a direct share of financial gains. In the first contract (n. 10.2.1969.1 of 18 January 2011) public support focused on the creation of an adequate research environment. It involved R\$ 12.892 million (\$7.524 million) aimed at the development of systems oriented towards precision farming based on Low-Temperature Co-Fired Ceramics (LTCC) and Microelectrical Mechanics. This in turn included investments in technology absorption, professional training, and building and equipping a laboratory for LTCC development. With regard to the mechanisms for the state's appropriation of research results, Clause XXV assigned to BNDES the priority right to buy (for 1 R\$ each) shares or any securities convertible into shares issued by companies in which CSEM Brazil might become an equity partner. In so doing, the contract effectively served to play out the scenario of creating a spin-off company. In contrast, Clause XXXII addressed the possibility of CSEM opting to produce and commercialise the results of the supported technology itself. Should that be the case, the research

centre faced the obligation of paying royalties of five percent (5%) of gross revenues to BNDES.

The interviews show that this contractual choice was also driven by some public officials' concern about intrinsic tensions in the entrepreneurial finance landscape; these tensions became apparent when the state acted as a risk-taker, in part, because this operation drew the attention of venture capitalists, who nonetheless were not putting resources in at that stage (Interviewee 20). Beyond that, what the industrial application of research results would be was still unclear, although the presence of an established research centre as a partner (CSEM Switzerland) signalled the possibility of important achievements (interviewees 14 and 20). These elements reinforce the idea that the amendments in the financial contract design openly challenged another potential imbalance in the risk–reward relationship, not only because an exclusive technology licence prevented the public bank from fulfilling its expectations of achieving high spillover effects, but also due to the presence of venture capitalists being perceived as representing an imminent risk of disconnection between those who would bear the risks and those who would reap the rewards of innovation (Mazzucato 2013; Lazonick & Mazzucato 2013).

A key feature of the contractual tool adopted was its flexibility, as it provided for different forms of remuneration of the state's contribution, depending on the circumstances at issue (Clauses XXV and XXXII). However, some limitations can also be observed. Clause XXXII, in particular, did not specify a minimum revenue basis, a maximum cap, nor the time frame for the companies' obligation to pay royalties to BNDES. While these omissions could have been the focus of additional tensions and technical difficulties in the implementation (Windus &

Schiffel 1976), they could also have been a sign of the public institution's caution. Allowing some room for manoeuvre was important to avoid imposing too strict a set of measures that could have hurt SMEs – which would have been at odds with the very policy objective of promoting their growth.

The second contract (n. 13.2.0371.1 of 21 May 2013) introduced positive changes. The circumstances were also different, starting with the much higher value at stake, namely R\$ 32.321 million (\$17.247 million) and the greater clarity in relation to the expected results, which now would go beyond R&D infrastructure and process to include product innovation. The stated aims of the contract were the installation of an OPV technology platform *and* the development of low-cost solar panels. This contract mirrored that devised in 2011 in that it defined the right of priority to BNDES (now under clause XXXI), and of receiving a share of revenues (now XXXVI). It also kept open some important aspects of the implementation of this latter provision. Nonetheless, it differed in that it established a term of 15 years within which those rights could be exercised (Final paragraph in the third Section of the agreement). Thus, in this regard, the 2013 contract design was an improvement in relation to the previous contract in that it helped to reduce the uncertainties (and eventual conflicts) that the lack of boundaries for the sharing of rewards of high-risk ventures could potentiate. Table 3.3 below summarises some of the contract amendments.

Table 3.3 Contract design before and with the CSEM case

Provisions	Before CSEM (2007–2010)	CSEM contracts (2011 and 2013)
Purpose of public support	Multiple	R&D infrastructure, process innovation and capability building (2011) Technology platform and product innovation (2013)
Value of public disbursement	R\$ 277 million (aggregate)*	R\$ 12.892 million (2011) R\$ 32.321 million (2013)
Recoupment mechanism	None	Priority right over shares or convertible securities issued by company in which supported institution may become partner OR Royalties of 5% of gross revenues
Boundaries for recoupment implementation	None	Non-written (2011) 15-year term for exercising those rights (2013)

Source: Own elaboration. (*) Based on figures reported by Souza et al. (2016).

It was only when CSEM's efforts in OPV began to bear fruit that these agreements with BNDES were put to the test. In 2015, the research centre created its first spin-off company, Sunew, "launched as the largest and most modern OPV manufacturing line in the world."³¹ BNDES then opted to exercise its right through BNDESPAR, participating as a minority shareholder with nearly 25% equity stakes. Besides CSEM Brazil and FIR Capital (venture capital fund behind CSEM Brazil), who had been working together with BNDES since the inception of OPV research, Sunew attracted two investors from the energy sector, Tradener and

³¹ CSEM Brazil. <http://csembrasil.com.br/> (Accessed on 3 June 2019).

CMU. They also became equity partners. From that moment, Sunew was constituted as a company with full national capital ownership. The company has shown signs of expansion ever since (Table 3.4). In this manner, the ingenuity of public officials proved effective in enabling government funds to co-create a high-value venture, while shaping an equitable financial relationship insofar as the appropriation of potential financial gains was concerned.

Table 3.4 Timeline of a successful attempt at building the risk–reward nexus

Year	Event
2006	CSEM Brazil, a joint venture between FIR Capital and CSEM Switzerland is set up; its focus is to create new products and undertake research into innovative solutions.
2008	CSEM Brazil starts its operations, with support from public (FAPEMIG and FINEP among others) and private sources.
2010	The research and development of OPV technology begins.
2011	Signature of first contract with BNDES involving R\$ 12.892 million (via FUNTEC).
2013	Signature of second contract with BNDES involving R\$ 32.321 million (FUNTEC).
2014	Roll-to-roll printing equipment developed by CSEM Brazil team, manufactured in Germany, is brought to Belo Horizonte for installation and initial testing.
2015	Sunew is set up, a spin-off responsible for manufacturing and commercialising large-scale OPV film, with the largest and most modern production structure in the world. BNDES exercises its stock option and becomes a minority shareholder (25%), together with CSEM Brazil, FIR Capital, Tradener and CMU.
2016	Sunew produces and delivers the largest OPV installation in the world at Totvs headquarters in the city of Sao Paulo, Brazil.
2018	Sunew opens an office in Silicon Valley.
2019	Sunew signs a contract with EDP – a leading company that operates in all segments of the electricity sector – that will result in the largest installation in the world to use adhesive OPV technology on facades.

Source: Author's adaptation of Sunew's timeline. (<https://sunew.com.br/>) (Accessed on 15 July 2019). FAPEMG, Foundation for Research of the State of Minas Gerais.

To sum up, this case illustrated a situation in which the public sector explicitly aimed to act as a risk-taker, but encountered legal–institutional obstacles – one of which consisted of an imbalance in the risk–reward nexus. The contractual amendments ensuring an equitable sharing of the rewards of financing innovation between the public sponsor institution and the private sector was then devised as a tool for enabling this partnership to materialise. This also meant incorporating a greater degree of flexibility into the originally non-refundable financial instrument so that the parties could adjust to the circumstances at issue.

3.5 Towards symbiotic innovation ecosystems: lessons from financial contract design

Although the circumstances underlying the partnership between BNDES and CSEM are unique in the context of the bank’s allocation of FUNTEC funds, this case study offers an opportunity to explore in detail the perceptions of public officials regarding this experience and to derive the main lessons about the risk-taking role of the state in shaping symbiotic innovation ecosystems. In this section, key issues are discussed that public funding agencies may need to confront: devising robust but flexible and enabling financial contracts; learning to design and negotiate these contracts; developing institutional strategies to fulfil the potentials for socialising the rewards, not just the risks; and tackling existing limitations, whether at the domestic level, or those arising at the interface between the local scope of government funding and the global financial landscape. On that basis, it is possible to identify some desirable attributes and emerging functions of contracts, aimed at building a balanced risk–reward nexus in public–private partnerships (Table 3.5). These features, which are closely interconnected and to some extent overlap, are examined below.

Table 3.5 Key lessons from contract design: attributes and emerging functions for balancing risks and rewards

Attributes/ Functions	Key lessons
Flexibility	<ul style="list-style-type: none"> - Public recoupment can be optional and attached to the occurrence of pre-specified events linked to successful performance; - Provision of alternative mechanisms for implementation (e.g. equity stakes, royalties on revenues, or others) can increase the likelihood of attracting business;
Ambiguity	<ul style="list-style-type: none"> - Loose boundaries for recoupment (e.g. no term of duration, no cap) can provide for manoeuvring room; - However, conflict between the parties is highly likely.
Levering	<ul style="list-style-type: none"> - Recoupment mechanisms negotiated on a case-by-case basis can increase the chances of striking a deal; - Choice of implementation tool for taking into account the relative strength of alignment with supported firm's residual value can help build a balanced risk–reward nexus.
Legitimation	<ul style="list-style-type: none"> - Negotiation of recoupment outcomes as one of the assessment criteria of the performance of public funding institutions can help to create a shared vision of the importance of the role of the state in innovation; - Institutionalisation of revolving funds through which the amounts recouped can be continuously reinvested into R&D and innovation also contribute to signalling the value of the role of the state, if public investments target contextual social needs; - Signalling that state involvement is not an end itself but meant to lead to success and exit, whenever possible, also plays a positive legitimising function.
Preservation	<ul style="list-style-type: none"> - Institutionalisation of revolving funds through which the amounts recouped can be continuously reinvested into R&D and innovation also contribute to signalling the value of the role of the state, if public investments target contextual social needs; - Negotiation of safeguards to protect the value generated through public support, such as through retaining golden shares in strategic supported companies or devising other solutions, are key for tackling the risk of denationalisation.

Source: Own elaboration

Flexibility. Implementing an active role of the state at the incipient stage of technology development, which is fraught with high uncertainty and high technological and market risks, requires the fashioning of a widely flexible contractual instrument. Compared with the standard design of non-refundable grants, the new clauses adopted in both the 2011 and 2013 contracts embodied alternative mechanisms of public recoupment: stock options/convertible securities; or royalty fees upon revenues. Such flexibility is desirable in order to adjust the deal to the circumstances that will only become clear as the innovation process unfolds. The occurrence of specified events associated with the success of the R&D endeavour and CSEM's strategy to exploit it (Arruda et al. 2016), would then trigger BNDES' modes of participation in the results. In this regard, the contract incorporated a distinctive characteristic of venture capital, which makes the sharing of rewards conditional upon the success of the project (Triantis 2001). Hence, the analysis of this case corroborates the observation of legal scholarship on finance that the rigidity of financial commitments varies and to some extent is a matter of legal choice (Choi & Triantis 2013; Pistor 2013).

In addition, there are indications that broadening public agencies' mechanisms of public appropriability into initiatives aimed at stimulating the involvement of industries may bring other advantages. One of the lessons learned during BNDES' efforts to encourage another industry, namely ICT design services, was that the exceptional temporary exclusivity in technology licensing agreements may not be enough to activate the "animal spirits" of private sector entrepreneurs (Interviewee 1). On the other hand, this instrument proved useful in the promotion of advanced solar panels, as the CSEM case illustrates. There are good reasons to believe that the relative importance of IPR as an appropriability mechanism is

industry-specific and determined by the modes of innovation therein (Pavitt 1984). Thus, it makes sense to expect that having a range of alternative reward-sharing mechanisms when negotiating with companies from a wide range of sectors – as opposed to a one-size-fits-all type of provision – increases public agencies' chances of striking a deal.

Ambiguity. In the light of the highly uncertain and cumulative nature of the innovation process, it also seems desirable for contracts to allow room for adaptation, renegotiation and learning, which in turn requires the written language to embody some level of openness. Indeed, the presence of a mix of comprehensive and vague provisions could be found in both contracts examined. The clauses that specified different modalities of public recoupment coexisted with no definition of the time during which BNDES' options could be exercised (in the 2011 contract) and unclear boundaries for the payment of royalties (in both contracts). This suggests some ambiguity in the role of the state in the legal structuring of finance. It has been pointed that such ambiguity is manifested in the establishment of regulations essential to the functioning of financial relationships, but whose effects are eventually suspended, whenever the sustainability of the whole financial system is at risk (Pistor 2013).

In the context of government financing of innovative SMEs, this appears as a tension between wanting to spur on innovation on the one hand, and applying caution on the other, so as not to drive businesses away or harm them; because what matters the most is often ensuring incumbent SMEs a robust financial position rather than short-term gains (Kaivanto & Stoneman 2007), too much of an emphasis on reward-sharing could be counterproductive. In practice, BNDES addressed this issue on a case-by-case basis and eventually withdrew or

postponed the payment of royalties and renegotiated payment conditions (Schapiro 2012; Chapter 2). In the case study, despite the contractual alternative involving recoupment through royalties on revenues having not materialised, it is plausible to assume that the adoption of vague terms was partly intentional, since this is commonplace in contract practice (Scott & Triantis 2005). Furthermore, given that combinations of formal and informal mechanisms have been identified as the governance pattern in inter-firm contracts for R&D collaboration (Gilson et al. 2009, 2010), the finding of a similar mode of public–private interaction is not surprising. A closer and more open-ended interaction is consistent with the purposes of problem-solving and learning that condition the success of the partnerships.

Changes in public–private relationships are reflected in contracts and thus the degree of specification of contract provisions is also subject to change. While the 2011 contract did not clarify the timing during which recoupment provisions could be implemented, in 2013 this gap was filled by the definition of a term of 15 years within which those rights could be exercised (Final paragraph in the third Section of the agreement). In view of the fact that some gaps continued to exist, this case shows that financial contract design is as much an enabling policy tool as it is a gradual process: it co-evolves with the broader legal framework, the underlying conditions of the partnership in question and the experience accumulated by the actors involved.

In addition to the attributes of flexibility and ambiguity just noted, there are at least three essential functions that contract design processes should aim to perform, which are examined next.

Levering. Although the contractual relationship is established between the public institution and an actor in the private sector, its legal form must be thought of as governing interactions among a broader range of actors (Herder 2008; Laplane & Mazzucato 2019). Engaging with business requires the building of mutual trust. However, firms may not be equally receptive to the different mechanisms that allow for public institutions to recoup a share of the rewards of innovation. Not long before, in 2010, in the framework that was set up to enable the BNDES Profarma line to support pharmaceutical R&D, the bank attempted to introduce a new financial instrument that involved a profit-sharing scheme similar to the royalty provision established in the CSEM contract – the Risk-Sharing Contract with Participation in Future Results (BNDES 2010). However, from interviews with public officials, it appears that this initiative failed due to a general aversion on the part of companies (Chapter 2), among other reasons. German public institutions had had an analogous experience, one study found (Rothgang et al. 2003). Accordingly, grants with qualified repayment schemes lacked businesses' acceptance partly because of the requirement to disclose sensitive information. Therefore, contract design needs to enable solutions that are compatible with companies' confidentiality, notwithstanding the standard requirements for transparency within, and accountability of, public institutions.

Regarding the interactions among financial actors in the innovation funding landscape, the contract – together with other mechanisms such as market competition and regulation – plays a role in determining the magnitude of the shares of rewards that different actors may be able to appropriate. As one of the interviewees asserted, amendments in the contract went beyond addressing an imbalance in the relationship between BNDES and CSEM. It also sought to

mediate the tension generated by the coexistence of other types of financial actors, operating under a short-term, high-return rationale (Interviewee 20). Due to way in which private venture capital funds operate, one can infer that having BNDESPAR participate in the capital gains of the newly created company, which had benefited from high-risk public support early on, can be seen as a superior policy choice to other profit-sharing tools, which only allow for lower or indirect alignment between risks and rewards (Table 3.1). If the aim is to shape a symbiotic innovation ecosystem, then the revenue basis for government recoupment (and the timing of exit) are relevant dimensions to be taken into account in the process of leveraging private investments (Laplane & Mazzucato 2019).

Legitimation. The contracts underpinning public–private partnerships also play a legitimising function, which is equally important for sustaining the entrepreneurial activity of the state (Laplane & Mazzucato 2019). The timeline shown in Table 3.4 illustrates the sequence of events that led to the emergence of Sunew and its continuing appreciation. The company is currently well capitalised (BNDES 2018) and owns installed production capacity in OPV solar panels of 600,000 m² per year.³² In that connection, while the financial return to BNDES was a secondary objective – as in fact it emerged from a rather ad hoc contract design in FUNTEC disbursements – some public officials perceived it as useful policy tool for signalling the value of the state’s role:

BNDES exercised the right to participate in the company that was created, which is a [direct] return to the bank and demonstrates that projects supported by BNDES FUNTEC can reflect on the development of value for BNDES (Public official’s quote drawn from BNDES (2018)).

³² www.sunew.com.br (Accessed on 22 July 2019).

This perspective implies that enabling public actors to recoup a share of financial rewards provides for an objective measure of success of their performance, in addition to highlighting the contribution to addressing socially desirable policy objectives (Mazzucato 2016). Furthermore, it is also useful as management tool, as it offers opportunities for monitoring the performance of supported firms. Hence, the evidence supports the interpretation that developing tools for favouring a balanced risk–reward nexus serves the purpose of building a shared notion of the importance of public finance (Laplane & Mazzucato 2019).

It is worth mentioning that legitimization was an especially relevant issue in the Brazilian context, where the legal foundations for public risk-taking were (and still are) in the making (Chapter 2). Speeding up this political and legal construction, in turn, requires a key focus of tension within government to be overcome, which can be boiled down to the assessment criteria used to control public expenditures. According to interviewees, external and internal oversight bodies rely on standardised rules, which have been interpreted as impeding the state's entrepreneurial function:

The rules (...) are the same regardless of the operation [e.g. size or profile of the company] (...). Control bodies would need to allow the bank to expose itself to more risk [which in turn] would require BNDES to adapt [its] financial instruments, like we did with CSEM (Interviewee 20).

For some interviewees, the pathway for mitigating this tension involved taking active steps to negotiate assessment criteria (interviewees 6 and 20). But there were also perceptions that transforming the ad hoc and bold contractual design

analysed here into an institutionalised practice could help to solve the issue (interviewees 1, 6, 18 and 20):

Institutions [supported through FUNTEC] develop new things, generate spin-offs and obtain gains that we don't appropriate. If we had some mechanism that enabled us to obtain some return, be it in the form of equity stakes or recoupment of the amounts offered, we would be much more comfortable about offering further support to those who have already benefited from public funding before (Interviewee 1).

As a matter of fact, ideas to make FUNTEC a revolving fund were mentioned. The experiences of this type of government initiative in countries such as Israel, Finland and Switzerland, indicate that states can successfully engineer and manage venture capital funds while building equitable public–private partnerships. In spite of this, in the context of BNDES' recent role in fostering business innovation, this and other ideas on how to approach the risk–reward nexus have yet to mature. This is something that public officials acknowledge (Interviewee 14). Hence, the case study shows that as public institutions explicitly move towards proactive risk-taking and sharing, they are confronted by the need to re-frame and implement their views regarding the direct appropriation of potential rewards.

Preservation. The analysis of the positive functions that contract designs can have on public–private partnerships should also include some caveats. On the one hand, at the local level, there are institutional difficulties that need to be overcome in order to ensure that any amounts eventually recouped by public actors will be used to replenish public funds and be reinvested into R&D and innovation. Public officials' accounts of the constraints they were faced with over proposals for turning FUNTEC into a self-sustainable fund (mentioned above),

illustrates this issue. On the other hand, as the literature on industrial policy has highlighted, the increasingly competitive and global playing field imposes additional challenges for local governments to reap the potential rewards of investments in tech-based firms. Hockett and Omarova (2014) identified ‘market-preserving’ as one of the state’s instrumentalities in the US financial sector. Drawing a parallel, the problem of public institutions taking on the financing of innovation can be seen as one of preserving the new markets that their risk-taking role helped to create, in a context of increasing international capital mobility.

Issues of this nature – (de)nationalisation – that have increasingly become a concern for policymakers in middle-income countries³³ (Andreoni 2016), seem to have more general scope. In the partnership between BNDES and CSEM Brazil, the presence of BNDEDPAR as an equity partner in the spin-off company Sunew helped to ensure national, instead of foreign, capital ownership. This strategic aspect regarding national sovereignty is even recognised by some Brazilian companies (Chapter 2). Nevertheless, the fact that the state-owned bank acts as a minority shareholder means that it has no right of veto over key corporate events such as the potential sale to foreign groups. In contrast, during the period of privatisations in the 1980s and 1990s, several governments throughout the world, including the UK, made use of golden share clauses as a means to safeguard national industries (Jones et al. 1999). Therefore, legal choices are not equally effective in meeting a ‘market-preserving’ policy goal.

³³ “Deindustrialisation (the loss of strategic manufacturing industries), increasing trade imbalances, and decreasing technological dynamism have all been major concerns in advanced industrial economies. Meanwhile, in middle-income countries, governments have been increasingly threatened by emerging giants that are capturing global manufacturing production and export shares, aggressively pulling ahead in the global technological race” (Andreoni 2016, p. 245).

More recently, within the framework of Germany's National Industry Strategy 2030 launched on 5 February 2019, the government announced the creation of an investment fund aimed at protecting those of its companies deemed strategic from a technological standpoint. The policy document affirms that the state may do so "for a limited period of time", if necessary to prevent them from being controlled by foreign shareholders (Federal Ministry for Economic Affairs and Energy 2019). It is still too early to know which contractual tool will be adopted, and how effective it will be in Germany. However, two key observations can be made in light of the comparison with the BNDES–CSEM partnership. The first aspect to highlight is the asymmetries in terms of governments' accumulated power, resources and institutional capacities in the two cases, as determinants of the reach of their actions. In resuming its role as coordinator of the industrial strategy in Brazil, following the neoliberal experience of the 1990s, BNDES only went as far as becoming an equity partner of a few new firms; in contrast, in Germany, where industrial and innovation policies have been kept active over recent decades, the government now seems to have the confidence to go one step further in sustaining its position in the global market. The second observation brings some hope. BNDES' very experience with CSEM illustrates, once again (Chapter 2), that favourable political, economic and institutional conditions can allow room for experimentation with legal designs and improvements in public–private relationships that has promising outcomes. The recognition of the leading role of state as an investor is, thus, essential for encouraging creativity in contractual solutions that are suitable for playing the risk–reward game in local and global playing fields.

3.6 Conclusion

The aim of this chapter has been to identify desirable attributes and emerging functions of contracts that can allow for public–private partnerships to share both the risks and rewards of financing innovation. To this end, the purposes of public funding bodies opting to recoup part of their investments, as opposed to relying on non-refundable grants, have been explored. Emphasis has been given to the challenges of creating new policy instruments, while overcoming institutional obstacles, for sustaining dynamic and symbiotic innovation ecosystems.

The case study involving the partnership between BNDES and the research centre CSEM Brazil has provided key insights. Specificities underlying the R&D project – i.e. an exclusive IPR licence blocking follow-up innovations and diffusion, in addition to perceptions concerning the opportunism by risk-averse private venture funds – created an imbalance in the risk–reward relationship that impeded the materialisation of the partnership. The solution found was to incorporate contractual provisions that rendered the non-repayable grant similar to venture capital. That is, in the case of success, the occurrence of certain events would give the public investor the possibility of capturing a share of financial return, through alternative means – equity stakes or royalties on revenues. To that effect, the contracts embodied attributes such as flexibility and ambiguity, as well as leveraging, legitimising and preserving functions. Further empirical analysis could help shed additional light on the theory and practice of contracts led by entrepreneurial public institutions.

The analysis of this experience of contract design, and the resulting lessons, lead to some conclusions.

1. While it is true that the underlying institutional and legal frameworks within which governments operate condition their ability to step towards the entrepreneurial endeavour, there is also some degree of agency. Contract design, in particular, has been shown to be an effective enabler of the role of the state as a creator of a new market and shaper of a symbiotic ecosystem. A trade-off must be noted, however, between the formalisation that provides for the stability and predictability of investment decisions, and the flexibility and ambiguity needed to adapt to contextual circumstances under high uncertainty. Finding a balance is a rather experimental exercise;

2. The engineering of these tools is also highly dependent on the knowledge and capabilities accumulated in public funding institutions; but there are instances in which these can be harnessed and improved over time, resulting in more equitable public–private partnerships. In the five-year period between the reactivation of FUNTEC and the CSEM case, BNDES was able to build up capabilities, improve the practice of non-refundable grant allocation, and sort out a contractual solution that was creative and effective. Therefore, it is also possible to change institutional frameworks in ways that allow for learning and result in enhanced policy outcomes;

3. Preserving these achievements, however, appears to be challenging. At the global level, the highly competitive, concentrated and internationalised nature of the financial landscape creates pressures for innovative responses from local governments. This is due to the increased potential for the benefits of successful high-risk investments to be reaped by global players, to the detriment of domestic investors. Just as important, at the domestic level, legitimising and institutionalising a strategic, future-looking attitude of the public sector encounter

significant barriers. There are major challenges in aligning the perceptions of auditing bodies over the progress and outcomes of public support, with the perceptions of policymakers and public officials. This, in turn, may translate into increased liability risks for public actors, which can discourage, instead of nurture, the desirable contractual solutions for the sake of promoting technological innovations. Another challenge that must be overcome is the possibility of policy discontinuities. Although there is evidence indicating that contract design underpinning reward-sharing in public–public partnerships is seen as a useful tool for mitigating this problem, building a shared vision that can lead to institutionalising such practices is a long-term process.

It would not be reasonable to assume that economic policies (and especially innovation policies) will not involve errors. Most of these are inevitable, given the high-risk nature of the investments required. Precisely because of this, it is crucial that public institutions get to learn from failure. Likewise, since the successes will be rare though transformational, they deserve due recognition (the case of BNDES–CSEM illustrates that promoting such transformation is indeed possible). It remains to be seen whether the OPV solar panel technologies will mature and whether the emerging tech company Sunew will attain the first-mover advantages in the world market, the potential for which had motivated BNDES to fund it. Meanwhile, the equity participation owned by BNDESPAR leaves a traceable record. If the company succeeds, society and the bank itself will be rewarded appropriately. If, in addition, such rewards were to be used to replenish the funds that first originated the investment, and to continue to support new high-risk ventures, societal benefit could be maximised.

Chapter 4 Conclusion

In this thesis I have analysed the emergence of an active role of the state as a risk-taker and co-investor in technological innovation. In particular, I have focused on policy initiatives aimed at building public–private partnerships that allow public actors to directly appropriate financial rewards in the event of success. I have examined instruments like royalties, equity stakes and conditionalities involving issues such as pricing, knowledge governance and reinvestment, among others. My main claim was that these initiatives cannot be fully understood without a framework that takes into account the position of public actors as market-creators and, hence, contract-makers and drivers of legal and institutional change (which I have called ‘market shaping’). I have also argued that this new approach could help tackle contemporary societal challenges.

Through three chapters³⁴ in this thesis, I have explored the following overarching question: *How can public–private partnerships be effectively implemented and scaled up to address contemporary societal challenges?* In this concluding section, I return to this question by, first, summarising the findings and contributions of the chapters to the argument made in the thesis and, second, highlighting key policy implications. I then reflect on some limitations of the thesis and conclude by outlining avenues for future research.

³⁴ Chapter 1 is a slightly modified version of a working paper that I published with one of my supervisors (Laplane & Mazzucato 2019) and that is currently under review in *Research Policy*; Chapter 2 is an extension to a paper that I presented for review to the *SPRU Working Paper Series*; Chapter 3 is the outcome of a case study that I conducted specifically for this qualification.

4.1 Findings and contributions

In Chapter 1 a normative question was posed: How can both the risks of innovation and the rewards be shared between public and private actors? I answered this question through reviewing, discussing and analysing different theoretical approaches. This allowed me to identify the dominant narrative as one that construes the role of the state as limited to the correction of market failures and therefore having no reason to be rewarded beyond the natural mechanisms of economic growth and taxation. I also developed an alternative account. If the rationale for the role of the state is viewed further as co-creating and shaping markets, then, through active risk-taking, a public actor might be motivated to resort to a broader set of instruments to appropriate a share of rewards. I have classified these rewards into two categories: profit-sharing and conditionalities. Overall, the analysis in Chapter 1 drew attention to the legal dimension as one of the drivers of how, through experimentation and incremental changes to the framework conditions, the state may be able to accumulate the capabilities and powers to build effective and equitable partnerships geared to the solution of contextual problems.

In chapters 2 and 3 I offered qualitative evidence in support of the initial framework published in Laplane and Mazzucato (2019); I also highlighted some qualifications. In Chapter 2, I presented my analysis of a comprehensive comparative case study of two R&D programmes in Brazil that had features of mission-orientation. These programmes involved advanced biofuels and health. I found evidence related to five dimensions of effective public–private partnerships, including the objectives of the programmes. These dimensions were: the presence of public actors seizing mapped opportunities in areas of high

social benefit, taking the lead, engaging in risk-sharing and institutional building, pursuing measures to manage the risks, and seeking to share in any rewards through profit-sharing and conditionalities.

Furthermore, my analysis of the preliminary results of the programmes through the lens of the risk–reward nexus has led to some potentially significant findings. Not only were the risks taken by public and private actors linked to one another, but so were their potential rewards. While public risk-taking has both attracted and accelerated private investments, limitations in the partnerships and those regarding the instruments adopted for sharing the rewards became apparent. The latter, in particular, exposed the importance of appreciating the specific dynamics between the local scope of the policies and the increasingly global character of the economy – and these dynamics represent a potential source of disconnection in the risk–reward nexus.

In Chapter 3, I deepened the analysis of the legal underpinning of public–private partnerships, focusing on the features of contracts that enable reward-sharing among the parties. In a market-failure framework, one would expect financial contracts embodying attributes like predictability, efficiency and security, if they were to fulfil their function as cost-mitigating devices. I formulated the hypothesis that additional features (attributes and functions) would appear in contracts designed by public actors who embraced an active entrepreneurial role, and investigated it empirically. The research question was: What attributes and emerging functions of contracts enable a move from a situation where the parties do not share any rewards, to another that facilitates the construction of a balanced risk–reward nexus? Based on an in-depth case study of the partnership between BNDES and CSEM Brazil geared to R&D in second-generation solar

panels, I was able to identify the attributes of flexibility and ambiguity, and new functions, namely, leveraging, legitimation and preservation. While contract design has been shown to be effective in building the risk–reward nexus, important challenges for institutionalising this type of practice were also noted. These were mainly related to the misalignment between the perceptions of auditing bodies and those of policymakers regarding what constitutes good performance in innovation policy.

Taken together, the three chapters in the thesis contribute to the academic literature at the intersection between the fields of the developmental state, legal institutionalism and the entrepreneurial state and, in particular, to the discussion on the nexus between risks and rewards in public investments in innovation. By combining elements of the three theoretical approaches mentioned above, the analysis in the thesis (Chapter 1) shows that they can enrich one another and generate insights into concrete innovation policy issues. Although the relationship between the role of the state in economic development and technological innovation has been explored in previous studies, legal institutionalism can bring to these fields an understanding of how the law constitutes and influences the governance structures underpinning such transformative processes. Also significant is what the legal institutionalism approach can learn from the literature on the developmental state and the entrepreneurial state: namely, how institutions govern development processes and how state risk-taking capacity can drive economic performance, innovation and its direction. In addition, by exploring the connections between these three bodies of literature, the analysis in the thesis has enabled an understanding of how the law can structure and shift reward distributions between actors in the public and private sectors – and which

instruments could help to improve any imbalances – in favour of those states who opt for playing an active role in innovation policy.

Besides illustrating two theoretical perspectives on the risk–reward nexus, which are linked to different rationales for the involvement of the state in innovation, and identifying two set of policy instruments that can help to build a direct risk–reward nexus, the analysis in the thesis (Chapter 1) promotes the understanding of the process underlying the construction of symbiotic partnerships. By situating this ‘shaping’ process within the dynamics and tensions among state powers, within and across public organisations, and, between these, the private sector and citizens, I highlighted how the recognition of a direct risk–reward nexus can help to build a shared notion of the value of the role of the state as an investor. This value was noticeable in the analysis of concrete cases, both in the promotion of renewable energies (chapters 2 and 3) and access to health (Chapter 2).

The analysis of innovation policies in the context of Brazil, where legal and institutional frameworks for innovation are still under construction, warranted additional insights into the risk–reward nexus. First, it made it possible to qualify the nexus both as an outcome of social and legal developments – and hence, contingent upon those developments – and a process marked by tensions, power and learning relations among all those involved (Chapter 2). Second, the analysis revealed the need to broaden our understanding of this problem beyond local or national levels, and also to consider the international dynamics, especially in light of an increasingly global economy dominated by powerful global players (chapters 2 and 3). Finally, the study of the role of the state as a contract-maker (in Chapter 3), allowed me to identify features of contracts geared towards enabling risk-taking while ensuring potential rewards are shared, and to show

that the attributes and features found were useful for the successful implementation of the entrepreneurial role of the state.

The research summarised in the thesis also provides an empirical contribution to studies about the effectiveness and legitimacy of policies oriented towards market creation. Previous researchers have sometimes asserted a risk–reward nexus, but they have not investigated it empirically in concrete cases. In chapters 2 and 3 I help to fill this gap by explicitly linking the relative balance between risks taken and rewards appropriated by actors in a public–private investment partnership to a broad-based rationale for policy. On the one hand, variables such as the objectives of the policy, the stage of technology development that benefited from public support, and the depth and breadth of public funding indicated the presence of an active role of the state as an investor. On the other hand, the features of the financial instruments themselves and their actual implementation allowed me to observe how public actors may seek to appropriate any rewards using profit-sharing or conditionalities. In Chapter 3 I contribute further to the study of the risk–reward nexus in public–private partnerships by using qualitative data on financial contracts. This has made it possible for me to uncover features and functions of the contracts geared towards allowing for reward-sharing which until now have received little attention.

4.2 Policy implications

The analysis presented in this thesis could be used to assist the design, implementation and assessment of explicit innovation policies oriented towards tackling contemporary societal challenges. I outline these broad implications below.

Policy design. My research has shown that the potential for a strategic role of the state as a co-investor comes with numerous challenges, but it can be politically and legally constructed. Accordingly, policies could be designed to enable the state to act as a risk-taker, and to build a clear risk–reward nexus at the same time. While there is no blueprint for this, the specific characteristics of each context in terms of the knowledge accumulated in public institutions, the legal framework, and characteristics of the industries and firms involved must be taken into account. Direct instruments through which the state could reap a share of financial gains – such as repayable grants, royalties, equity stakes and hybrid instruments (as profit-sharing), and conditionalities on pricing, knowledge governance and reinvestment – could be useful to that end.

Implementation. The studies presented in the thesis offer evidence on the experimental nature of the process of shaping such a balanced risk–reward nexus. Each of the three cases analysed in chapters 2 and 3 illustrated attempts at implementing new financial instruments meant to allow for public investors to fulfil their roles as entrepreneurs and to capture a share of any arising financial gains. In light of these experiences, public institutions could explore various instruments, through trial and error, and learning, as opposed to relying on a one-size-fits-all type of measure. This, in turn, would require the development of higher degrees of flexibility in terms of legal contracts and new rules to avoid harming supported SMEs or discouraging further investments in innovation. By way of example, legal frameworks could allow public actors to take risks and appropriate rewards (via profit-sharing and conditionalities) by providing a non-exhaustive list of examples of instruments that could serve that purpose. Likewise, the implementation of these instruments should require that

governments build adequate governance structures. In particular, it is important that government structures develop in the directions that offer enhanced guarantees that any amounts eventually recouped by public actors will be reinvested towards tackling the pressing needs of the population. This guarantee is needed in order for entrepreneurial states to become legitimate.

Assessment. Indeed, my research has revealed that the recognition of a direct risk–reward nexus could help to build a shared notion of the value of the role of the state as an investor. However, it also showed that the misalignment between the perceptions of auditing bodies and those involved in the policy implementation has proved to be one of the most significant challenges for the legitimation and scaling up of public–private partnerships. To tackle this, the authorities involved in the assessment of the performance of broad-based policy initiatives could develop more tolerance to failures – after all, these are bound to occur because of the risky nature of investments in innovation. At the same time, they could look upon those revenues that are eventually recouped as an objective measure of success (in addition to using other quantitative and qualitative criteria); they could also regard the presence of recoupment instruments as an indication of the equity of the partnerships. To achieve this, the interactions among the actors involved in the policy process must go well beyond what they are now. Overall, such a trust-building process could bring significant benefits in terms of setting new standards for failure and success of public initiatives that are better suited to twenty-first century innovation policies.

4.3 Limitations

While the main insights generated on the basis of this research have been highlighted, some limitations to the work must be acknowledged. These are mostly related to the scope and focus of the research design adopted. In any qualitative study, researchers are faced with a difficult trade-off decision. One can either opt for widening the scope of the analysis, in favour of a greater degree of generalisation of results, or rely on a more focused design, in favour of depth and detail. Both carry advantages, but they also imply giving up on something, namely, depth on the one hand, and scope on the other.

In considering these options in my investigation of the risk–reward nexus – an understudied issue, about which there was scant theoretical or empirical work – I gave priority to focus and depth. This means, however, that I limited myself to covering a relatively small number of cases (and their corresponding programmes, actors and policy instruments), all of which were bounded within the context of a single country. Nevertheless, in light of the evidence here produced, it is possible to assume that studies that cover a more extensive range of cases and contexts could contribute to an increased analytical generalisation.

4.4 Additional reflections on the Brazilian experience

As explained in the Introduction to the thesis and in Section 2.4, Brazil was far from having anything akin to a developmental/entrepreneurial state, neither before nor after the sudden liberalisation of markets in the 1990s. The cases examined in my research (chapters 2 and 3) are nonetheless interesting precisely because they constitute clear departures from the status quo where neither the private nor the public sectors took the risks of investing in innovation. While they

portray unusual manifestations of the role of the state in supporting innovation in the wider context of Brazil, these experiences serve to illustrate a potential direction for policy learning.

The historical evidence on all successful experiences of economic transformation shows that they have only been possible where, through sustained efforts, the state has mastered how to design and implement industrial and innovation policies effectively (see Johnson (1982), Amsden (1989), Wade (1990), Andreoni (2016)). In the United States, for example, the successful development of complex systems of innovation in areas such as defence and health took decades to be accomplished.

Currently, Brazil has no such policies in place, and only ad hoc efforts have been made so far. However, the experiences of the federal funding programmes and partnerships investigated in the thesis could offer a foundation upon which to build future strategies. In my empirical analysis I have highlighted the challenges that need to be overcome when the government decides to go down this path; I have done so by documenting key issues that policymakers faced in the political, financial, legal and institutional spheres, and by pointing out some of the limitations of the solutions devised. These challenges, albeit substantial, should not be seen as justification for the government's inertia; rather, they suggest the need for a more systematic process of policy learning. In this sense, part of the value of my empirical case studies lies in showing what and how much remains to be learned in Brazil in order to develop the conditions for the state to play a more entrepreneurial role.

4.5 Future research

To continue to develop the line of inquiry pursued in this study, I anticipate at least three interesting avenues for future research: (i) mapping profit-sharing and conditionalities; (ii) exploring the relationship between changes in contract design for public financing of innovation and financial innovations; and (iii) examining the crucial role of political coalitions and power relations behind developmental strategies.

My research has led me to identify some of the policy instruments that could help to build a clear risk–reward nexus in public–private investment partnerships. However, more systematic efforts are needed to map existing policy instruments that perform the functions of profit-sharing and conditionalities in different countries, and to study their effects (both those that are intended and unintended). In this thesis I have also exposed important concerns raised by policymakers about the possibility of the rewards achieved by local partnerships being extracted by foreign actors – an aspect that also needs to be taken into account in the mapping exercises here proposed. Future research could explore the range of policy instruments and institutional arrangements devised to respond to this problem so as to derive relevant lessons.

Another issue that deserves attention is that my empirical analysis of the contracts underpinning public–private partnerships implied similarities between these legal instruments and those used in the financial sector. That is partly because, in the discussion, I drew on insights from the legal scholarship on finance and corporate governance (e.g. Triantis (2001); Gilson et al. (2009, 2010); Pistor (2013); Hockett and Omarova (2014)). The finding of features such

as flexibility and ambiguity in particular, suggests the possibility that there might be more similarities between the contractual solutions sought to deal with uncertainty in the field of technological innovation, and those aimed at mitigating the problems of instability and high volatility in the financial markets. Future research could explore further the relationship between the two and seek to establish the link with earlier empirical studies of financial innovations (Frame & White 2004; Lerner & Tufano 2011), with an emphasis on the risk–reward nexus.

Last, but not least, while my empirical analysis covered a period in Brazilian contemporary history (2003–2016) in which the federal government stated its commitment with a developmental agenda, in hindsight it seems clear that the political coalitions needed to carry out this agenda were not strong enough. President Dilma Rousseff was ousted in 2016 and since then the space for state action in the economy has reduced. Nonetheless, the cases that I have analysed, although exceptional in this broader context, show that there are circumstances in which the political construction of public–private collaborations to serve a common purpose may bear fruit. Future research could explore further the role of political coalitions and power relations in market creation and development strategies and seek to understand the relationship between the conflict resolution function of the state and its entrepreneurial role – and indeed this is an area that Andreoni and Chang (2019) have begun to investigate.

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Appendix

Interview codes

PublMa	<ul style="list-style-type: none">• Interviewees from the public sector (numbers 1,2,3,4,5,6,7,8,9,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,31,33,34,35,42,43,44,45,47,48,51)
PrivMa	<ul style="list-style-type: none">• Interviewees from the private sector (numbers 10,29,30,37,38,39,40,41)
CivSoc	<ul style="list-style-type: none">• Interviewees from non-profit organisations (Public: numbers 29,32,36 and Private: numbers 46,49,50)

Source: Own elaboration

Interview guide

Chapters 2 and 3 have drawn upon semi-structured interviews as primary data sources. This means that instead of following a strict set of questions, the interviews were conducted within a framework of topics and thus were open-ended. This method is particularly suitable for eliciting ideas on fairly new topics.

Given the aim within this thesis has been to explore the meanings of, and practices regarding, the risk–reward nexus in public–private partnerships, the interview guide covered four main topics, all of which contained a mix of potential questions aimed at understanding the context and subject matter or allowing for triangulation. The greater flexibility in semi-structured as compared to structured interviews is an asset for researchers, who can then select and tailor the questions according to the context of the interview (e.g. different organisations) and specific people being interviewed. Therefore, the topics below are indicative only.

1. The role of the state: public investments in innovation

1.1 Within the context of your organisation (or specific programme or specific partnership) please describe the investments that your institution makes in innovation, in terms of:

1.1.1 The time frame (long term/short term).

1.1.2 The area of the innovation chain (basic research, applied research, development, commercialisation).

1.1.3 Instruments of support.

1.1.4 What areas, sectors or activities (if any) have been prioritised, and why?

- 1.1.5 How would you characterise the higher risks taken by your organisation in investing in innovation?
- 1.1.6 What criteria have been adopted for selecting R&D projects and/or firms for support?
- 1.1.7 How do you know whether the R&D project or firm could not have been funded elsewhere?

2. Returns on public investments

- 2.1 How are 'failure' and 'success' defined in the context of your organisation's activity in innovation? Have you noticed any changes over time?
- 2.2 How does your organisation expect to obtain a return of a successful investment?
 - 2.2.1 Prompt: via spillover effects only or also through instruments such as equities, royalties, share of intellectual property, price-capping schemes, commitment from firms to reinvest in innovation, performance targets, etc.
- 2.3 Any measures taken to ensure that these returns are captured to the benefit of the country? (For example, local or regional content requirements, capital control over supported firm, requirement that any arising patent be first filed in the country, etc.)
- 2.4 In case of financial returns being shared between public and private actors:
 - 2.4.1 Why has the state sought this kind of arrangement, rather than relying on more indirect measures of social returns? (For example, spillovers and revenues from taxation.)
 - 2.4.2 How does it work?
 - 2.4.3 Any obstacles to implementing it? If so, which ones?

2.4.4 If the public funding organisation receives a direct share of monetary returns:

2.4.5 Does this represent a substantive source of revenue?

2.4.6 Does the state resort to any auditing mechanism to check on the accuracy of the earnings stated by the companies?

2.4.7 How are the resources obtained through this source used?

2.5 In your opinion, which of the following describes the interactions, and the distribution of returns from innovation, between your organisation and private actors, and why?

2.5.1 Public and private agents benefit from the actions of one another, sharing risks and rewards of the research, development and innovation process.

2.5.2 Some agents benefit more than others, and risks and rewards are unevenly distributed.

2.5.3 Public and private agents are incapable of cooperating.

3. Legal aspects of public–private partnerships for innovation: contracts, rewards and legal framework

3.1 What type(s) of contract(s) underpin the relationship between your organisation and supported firms (e.g. credit, shareholder agreement, cooperation or others)?

3.2 Were any amendments made in contract design or enforcement in order to implement public–private partnerships for innovation? Which ones, and why?

3.3 How flexible is the contract, in light of the inherent uncertainties or any supervening circumstances that may emerge from the innovation process/innovative firm receiving support? Please give examples.

3.4 How are these contracts monitored and evaluated?

3.5 Regarding the choice of the instrument through which the organisation appropriates a share of the rewards:

3.5.1 Have any other designs been attempted and dropped?

3.5.2 Have you found any obstacles imposed by legislation to implement the instruments selected? Please give examples.

3.6 What are the main legal obstacles to your organisation investing in innovation? Have they changed over the past ten years?

3.6.1 Are these specific to your organisation or shared by others?

3.6.2 How important are the legal obstacles as compared to those of another nature such as skills, resources, etc.?

3.7 How could the legal framework be improved to engender more effective public–private partnerships for innovation? ('Effectivity' might be considered in terms of attracting more private investments, generating more innovations, and increasing the quality of societal benefits.)

4. State capacities for engaging in strategic partnerships with the private sector, promoting innovation and enhancing its social returns

4.1 What capacities are key for public organisations to achieve effective partnerships with the business sector? (For example, legal, monitoring, measuring, evaluation, coordination, others)?

4.2 What are the strengths and weaknesses of your organisation in contracting with business?

5. Follow-up

5.1 Would you be happy to answer follow-up questions by email?