PROMOTING INNOVATION IN LATIN AMERICA

WHAT COUNTRIES HAVE LEARNED (AND WHAT THEY HAVE NOT) IN DESIGNING AND IMPLEMENTING INNOVATION AND INTELLECTUAL PROPERTY POLICIES

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DISSERTATION

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To Ilma and Nico

ACRONYMS AND ABBREVIATIONS

BITs	Bilateral Investment Treaties
BNDES	Brazilian National Development Bank
ECLAC	Economic Commission for Latin America and the Caribbean of the United Nations
FDI	Foreign Direct Investment
FTAs	Free Trade Agreements
IADB	Inter-American Development Bank
ICT	Information and Communication Technologies
IPRs	Intellectual Property Rights
M&A	Mergers and Acquisitions
MNCs	Multinational Companies
NIS	National Innovation System
NPE	Non Practicing Entities
OECD	Organization for Economic Co-Operation and Development
PCT	Patent Co-Operation Treaty
R&D	Research and Development
RIS	Regional Innovation System
SMEs	Small and Medium Enterprises
STI	Science, Technology and Innovation
TRIPS	Trade-Related Aspects of Intellectual Property Rights
TTO	Technology Transfer Office
USPTO	United States Patent and Trademark Office
WTO	World Trade Organization

SUMMARY

This dissertation discusses the role of the state and the market in promoting innovation in Latin America. It analyzes the evolution of innovation policies over time, highlighting the institutional learning processes, as well as the rise of new topics in the innovation agenda, such as intellectual property. Due to the increasing relevance of knowledge for our societies, I have decided to focus on the linkage between innovation and intellectual property policies. Intellectual property is not only a key policy field in contemporary global knowledge economies, but it is also one of the areas that better shows the complexity of designing and managing innovation policies today, due to the blurring boundaries between national and international policy domains and between science and business.

Latin America is certainly not the first region that comes to mind when discussing about innovation. Moreover, the image of Latin American policy making is often associated with a generalized distrust in the capacity of the state to promote production diversification and structural transformation. However, the Latin American experience in finding a balance between the role of the State and the market in promoting innovation represents an interesting field of study.

First, the experience of Latin America has been less studied from the perspective of learning in policy making than the South East Asian one. The literature on "catching up" and economic transformation is rich in old and new examples of East Asian economies, capable of getting market incentives "wrong" to favor the creation of new comparative advantages in key technologies and manufacturing activities. Often, the success of East Asian countries has been contrasted with the "failure" of Latin America. The differences between the two regions are deep and well known; they range from the levels of inequality between people at the time when the two regions embraced their transformation strategies, to the different geo-political alliances, and the different forms of rents' management and strategies for the identification of "national interest" and development visions. However, despite the fact that Latin America seems to stagnate with respect to scientific, technological and industrial development, the experience of the countries of the region offers relevant insights about the role of science, knowledge and technology in shaping development trajectories and on the interplay between the state and the market in promoting innovation.

Second, a new geography of science, production and innovation is emerging. Developing countries are confronted with stronger pressures to respond to the aspirations of their young and growing middle-classes. Understanding the role that science, technology and innovation are playing in the development of Latin America and what role they will be playing in the future requires a clear understanding of

the past experiences of the region. Policies advance through trial and error and by processes of continuous institutional evolution. To what extent Latin America will be able to forge ahead and improve the standards of living of its citizens will not only depend on its strategies and policies, but also on the capacity to generate a consensus in promoting structural transformation and putting the generation of knowledge at the center of its societies.

Thirdly, the interest in analyzing the experience of Latin America in implementing policies to promote innovation goes beyond development economics. It also matters for the evolution of global contemporary capitalist development. From the analysis of innovation policies, Latin America appears as a region in progress, where governments and the society are increasingly aware of the importance of generating and diffusing knowledge to sustain more inclusive and sustainable growth. This is also happening in the countries of the region that are facing a positive conjuncture due to high and rising prices of raw materials and a sustained and growing demand for their exports coming from China. This image of a region that seems to have politically understood the relevance of the mastering of science and technology for development, contrast, quite evidently, with some European countries that, besides having built their fortunes on diffused scientific and technical competences, today are finding it difficult to preserve the investments in innovation, due to the predominance of austerity and fiscal consolidation programmes. France, Italy and Spain are some, albeit different, cases in point. Therefore, there could be some lessons for Europe, and OECD countries in general, that come out of the analysis of innovation policies in Latin American countries.

MAIN RESEARCH QUESTIONS

This dissertation discusses the return of innovation in the development strategies of Latin American countries. It highlights the evolution of innovation policy models, the rise of intellectual property as a domain of action for innovation policies, and the changes of intellectual property regimes at the global level that are re-defining the policy spaces and the innovation strategies of firms. In particular, this dissertation addresses three main questions:

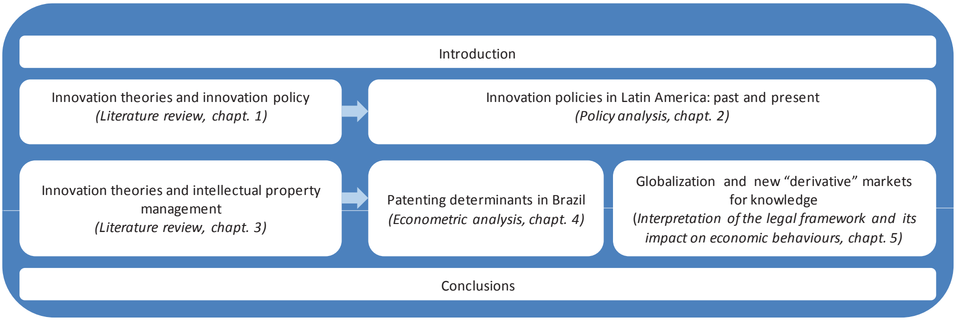
1. What has been the evolution of innovation policies in Latin America? To what extent the different theoretical frameworks have influenced and are influencing innovation policies in the region? What are the major characteristics of innovation policies in Latin America today?
2. What do we know about appropriability strategies of innovative firms in Latin America? What does the empirical evidence suggest to improve the design of innovation and patent policies in the countries of the region?
3. How are globalization and the changes in intellectual property regimes influencing the policy spaces for scientific and technological development in developing countries, and in particular in Latin America? Are the changes in intellec-

tual property regimes re-shaping the functioning and rationale of the markets for technology? What are the implications for innovation policies?

STRUCTURE OF THE DISSERTATION

This dissertation is structured in five chapters that follow different methodologies and draw upon different data sources (Figure 1).

Figure 1 Structure of the dissertation.



The first chapter reviews the economic literature on innovation. It highlights the variety of economic approaches to innovation and the differences in defining the rationale, intensity and direction of policy action. It discusses the impact of innovation theory on innovation policy, showing why the heterodox approaches offer a relevant (although fragmented) framework for policy in the new global economic context characterized by rising uncertainty and complexity.

The second chapter discusses the evolution of innovation policies in Latin America and the learning in policy making from an historical perspective, highlighting the impact of different economic models on policy choices. It presents a detailed analysis of governance structures, innovation strategies and policy instruments drawing attention to the similarities and differences between the countries of the region. It concludes by discussing the achievements and challenges for Latin America to go forward.

The third chapter discusses how the literature on innovation reshapes the debate on intellectual property policies. It re-examines the appropriability and the disclosure function of the patent system on the basis of the properties of knowledge, technology and learning. It emphasizes that their transferability is limited due to their intrinsic characteristics (e.g. tacit, complex, and embedded) and to the imperfections of the patent system itself (e.g. patent quality). It clarifies that appropriability goes beyond the legal rights conferred to the innovators. The chapter argues that intellectual property policies should be planned in coordination with innovation policies; they could be more effective if they were framed under the perspective of knowledge governance, i.e. focusing not only on appropriability, but also on the norms that define the conditions for knowledge creation and diffusion.

The fourth chapter focuses on Brazil. It presents a simple econometric study based on the national innovation survey. Following the existing literature, a probit model of the determinants of patenting of innovative firms in the manufacturing industry is carried out, after having rejected the hypothesis of sample selection bias. A second step estimation is carried out to verify if patenting and trade secret are complementary or alternative strategies. Results show that appropriability strategies of innovative firms in Brazil do not differ from the results found by similar studies for OECD countries. Even though, differently from the OECD countries, the share of firms that are more likely to patent is much lower in Brazil than in more advanced countries.

The fifth chapter discusses the implications of the global changes in intellectual property regimes on the rationale and functioning of technology markets. It presents some stylized facts about markets for knowledge and it overviews the major changes in intellectual property regimes in the United States and at the international level, focusing on the TRIPS agreement and its flexibilities, as well as on the restrictions of policy spaces caused by the US bilateral trade and investment agreements. The chapter presents an interpretation of contemporary markets for knowledge, highlighting that new "derivative" markets are developing due to the changes in global intellectual property regimes. The chapter concludes by advocating for more awareness in Latin America regarding the new trends in intellectual property management and their potential implications for development and for innovation policies.

MAIN FINDINGS

The experience of Latin America offers interesting insights about the relationship between technology, innovation and development and the challenges of governments to promote learning and innovation. Most of the existing studies on catching up focus on the successful experiences of South East Asian countries; however, the experience of Latin America is a story of a (slow) learning process from which relevant policy lessons can be learned.

Since the end of the 1990s innovation has become an issue of rising concern in Latin America, but the countries have, on general, struggled in achieving the right reforms and consensus to support innovation. On the one hand, the states were debilitated by the structural reforms of the Washington Consensus which not only weakened several public institutions, but engendered a generalized mistrust in government intervention, and especially in its capacity to shape industrial development and select technologies. On the other hand, the structural reforms have interrupted the learning processes in the private sector. The development agenda shifted towards economic stabilization, therefore damaging certain industrial sectors and jobs, and implicitly favoring the specialization in natural resources in the Southern Cone of Latin America and in the *maquila* in Central America.

In this context, Latin American countries have accumulated learning in how to design and implement innovation policies, even though they have often done so through abrupt changes in policy models. They have started to collect and analyze data at the firm level to shift towards more evidence-based policy models, and have learned that intellectual property management is a key component of innovation policies in the 21st century.

In particular, the experience of Latin American countries shows that:

i. Innovation policy is not neutral with respect to economic theory; different theoretical approaches shape policy design and impact in different ways (Chapter 1 and 3).
   The dominance of the conventional approach in policy making has led to a detachment between the innovation policy agenda, and structural transformation and industrial policies, thus reducing the effectiveness of innovation policies in many cases. Innovation theories could also help in taking a better stance towards intellectual property management. The transferability of knowledge, technology and learning is limited due to their intrinsic characteristics (e.g. tacit, complex, and embedded) and to the imperfections of the patent system itself (e.g. patent quality). The appropriability of innovation goes beyond the legal rights conferred to the innovators. Therefore, innovation cannot be promoted by acting only on the intellectual property management side.
   Innovation policies in Latin America evolved from a linear-supply to a linear-demand oriented approach from the 1950s to the 1990s. Innovation was first assumed to directly flow from scientific discoveries, then it was mostly associated with the private sector. Only since the late 1990s, the countries of the region have started to conceive innovation as a phenomenon that occurs thanks to a combination of factors defined by the quality and density of the national production and innovation system. Most countries have started to design sector specific instruments based on public-private partnerships and have opened new spaces for policy coordination, including with industrial policy (OECD, 2013). Latin American countries have accumulated relevant experience in innovation policy. The challenge is not only to improve the design of policy instruments, but also to create a real consensus for innovation and to get the commitment of the private sector to invest in it. In addition, in most Latin American countries, innovation policies need to develop a capacity to deal with the territory in a more balanced way in order to mobilize untapped development opportunities (Chapter 2).

ii. Since the late 1990s, intellectual property management has emerged as an issue of growing importance in Latin American innovation strategies, due to the inclusion of intellectual property provisions in free trade agreements and in bilateral investment treaties, as well as due to a growing attention devoted to intellectual property in more advanced countries, especially in the US.

iii. The appropriability strategies of innovative firms in Latin America are similar to the ones in more advanced countries. Innovative firms in Brazil use patent and trade secret as complementary mechanisms. Patent propensity is sector-specific and large firms tend to patent more than small firms. The difference is that in Brazil foreign firms are more likely to patent than domestic ones. Therefore, strengthened intellectual property protection might favor disproportionally large and foreign firms, rather than domestic ones, in the absence of targeted policies to support structural change and upgrading of current production specialization. Brazil, as all other Latin American countries, suffers of structural heterogeneity. Highly innovative firms are few, and co-exist in sectors that generally operate at much lower levels of technology and productivity.

iv. Defining patent policies in Latin American countries is challenging due to the structural heterogeneity that prevails within the countries of the region. Top performing firms will benefit from intellectual property protection in line with global standards, but for the majority of firms intellectual property regimes in line with global standards might be irrelevant, because these firms will often not be able to carry out patentable innovations, or, might even be counter-productive because they raise the barriers to entry in given innovation fields. In addition, patent policy needs to be defined taking into account the time dimension; as countries became originators of substantial flows of innovation, a demand for higher patent protection will ensue. There are no easy answers to this dilemma, but history shows that patent policies are better defined when they are nested into broader industrial development strategies and when they take into account not only the need for appropriability, but also the need for knowledge diffusion (Chapter 4 and 5).

v. The introduction of intellectual property provisions in trade agreements in 1994 through the adoption of the TRIPS agreement and in bilateral trade and investment agreements, coupled with the changes in the intellectual property regime in the United States have contributed to reshape the markets for technology creating new "derivative" markets for knowledge. Patents have become "liquid" assets whose value is increasingly disentangled from the value derived from the industrial application of the patented technology. The rise of these new markets is reshaping the incentives to patent and it is raising barriers for innovation, both for incumbents and newcomers. Patents can be assimilated to liquid assets in firms' portfolios and can be used to extract rents beyond technology licensing. The creation and development of "derivative" markets for knowledge is raising concerns in advanced economies on the potential adverse impacts of patent thickets on the generation and diffusion of innovation as well as on rising legal costs. Latin American countries should increase their awareness about these global trends to define their positions based on their national interests (Chapter 5).

vi. Designing and implementing innovation policies in global open economies entails a high degree of complexity, especially for developing economies like Latin American ones which suffer of high structural heterogeneity. High level diagnostics and foresight capacities are needed, as well as sophisticated and complementary policy mix. Moreover, the innovation agenda of the 21st century cannot be carried out in "isolation"; science, technology and innovation have an overarching impact on development, quality of life and services that can be delivered to citizens. Different communities should be conveyed to define the innovation agenda, including the civil society.

Latin American countries are learning to do business in the new global landscape and their governments (some faster than others) are promoting new development models, based on domestic demand promotion, together with more strategic integration into world markets. The high GDP growth experienced by Latin America in the second half of the 2000s opens opportunities, but it also raises new challenges. Markets are not generating incentives for structural transformation, but now more than ever Latin American countries need to embrace a transformation agenda. Latin American countries have more fiscal space, their societies are young and with new aspirations and, in addition, the whole world is facing epochal changes. Some windows of opportunities will be available, but targeted and proactive policies are needed together with new forms of partnership with the private sector. The challenge for Latin America is the generation of incentives for the creation of first class domestic entrepreneurs. And that is where the region needs to break its elite chains and forge ahead to define the society of the future, which should be more innovative and more inclusive in order to be more equal.

SAMENVATTING (Summary in Dutch)

In deze scriptie wordt de rol van de staat en de markt besproken bij de bevordering van innovatie in Latijns-Amerika. De evolutie van het innovatiebeleid wordt geanalyseerd over de tijd, waarbij de institutionele leerprocessen benadrukt worden, alsook de opkomst van nieuwe onderwerpen op de innovatieagenda, zoals intellectuele eigendom. Ten gevolgde van de toenemende relevantie van kennis voor onze maatschappijen heb ik besloten me te concentreren op het verband tussen innovatie het beleid van intellectuele eigendoms. Intellectuele eigendom is niet alleen een uiterst belangrijke beleidsveld in moderne globale kenniseconomieën, maar het is ook een van de gebieden die de huidige complexiteit van het ontwerp en beheer van het innovatiebeleid illustreert, ten gevolge van de vervagende grenzen tussen nationale en internationale beleidsdomeinen en tussen wetenschap en zaken.

Latijns-Amerika is zeker niet de eerste regio waaraan we denken, wanneer we het over innovatie hebben. Bovendien wordt het imago van het Latijns-Amerikaanse beleidsmaken vaak geassocieerd met een algemeen wanvertrouwen in het vermogen van de staat om productiediversificatie en structurele transformatie te bevorderen. De Latijns-Amerikaanse ervaring om een evenwicht te vinden tussen de rol van de staat en de markt bij de bevordering van innovatie vormt echter wel een interessant studiegebied.

Ten eerste, is de Latijns-Amerikaanse ervaring minder bestudeerd van uit het leerperspectief van het beleidsmaken dan die in Zuid-Oost-Azië. De literatuur over "bijbenen" en economische transformatie bevat heel veel oude en nieuwe voorbeelden van Oost-Aziatische economieën, die erin slagen marktprikkels te "verknoeien" om de creatie van nieuwe comparatieve voordelen in belangrijke technologieën en productieactiviteiten te begunstigen. Het succes van de Oost-Aziatische landen wordt vaak gecontrastreerd met de "mislukking" van Latijns-Amerika. De verschillen tussen de twee regio's zijn diepgaand en goed bekend; ze gaan van de niveaus van ongelijkheid tussen de mensen in de periode dat de twee regio's hun transformatiestrategieën omarmden, tot de verschillende geopolitieke allianties en de verschillende vormen van huurbeheer en strategieën voor de identificatie van "nationale interesses" en ontwikkelingsvisies. Ondanks het feit dat Latijns-Amerika lijkt te stagneren op het vlak van wetenschappelijke, technologische en industriële ontwikkeling biedt de ervaring van de landen uit de regio toch relevante inzichten over de rol van wetenschap, kennis en technologie bij de vorming van ontwikkelingskoersen en over het samenspel tussen de staat en de markt bij de bevordering van innovatie.

Ten tweede is er een nieuwe geografie van wetenschap, productie en innovatie aan het opkomen. De ontwikkelingslanden worden geconfronteerd met sterkere druk om te beantwoorden aan de ambities van hun jonge en groeiende middenklassen. Om de rol die wetenschap, technologie en innovatie spelen bij de ontwikkeling van Latijns-Amerika en welke rol ze zullen spelen in de toekomst te begrijpen is er een duidelijk begrip nodig van de verleden ervaringen van de regio. Beleidsvormen verlopen proefondervindelijk en door middel van processen van voortdurende institutionele evolutie. De mate waarin Latijns-Amerika erin zal slagen vooruit te streven en de levensstandaarden van zijn burgers te verbeteren zal niet alleen afhangen van zijn strategieën en beleidsvormen, maar ook van het vermogen om tot een consensus te komen om structurele transformatie te bevorderen en om de kennisgenerering in het centrum van zijn maatschappijen te plaatsen.

Ten derde, gaat de interesse van de analyse van de ervaring van Latijns-Amerika bij de implementatie van beleidsvormen om innovatie te bevorderen verder dan ontwikkelingseconomie. Ze is ook belangrijk voor de evolutie van de globale moderne kapitalistische ontwikkeling. Uit de analyse van het innovatiebeleid blijkt Latijns-Amerika een regio te zijn die aan de gang is, waar de regeringen en de maatschappij zich steeds meer bewust zijn van het belang van de kennisgenerering en -verspreiding om meer omvattende en duurzamere groei te ondersteunen. Dit gebeurt ook in de landen van de regio die te maken hebben met een positieve conjunctuur ten gevolge van de hoge en stijgende prijzen van grondstoffen en de aangehouden en groeiende vraag voor de export ervan komende uit China. Dit beeld van een regio die de relevantie van de beheersing van wetenschap en technologie voor de ontwikkeling politiek begrepen lijkt te hebben, contrasteert, heel duidelijk, met sommige Europese landen die, hoewel ze hun fortuin gebouwd hebben op basis van verspreide wetenschappelijke en technische competenties, het nu moeilijk vinden om de investeringen in innovatie te behouden, ten gevolge van de heerschappij van soberheids- en fiscale consolidatieprogramma's. Frankrijk, Italië en Spanje zijn, hoewel verschillend, voorbeelden daarvan. Daarom zouden er voor Europa en de OESO-landen in het algemeen, een paar lessen getrokken kunnen worden uit de analyse van het innovatiebeleid in Latijns-Amerikaanse landen.

VOORNAAMSTE ONDERZOEKSVRAGEN

In deze scriptie wordt de terugkeer van innovatie in de ontwikkelingsstrategieën van Latijns-Amerikaanse landen bestudeerd. Ze benadrukt de evolutie van innovatiebeleidsmodellen, de opkomst van intellectuele eigendom als een actiegebied voor innovatiebeleid en de veranderingen van intellectuele eigendomsregimes op het globale niveau die de beleidsruimtes en de innovatiestrategieën van bedrijven opnieuw definiëren. In het bijzonder worden in deze scriptie drie hoofdvragen behandeld:

1. Wat is de evolutie van het innovatiebeleid in Latijns-Amerika? In welke mate hebben de verschillende theoretische raamwerken het innovatiebeleid in de

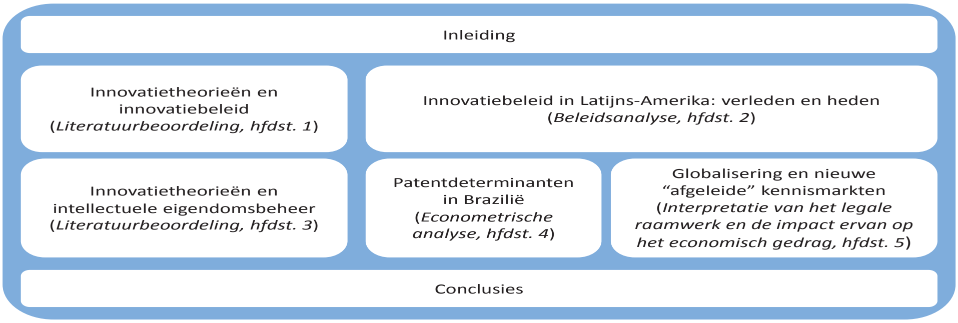
regio beïnvloed en doen ze dat momenteel nog? Wat zijn de voornaamste kenmerken van het innovatiebeleid in Latijns-Amerika vandaag?

2. Wat weten we over de toe-eigenbaarheidsstrategieën van innovatieve bedrijven in Latijns-Amerika? Wat suggereert het empirisch bewijs om het ontwerp van het innovatie- en patentbeleid in de landen van de regio te verbeteren?
3. Hoe beïnvloeden globalisering en de veranderingen in de intellectuele eigendomsregimes de beleidsruimtes voor wetenschappelijke en technologische ontwikkeling in ontwikkelingslanden en in het bijzonder in Latijns-Amerika? Hervormen de veranderingen in de intellectuele eigendomsregimes de werking en de grondgedachte van de technologiemarkten? Wat zijn de implicaties voor het innovatiebeleid?

STRUCTUUR VAN DE SCRIPTIE

Deze scriptie is gestructureerd in vijf hoofdstukken die verschillende methodologieën volgen en steunen op verschillende gegevensbronnen (figuur 1).

Figuur 1 Structuur van de scriptie.



In het eerste hoofdstuk wordt de literatuur over innovatie bekeken. De variëteit aan economische aanpakken voor innovatie en de verschillen in de definiëring van de grondgedachte, intensiteit en richting van de beleidsactie worden erin toegelicht. De impact van innovatietheorieën op het innovatiebeleid wordt besproken, waarbij wordt aangetoond waarom de heterodoxe aanpakken een relevant (hoewel gefragmenteerd) raamwerk bieden voor beleidsvormen in de nieuwe globale economische context die gekenmerkt wordt door stijgende onzekerheid en complexiteit.

In het tweede hoofdstuk wordt de evolutie van het innovatiebeleid in Latijns-Amerika en van het leerproces van het beleidsmaken besproken van uit een historisch perspectief, waarbij de impact van verschillende economische modellen op de beleidskeuzes wordt benadrukt. In dit hoofdstuk wordt een gedetailleerde analyse van de governancestructuren, innovatiestrategieën en beleidsinstrumenten voor-gesteld, waarbij de aandacht wordt gevestigd op de gelijkenissen en verschillen tussen de landen van de regio. Ten slotte worden de prestaties en uitdagingen besproken waarmee Latijns-Amerika bij zijn opgang mee te maken heeft.

In het derde hoofdstuk wordt behandeld hoe de literatuur over innovatie het debat over het intellectuele eigendomsbeleid hervormt. De toe-eigenbaarheid en de onthullingsfunctie van het patentsysteem worden opnieuw bekeken op basis van de eigenschappen kennis, technologie en leren. In het hoofdstuk wordt benadrukt dat hun overdraagbaarheid beperkt is door hun intrinsieke kenmerken (bv. stilzwijgend, complex en ingebed) en de onvolmaaktheden van het patentsysteem zelf (bv. patentkwaliteit). Er wordt verduidelijkt dat toe-eigenbaarheid de legale rechten die verleend zijn aan de innovators overschrijdt. In het hoofdstuk wordt gesteld dat het intellectuele eigendomsbeleid gepland moet worden in coördinatie met het innovatiebeleid; het zou doeltreffender kunnen zijn als het gekaderd was onder het perspectief van kennisgovernance, d.w.z. door zich niet alleen te concentreren op toe-eigenbaarheid, maar ook op de normen die de voorwaarden voor kenniscreatie en -verspreiding definiëren.

In het vierde hoofdstuk wordt Brazilië behandeld. Er wordt een eenvoudige econometrische studie gepresenteerd die gebaseerd is op de nationale innovatie-enquête. Gebaseerd op de bestaande literatuur wordt er een probitmodel van de determinanten van het patenteren van innovatieve bedrijven in de productie-industrie uitgevoerd, nadat de hypothese van zelfselectiebasis is afgewezen. Er wordt een tweede stapsgewijze schatting uitgevoerd om te verifiëren of patent- en handelsgeheimen complementaire of alternatieve strategieën zijn. Uit de resultaten blijkt dat de toe-eigenbaarheidsstrategieën van innovatieve bedrijven in Brazilië niet afwijken van de gevonden resultaten van soortgelijke studies voor OESO-landen. Toch is het aandeel bedrijven dat meer geneigd is te patenteren in tegenstelling tot OESO-landen veel lager in Brazilië dan in meer geavanceerde landen.

In het vijfde hoofdstuk worden de implicaties besproken van de globale veranderingen in de intellectuele eigendomsregimes op de grondgedachte en werking van technologiemarkten. Er worden enkele gestileerde feiten voorgelegd over kennismarkten en er wordt een overzicht gegeven van de grootste veranderingen in de intellectuele eigendomsregimes in de Verenigde Staten en op het internationale niveau, waarbij de nadruk wordt gelegd op het TRIPS-verdrag en zijn flexibiliteiten, alsook op de beperkingen van beleidsruimtes ten gevolge van de Amerikaanse bilaterale handels- en investeringsverdragen. In het hoofdstuk wordt een interpretatie van moderne kennismarkten gepresenteerd, waarbij er nadruk wordt gelegd dat er zich nieuwe "afgeleide" markten ontwikkelen ten gevolge van de veranderingen in de globale intellectuele eigendomsregimes. Op het einde wordt er gepleit voor meer bewustzijn in Latijns-Amerika met betrekking tot de nieuwe tendensen in het beheer van intellectuele eigendom en hun potentiële implicaties voor het ontwikkelings- en innovatiebeleid.

VOORNAAMSTE BEVINDINGEN

De ervaring van Latijns-Amerika biedt interessante inzichten over de relatie tussen technologie, innovatie en ontwikkeling en de uitdagingen waarmee regeringen te maken hebben bij de bevordering van leren en innovatie. In de meeste van de bestaande studies over bijbenen ligt de nadruk op de succesvolle ervaringen van de Zuid-Oost-Aziatische landen; de ervaring van Latijns-Amerika is echter het verhaal van een (traag) leerproces waaruit relevante beleidslessen getrokken kunnen worden.

Sinds het einde van de jaren '90 is innovatie het onderwerp van stijgende ongerustheid in Latijns-Amerika geworden, maar de landen hebben, in het algemeen, moeite gehad om tot de juiste hervormingen en een consensus te komen om de innovatie te ondersteunen. Enerzijds werden de staten afgezwakt door de structurele hervormingen van de Washington Consensus die niet alleen verschillende openbare instellingen heeft verzwakt, maar een algemeen wantrouwen in tussenkomst door de regering heeft opgewekt en vooral in haar vermogen om de industriële ontwikkeling te vormen en technologieën te selecteren. Anderzijds hebben de structurele hervormingen de leerprocessen in de privésector onderbroken. De ontwikkelingsagenda is verschoven naar economische stabilisatie, waardoor bepaalde industriële sectoren en banen geschaad werden en impliciet de specialisatie werd begunstigd in natuurlijke hulpbronnen in de Zuidkegel van Latijns-Amerika en in de *maquilas* in Centraal-Amerika.

In deze context hebben Latijns-Amerikaanse landen geleerd hoe innovatiebeleidsvormen te ontwerpen en te implementeren, hoewel ze dat vaak gedaan hebben door middel van abrupte wijzigingen van de beleidsmodellen. Ze zijn begonnen met de verzameling en analyse van gegevens op het bedrijfsniveau om vervolgens te verschuiven naar meer op bewijs gebaseerde beleidsmodellen en hebben geleerd dat intellectuele eigendomsbeheer een sleutelonderdeel is van het innovatiebeleid van de 21ste eeuw.

In het bijzonder toont de ervaring van Latijns-Amerikaanse landen:

i. Innovatiebeleid is niet neutraal met betrekking tot de economische theorie; verschillende theoretische aanpakken vormen het beleidsontwerp en de beleidsimpact op verschillende manieren (Hoofdstuk 1 en 3).
   De dominantie van de conventionele aanpak in het beleidsmaken heeft geleid tot een breuk tussen de innovatiebeleidsagenda en structurele transformatie- en industriële beleidsvormen, waardoor de doeltreffendheid van het innovatiebeleid in vele gevallen wordt verminderd. Innovatietheorieën zouden er ook voor kunnen zorgen dat er een betere positie wordt aangenomen tegenover het beheer van intellectuele eigendom. De overdraagbaarheid van kennis, technologie en leren is beperkt door hun intrinsieke kenmerken (bv. stilzwijgend, complex en ingebed) en de onvolmaaktheden van het patentsysteem zelf (bv. patentkwaliteit). De toe-eigenbaarheid overschrijdt de legale rechten die ver-

leend zijn aan de innovators. Daarom kan innovatie niet bevorderd worden door alleen te handelen aan de kant van intellectuele eigendomsbeheer.

Het innovatiebeleid in Latijns-Amerika is van de jaren '50 tot de jaren '90 geëvolueerd van een aanpak georiënteerd op lineair aanbod naar een aanpak georiënteerd op lineaire vraag. Er werd van innovatie eerst aangenomen dat ze direct uit wetenschappelijke ontdekking zou voortstromen, maar daarna werd ze vooral geassocieerd met de privésector. Pas sinds de late jaren '90 zijn de landen in de regio innovatie beginnen te beschouwen als een fenomeen dat zich voordoet dankzij een combinatie van factoren die gedefinieerd worden door de kwaliteit en dichtheid van het nationale productie- en innovatiesysteem. De meeste landen zijn begonnen sectorspecifieke instrumenten te ontwerpen gebaseerd op openbare en privépartnerschappen en hebben nieuwe ruimtes geopend voor beleidscoördinatie, inclusief het industriële beleid (OESO, 2013). De Latijns-Amerikaanse landen hebben relevante ervaring opgedaan op het vlak van het innovatiebeleid. Het is niet alleen de uitdaging om het ontwerp van beleidsinstrumenten te verbeteren, maar ook om een echte consensus voor innovatie te creëren en om het engagement van de privésector te krijgen om erin te investeren. Bovendien moet het innovatiebeleid voor de meeste Latijns-Amerikaanse landen een vermogen ontwikkelen om op een evenwichtigere manier om te gaan met het grondgebied om niet aangeboorde ontwikkelingskansen te mobiliseren (Hoofdstuk 2).

ii. Sinds de late jaren '90 is intellectuele eigendomsbeheer komen bovendrijven als een steeds belangrijker thema in de Latijns-Amerikaanse innovatiestrategieën, ten gevolge van de omvatting van intellectuele eigendomsvoorwaarden in vrijhandelsverdragen en in bilaterale investeringsakkoorden, alsook ten gevolge van de groeiende aandacht die besteed wordt aan intellectuele eigendom in meer geavanceerde landen, vooral in de VS.

iii. De toe-eigenbaarheidsstategieën van innovatieve bedrijven in Latijns-Amerika lijken op die in meer geavanceerde landen. Innovatieve bedrijven in Brazilië gebruiken patent- en handelsgeheimen als complementaire mechanismen. De patentgeneigdheid is sectorspecifiek en grote bedrijven zijn meer geneigd patenten aan te vragen dan kleine bedrijven. Het verschil is dat in Brazilië buitenlandse bedrijven meer geneigd zijn patenten aan te vragen dan binnenlandse. Daarom kan een versterkte intellectuele eigendomsbescherming grote en buitenlandse bedrijven buiten verhouding begunstigen, in plaats van binnenlandse bedrijven, bij afwezigheid van een doelmatig beleid om structurele veranderingen en de upgrade van de huidige productiespecialisatie te ondersteunen. Brazilië, zoals alle ander Latijns-Amerikaanse landen, lijdt onder structurele heterogeniteit. Er zijn weinig uiterst innovatieve bedrijven en ze bestaan in sectoren die in het algemeen actief zijn op veel lagere technologie- en productiviteitsniveaus.

iv. Het is moeilijk om een patentbeleid te definiëren in Latijns-Amerika tengevolge van de structurele heterogeniteit die overheerst in de landen van de regio. Enerzijds zullen uitstekend presterende bedrijven profiteren van de intellectuele eigendomsbescherming volgens de globale standaarden; anderzijds kunnen voor de meerderheid van de bedrijven in het land de intellectuele eigendomsregimes volgens de globale standaarden irrelevant zijn op het vlak van toe-eigenbaarheidsmechanismen, omdat deze bedrijven geen patenteerbare innovaties zullen kunnen doorvoeren of in andere gevallen kunnen ze contraproductief zijn, omdat ze de barrières om binnen te treden in bepaalde innovatievelden kunnen verhogen. Daarbij moeten er patentbeleidsvereisten gedefinieerd worden waarbij rekening wordt gehouden met de tijdsdimensie; terwijl landen de aanzet geven voor aanzienlijke innovatiestromen, zal er een vraag voor een hogere patenbescherming volgen. Er zijn geen eenvoudige antwoorden op dit dilemma, maar uit de ervaring blijkt dat het patentbeleid beter gedefinieerd is, wanneer het omvat is in bredere industriële ontwikkelingsstragegieën en wanneer er niet alleen rekening wordt gehouden met de noodzaak van toe-eigenbaarheid, maar ook met de noodzaak van kennisverspreiding (Hoofdstuk 4 en 5).

v. De introductie van intellectuele eigendomsvoorwaarden in handelsverdagen in 1994 door middel van de aanvaarding van het TRIPS-verdrag en in bilaterale handels- en investeringsverdragen, gekoppeld aan de veranderingen in het intellectuele eigendomsregime in de Verenigde Staten heeft bijgedragen tot de hervorming van de technologiemarkten door nieuwe "afgeleide" kennismarkten te creëren. Zoals secondaire financiële markten zijn patenten liquide activa geworden, waarvan de waarde steeds meer losgekoppeld wordt van de waarde die afgeleid wordt uit de industriële toepassing van de gepatenteerde technologie. De opkomst van deze nieuwe markten hervormt de prikkels om te patenteren en verhoogt de barrières voor innovatie, zowel voor gevestigde bedrijven als voor nieuwkomers. Patenten kunnen geassimileerd worden tot liquide activa in de bedrijfsportfolio's en kunnen gebruikt worden om huur te verkrijgen naast de technologielicenties. De creatie en ontwikkeling van deze afgeleide kennismarkten leiden tot ongerustheid in de geavanceerde economieën over de potentiële negatieve impact van een patentdoolhof op de generering en verspreiding van innovatie en ook over de toenemende rechtskosten. Latijns-Amerikaanse landen moeten hun bewustzijn vergroten over deze globale tendensen om hun positie te definiëren op basis van hun nationale interesses (Hoofdstuk 5).

vi. Het ontwerpen en implementeren van een innovatiebeleid in globale open economieën leiden tot een hoge mate van complexiteit, vooral voor ontwikkelende economieën zoals de Latijns-Amerikaanse die lijden onder hoge structurele heterogeniteit. Er wordt een hoge mate aan diagnostiek- en voorspellingsvermogen vereist, alsook een gesofisticeerde en complementaire beleidsmix. Bovendien mag de innovatieagenda van de 21ste eeuw niet doorgevoerd worden in "isolatie"; wetenschap, technologie en innovatie hebben een overkoepelende impact op de ontwikkeling, levenskwaliteit en diensten die geleverd kunnen worden aan de burgers. Er moeten verschillende gemeenschappen geraadpleegd worden om de innovatieagenda te definiëren, inclusief de burgerlijke maatschappij.

Latijns-Amerikaanse landen leren om zaken te doen in het nieuwe globale landschap en hun regeringen (sommige sneller dan andere) bevorderen nieuwe ontwikkelingsmodellen, gebaseerd op binnenlandse vraagbevordering, samen met de strategischere integratie in de wereldmarkten. De hoge groei waarmee Latijns-Amerika te maken had in de tweede helft van de jaren '2000 opent kansen maar creëert ook uitdagingen voor de landen van de regio. De markten genereren geen prikkels voor structurele transformatie, maar Latijns-Amerikaanse landen moeten de transformatieagenda nu meer dan ooit omarmen. Latijns-Amerikaanse landen hebben meer fiscale ruimte, hun maatschappijen zijn jong en bruisen van nieuwe ambitie en bovendien wordt de hele wereld geconfronteerd met historische veranderingen. Er zullen enkele opportuniteiten beschikbaar zijn, maar er zijn doelmatige en proactieve beleidsvormen nodig samen met nieuwe vormen van partnerschap met de privésector. De uitdaging voor Latijns-Amerika ligt in het opwekken van prikkels om de eerste klasse binnenlandse ondernemers te creëren. En dat is waar de regio zijn elitaire kettingen moet verbreken en vooruitstreven om de maatschappij van de toekomst te definiëren, die innovatiever en inclusiever moet zijn om zo gelijker te zijn.

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INTRODUCTION

The success of countries and production systems is increasingly associated with the capacity to generate new knowledge, to solve problems and/or to create new markets. But, unlike some decades ago, innovation is not only happening in advanced countries. Developing countries are accumulating production and innovation capabilities and are increasingly looking at innovation as a source of growth and development[1]. However, at least in Latin America, the innovation for development debate has often resulted into a "soft" policy approach. In many cases the call for boosting innovation has been detached from the call to promote structural transformation and changes in the production specialisation of countries. During the 2000s, in many cases, the return of innovation policies ended up in a call for "getting the innovation systems" right, including by strengthening intellectual property protection, without addressing the need for structural change of the real economy. The innovation agenda appeared a kind of consensual policy area, at least in theory, exempt from the difficult sectoral choices that belonged to the field of industrial policies[2].

Globalization increased the complexity of the innovation policy scenario by making national boundaries a too stringent space for innovation promotion (national talents are increasingly trained abroad, foreign professionals operate in the national economy and firms tend to set up global operations). Globalization and the new forms of organization of production at the global level are also creating new incentives (and disincentives) for investing in innovation. For example, the global unbundling of production has increased the opportunity for large corporations to gain profits by diversifying market access and by implementing cost-reduction relocations. This easy rise in profit opportunities might even reduce the incentive for some companies to invest in risky and long term research and development (R&D) programmes in the future. This could radically change the organization of innovation in certain sectors, where until recently large companies have been the anchors around which innovation systems developed. Furthermore, globalization challenges the traditional rationale for state intervention. In the new economic landscape it is not clear upfront "who" will benefit from national budget expenditures on basic research, technology and skills' development.

In the new economic setting in which developing countries are giving more prominence to innovation policies in their national development strategies, a deep-

[1] See among others UNCTAD (2007), CEPAL (2009) and OECD (2013a).

[2] Cimoli, Ferraz and Primi (2005) and Soete (2007).

er understanding of the policy learning can be of help in designing and implementing better policies not only in Latin America, but also in other developing regions and in OECD countries.

INNOVATION, TECHNICAL CHANGE AND DEVELOPMENT: AN OLD POLICY DILEMMA

The fact that the capacity to introduce new products and processes, as well as to deliver new services and to invent new business models are primary sources of growth and development is not a new idea. In 1934, Schumpeter had described economic development as a process of qualitative change of the production structure associated with the generation and the diffusion of innovations[3]. The rise of new technologies, coupled with the discovery of new energy sources would contribute to the generation of new and faster means of transport, transform the production functions and determine the generation of new markets. This expansionary process was assumed to be at the origin of extended growth cycles. Growth in the long-run was, in fact, assumed to be mainly determined by the capacity to engage in processes of transformation of the production structures and, therefore of transformation of financing schemes, consumption patterns and labour markets regulations.

Early development theories had identified the change of production specialisation as the major determinant of development. In the 1950s there was a shared perception that developing economies were "structurally" different from developed ones: they were dependent on primary exports and they lacked endogenous technological capabilities[4]. Therefore, the "center" could capture the benefits of technical progress both through the higher rents generated services in their domestic economies due to technical progress and productivity spillovers from manufacturing to agriculture and through trade, by getting access to agricultural products and raw materials at lower prices, obtained by modernised production in the "periphery" through technology transfer from the "centre". The impact of technical change in the periphery resulted in modernization in traditional sectors and in lower prices for the centre's imports of commodities[5]. Development, in that context, was de-

[3] Schumpeter (1934).

[4] Even though early development economists differ in many respects, they share the view that developing economies are structurally different from advanced ones, and that backwardness is not a preliminary stage of development, but could become a "structural" feature if appropriate policies are not put in place. See among others: Prebisch (1950); Lewis (1954); Myrdal (1956) and Hirschman (1958).

[5] Prebish (1950) has established the pillars of the Latin American structuralism: (i) the importance of production specialisation; (ii) technical change as a major determinant of development in the long run.; (iii) the significance of demand and supply constraints to capital accumulation; (iv) the linkage between production structure specialization, social configuration and income distribution; and (v) the importance of public policies and institutions to shape development trajectories.

fined as a process of diversification of production structures,of institutional and social change determined by the shift of labour from low-productivity agricultural activities to more productive industrial sectors, and by the creation of backward and forward linkages[6]. This process needed state intervention to support the generation of endogenous technological capabilities because market incentives alone would have not been enough to foster structural change in the periphery[7].

While in the 1950s, the early Latin American structuralists were debating in defining an approach to economic development centered on the need of the region by taking into account the heterogeneity between Latin America and advanced countries, some scholars in the United States started to focus on the mechanisms that determined the allocation of scarce resources to the generation of new knowledge and invention in market economies. These seminal works paved the way to discuss the role of the state in financing innovation and the role of appropriability mechanisms[8]. State intervention was justified by the high risks and uncertainties associated with the process of invention. The market (i.e. private profit-motivated agents under perfect competition) would spend less than what is socially desirable on the generation of new knowledge, given the risk and uncertainty associated with investments in its generation. Therefore, the state was required to financially contribute to the generation of knew knowledge to correct the imbalance between private and social marginal benefit[9]. The state was also supposed to intervene to guarantee the appropriability of knowledge. In fact, in the absence of adequate mechanisms to protect it, the economy would face an underinvestment in invention generation, due to potential free-riding behaviors[10]. On the basis of this literature, a heterogeneous group of scholars has contributed, in the following years, to increase the knowledge about how innovations are created and diffused in socio-economic systems by shading new lights on the properties of learning, institutions and routines in shaping technical change and innovation[11].

However, even though economic theory was increasingly better endowed to understand development as an evolutionary process of structural and social change, these theories did not make it in substituting the conventional approach in the policy debate, especially in developing countries. Despite the evidences of the fallacies of the Washington Consensus approach, free markets permeated most of

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[6] Hirschman (1958); Datta (1966).

[7] Modern economics has advanced in the understanding of development as process of change of economic and social structure and on the relevance of technology and trade in shaping this process. See among others, Nelson and Winter (1982), Dosi (1988a); Dosi *et al.* (1988) and Dosi, Pavitt and Soete (1990) in the evolutionary school and Grossman and Helpman (1991) and Aghion and Howitt (1992; 1998) in the new growth theory approach.

[8] Nelson (1959) and Arrow (1962).

[9] Nelson (1959).

[10] Arrow (1962).

[11] See, among others: Atkinson and Stiglitz (1969); David (1985); Teece (1986); Perez and Soete (1988), Arthur (1989); Cimoli and Dosi (1995) and Freeman and Soete (1997).

the policy arena and became the referential paradigm in policy making. This is due to several reasons, not lastly the fact that most of the influential policy makers in Latin America had been trained in the same universities where that ideology had originated. The adoption of the structural reforms in the 1990s has shifted the policy consensus from production structure to trade openness as main growth determinant. In that context, innovation policies managed to keep a policy space, but they had to be, in most of the cases, compliant with the conventional free market approach, failing to openly address the issues of qualitative differences between economic activities and the need to align innovation promotion with industrial development. While these issues appeared clearly from the advancements of economic theory, a detachment between economic theory and policy emerged. In fact, innovation theories help to recognise that (Chapter 1):

i. Qualitative and quantitative differences between sectors and productive activities matter; therefore specialising according to comparative advantages is not always the best strategy when a country has an advantage in a sector or activity with low increasing return.

ii. Innovation is a sector specific activity and therefore promoting innovation needs to go hand in hand with support for production development in specific sectors.

iii. Institutions are paramount in determining development and in shaping the transition towards superior stages of development.

iv. Innovation is not merely a private sector business. It ensues through formal and informal networks and interactions between firms, research centers, universities and users. The quality, dynamism and density of innovation systems shape the capacity of the economy to be innovative and to sustain growth in the medium and long-run.

v. Building technological and innovation capabilities is a long-term effort based on experimentation, learning and interactions.

However, in practice innovation policies have often been designed around more linear policy models that do not take into account the complexity and sectoral specificities of what innovation theory reveals.

WHY FOCUSING ON LATIN AMERICA?

East Asian economies have been extensively studied as successful catching up cases. The capacity to promote learning, a proactive role of government and the strategic capacity to manage rents have been identified as key drivers of their success. The East Asian "miracle" has often been contrasted with the poor performance of Latin American countries. The two regions differ in geography, cultural heritage and geopolitical alliances, but comparing them reveals some of the key features that have allowed some economies to transform and go beyond factor endowments, and others to deepen their specialisation pattern in traditional sectors[12]. The South Korean success, as well as the rise of China, Malaysia, Taiwan and Singapore, rests upon different development models, but had in common the implementation of multi-annual plans backed up with multi-annual budgets, empowered institutions, high political support to the transformation agenda, strong execution capacities, promotion of science, technology and innovation in alignment with the production structure needs, strategic management of intellectual property rights and gradual opening to global markets[13]. These economies have used to a great extent state rents to foster specialisation in new sectors and to build new competitive advantages. But they have also been capable of managing rents on the basis of performance and to drop interventions when they were not yielding the expected results[14].

Focusing on Latin America to analyze the role of science, technology and innovation in development and the role of the state in promoting them might seem an odd choice. Latin America is not the first place that comes to mind when talking about innovation and economic transformation. The region is well known for the persistency of its structural weaknesses. Latin American countries still invest little in innovation and face high barriers to innovate, mostly due to the prevailing specialisation patterns, lack of finance and little domestic demand for innovative products (or better said high preference for imported goods rather than domestic production). However, it is precisely because of the challenges that the region is still facing and because of the return of the transformation challenge in the development agendas of many Latin American countries that deepening the understanding of the region's experience in innovation policy learning is relevant for improving future policy choices.

Latin America has invested in building innovation capabilities, but the early efforts have been interrupted by the structural reforms and then challenged by the open economy context. Most of the studies on Latin America focus on growth (why the region has not been growing or has been growing less than its potential[15]) or on the lack of structural change and the persistency of the productivity gap[16]. However, less is known about the cumulative process of learning in innovation policy making in the region, on the variety of approaches followed by the different countries, and on how the accumulated learning could help (or not) in advancing on a knowledge-based growth pattern[17]. Albeit Latin America is not yet an example of

[12] Palma (2009).
[13] See among others: Amsden (1989), Wade (1990), Sundaram (2007).
[14] Khan (2000).
[15] Velasco (2005); Solimano (2006).
[16] Katz (2000); Cimoli (2005).
[17] Cimoli (2000); Cimoli *et al.*(2005; 2009b); Sagasti (2011).

catching up, there is the possibility that the region forges ahead, especially if countries invest in identifying opportunities to profit from the current new global economic landscape and learn from their own past experience in policy making.

WHAT IS NEW IN THE INNOVATION POLICY AGENDA IN LATIN AMERICA?

Since the beginning of the 2000s, innovation has become a fashionable topic in Latin America. Most countries have started to elaborate national innovation plans including also incentives related to intellectual property management. The innovation policy model evolved from a linear supply-side approach, prevailing in the 1950s and 1960s, to a linear demand-side approach in the 1980s and 1990s, to more sophisticated policy approaches in the last decade. However, several discontents persist. In most countries of the region, science and technology policies have been de-linked from industrial policies, jeopardising the impact of the actions oriented to promote innovation. However, some countries have recently introduced new, more sophisticated forms of selectivity in their innovation strategies (Chapter 2).

In the new global knowledge economy the conditions that define access, appropriability and transferability of knowledge are of paramount importance. However, the capacity to appropriate the rents deriving from innovation goes beyond the regulatory framework and the established (intellectual) property rights (Cimoli and Primi, 2007; 2008 and Cimoli *et al.* 2009a). Innovative agents use a set of complex (sometimes complementary) mechanisms to appropriate intangibles, depending on the kind of innovation they are willing to protect, their size, availability of legal and financial skills to enforce the rights and their innovation strategies[18]. In fact, the legal recognition of the property right conferred by a patent is not automatically translated into effective capacity to guarantee the control over the patented technology. Patents only confer the right to defend a temporary and exclusive right through legal action. Effective appropriability is a function of the capacity and the willingness of the owner of the right to enforce the right[19]. Intellectual property rights matter because they influence the quality and quantity of the knowledge base and because they shape the incentives to exploit new technological opportunities, they should be discussed within the framework of innovation strategies taking into account local and global scientific and production development challenges (Chapter 3).

The rising relevance of innovation as a domain of action for public policy has increased the demand for empirical evidence on innovative behaviour. Some Latin

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[18] Levin *et al.* (1987); Coehn *et al.* (2000) and Dosi *et al.* (2006).

[19] Lemely and Shapiro (2005).

American countries have started to collect and analyze innovation surveys. Most of the existing studies focus on the determinants of R&D investment, on the profitability of innovation and on the relationship between openness and innovation[20]. However, few econometric studies have analyzed appropriability strategies of innovative firms in Latin America, on the basis of innovation surveys[21]. Chapter 4 contributes to this debate by presenting an analysis of the appropriability strategies of innovative firms in Brazil on the basis of the national innovation survey. These surveys can be useful to raise the awareness about innovation dynamics in Latin America, but their cross-country comparability needs to be improved. In addition, in order to be useful for policy making, a major challenge is to analyze data from these surveys with models that are able to take into account (and reveal) the variety of innovative behaviour of firms, avoiding to focus on the behaviour of the "representative" firm. Innovation policies need to factor in the variety of innovative behaviours to increase their effectiveness; targeting the "theoretical representative firm" does not help much in increasing policy impact.

Intellectual property systems have sensibly evolved over the last decades. As a consequence, new markets for technologies have ensued where patent-holders can monetize patents beyond technology licensing agreements. Patents are increasingly used to settle legal disputes, to increase bargaining power in mergers and acquisitions (M&A) and to defend research advantages in strategic fields. These new trends have given origin to what can be called "derivative" markets for knowledge (Chapter 5). The value of the patent is less and less related to the market value of the patented technology. It is increasingly attached to the expectations about potential relevance of the patent in future researches, as well as to the potential value of other patents in a patent pool. As innovation becomes more important as a source of inclusive and sustainable growth, developing countries need to understand the evolution of markets for knowledge and to take a stance about knowledge governance that reflects their development priorities of today, and more importantly, of tomorrow.

Latin America is called to face the innovation challenge in a fast moving world characterized by globalisation[22], the rise of China, increasing willingness to protect domestic industries to preserve job and competences in the US and in Europe, and new forms of doing business due to the rise of the green economy and new forms of production unbundling. Latin America is facing a *"bonanza"* period, with high growth rates and rising prices for its commodity exports. But for how long will this high-growth period last? The region is also confronted with the new demands of the emerging middle classes and of the new riches in developing economies. How-

[20] On the analysis of the evidence of innovation surveys in Latin America, see among others: Crespi and Katz (1999); Benavente (2006); Chudnowsky *et al.* (2006) and Cimoli, Primi and Rovira (2011).
[21] López and Orlicki (2006).
[22] See Soete (1991) and Archibugi and Iammarino (1999) for a discussion on the impact of globalisation on innovation policies.

ever, there are concerns regarding the capacity of the region to sustain growth in the long term on the basis of its current trade pattern, as well as on its capacity to deliver the services that its evolving society is demanding.

This dissertation, based on extensive field review of innovation policies in Latin America, shows that the region has accumulated institutional and policy capabilities to face the new landscape, but that a change in the prevailing economic model, as well as better metrics and more participatory foresight exercises are needed to overcome the Latin American structural weaknesses and to attain inclusive knowledge-based growth. This is even more urgent in the current context.

Advanced economies are losing ground (and power) in the new global economic landscape and South East Asian economies, especially China, are increasing their global power and are accumulating production and innovation capabilities. The new setting offers no guarantees for the development of Latin America. There will be increasing competition between old and emerging leaders, matched with the challenge of finding new energy sources for our planet. The winning societies of tomorrow will be the ones that today recognise that science and productive business founded on smart application of knowledge are the keys to forge ahead. The time for catching up strategies is gone. Today developed and developing countries are facing the need to forge ahead and define new forms of production, consumption and trade. Latin America can do it. The challenge is how to create the consensus for changing the *status-quo* and how to factor in voices for change. And this is a task for the Latin American societies as well as for their political leaderships.

CHAPTER 1

SCIENCE, TECHNOLOGY AND INNOVATION POLICIES:

A review of the literature (and an interpretation)

This chapter reviews the economic literature on innovation policy. It discusses the variety of approaches and their differences in defining the rationale, intensity and direction of policy action. It summarizes the impact of innovation theory on innovation policy, showing why the heterodox approaches offer a relevant (although fragmented) framework for policy action, especially in the new global context characterised by rising uncertainty and complexity of production and innovation systems.

INTRODUCTION

In the new global economic landscape, science, technology and innovation policies are more and more scrutinized. High expectations on their impact are nurtured by governments and by the society as a whole, as innovation is increasingly seen as a key driver to sustain inclusive growth and development. The 2008 financial and economic crisis, and the reshaping of the global economic outlook, mostly led by the rise of China, has increased the pressure to boost productivity and create more and better jobs in advanced and in developing economies.

In this context, innovation policies gained popularity and increasing political acceptability. The accumulation and the retaining of scientific, technological and innovation capabilities are seen as pillars for stronger growth and as assets to face the increasingly competitive global marketplace. However, too often policies seem to be designed following a "menu" approach that leads policy makers to choose between different instruments, instead of following a systemic approach.

Innovation policies have become a "must have" in developing countries' agendas, at least in terms of planning (even though much less in terms of budget). Nevertheless, the development agenda is still dominated by macro-stability and inflation targeting, and by the belief that getting the "framework conditions" right would suffice to spur innovation and development.

The 1990s have been characterised by a (dangerous) detachment between innovation and industrial policies, in developing and in advanced countries (Cimoli *et al.* 2005; 2009b; Soete, 2007). Recently, the return of industrial policies on the development agendas and the emergence of new forms of selectivity in government policies are contributing to overcome this pitfall. But developing countries still face a long and winding road (OECD, 2013a, b).

In a landscape in which governments, especially in developing countries, are more and more concerned with the promotion of technological development and innovation, a reflection on innovation theory, and its implications for policy, can help in going beyond ideological confrontations between the role of the state and the market in shaping learning and innovation trajectories. Different theoretical frameworks entail different understandings of the properties of knowledge and technology, and varied views about the micro-behavior of agents and of their learning patterns. Therefore, different theories imply different rationales, objectives and instruments for innovation policy. Analyzing the implications of different economic theories on policies goes beyond a pure theoretical debate. It molds the way in which policies are conceived and implemented in practice[23].

[23] The divergence between different schools of thought, evident in the case of industrial policy, is less pronounced in the field of science, technology and innovation (STI). See Chang (1994) and Peres and Primi (2009) for an overview of the differences between orthodox and heterodox schools in framing industrial policies.

There is a general consensus on the fact that government intervention is needed to support knowledge generation, application and diffusion. However, differences exist regarding the rationale, scope, intensity, and degree of selectivity of public support for innovation. Supporting: What? Whom? To what extent? This chapter reviews the economic literature on innovation and innovation policy. It highlights the variety of theoretical contributions and the differences between them. It concludes by clarifying why the heterodox contributions offer a relevant (although fragmented) framework for policy action, especially in the new global economic landscape.

1.1 VARIETY OF ECONOMIC APPROACHES TO INNOVATION POLICY

Innovation policies are the actions resulting from public strategies, and implemented by the State, to increase the innovative capabilities of economic systems. *Latu sensu* any kind of public policy (or action) affecting firm's costs, outputs and profitability has implications on the innovative behavior of firms and could be classified as an innovation policy. For example, Lundvall and Borrás (1998) include in the definition of policies for innovation, macro-policies aiming at guaranteeing macroeconomic stability, trade policies and micro-policies such as competition policy and other types of government actions affecting the business environment of firms.

The OECD defines innovation policies as the government actions influencing the innovative behavior of firms. The focus on firms differentiates innovation policy from science and research policy. Innovation policies focus on the conditions that allow transforming research into increased competitiveness in production (OECD, 1997). Others define innovation policies as actions to increment the available knowledge base and the conditions for appropriation and diffusion of knowledge, as well as initiatives like technology foresight programs and provision of relevant information (Georghiou and Metcalfe, 1998).

Beyond the shared perception that government action is needed when the generation of novelty is at stake, far less consensus exists among different schools of thought on rationale, scope and direction of state intervention. Standard orthodox theories assume perfect equilibrium and justify state intervention as a mechanism to correct market failures and asymmetries. In heterodox approaches, state intervention is needed to create asymmetries to support innovation and diversification.

In the late 80s, several authors have analyzed the differences between mainstream and heterodox approaches in science, technology and innovation (STI) policies (Hall, 1986; Wolf 1986; Stoneman, 1987; Metcalfe, 1995; Lall and Teubal, 1998). These studies highlighted that the heterodox framework was better endowed to provide a rationale for policy action.

The geography of production has changed and a new geography of innovation is emerging. New innovation poles are growing in emerging economies in addition to traditional innovation hot-spots in advanced countries. In addition, firms have also modified their innovation strategies due to new technological opportunities and to new demands from rising middle classes and the "new elites" in emerging economies. In parallel, the innovation literature has also evolved, providing increased understanding about how innovation occurs in the new more uncertain and complex global economic landscape. A review of the literature reveals that, despite the advancements, we are still far from getting a convergence regarding the role of the State in promoting innovation. Different schools of thought co-exist, and often evolve with little permeation between them. The following sections present an overview of the main characteristics of the orthodox approach and of the variety of heterodox contributions to innovation policies. The last sections concludes by summarizing the contributions of innovation theory on innovation policies and by highlighting some of the areas were more research is needed to close the gap between innovation theory and policy.

The orthodox approach: from market failure to government failure

Mainstream economics is a rich and fertile field of research; reviewing its contributions to innovation policy goes beyond the scope of this chapter; in this section, I only refer to some theoretical elements that frame the rationale for innovation policy.

In standard economics the need for State intervention to promote innovation arises from the recognition that markets fail to achieve the optimal allocation of resources, in the case of public goods, in the absence of competitive conditions and in the presence of externalities.[24]

Public goods are both non-rival and non-excludable in consumption. Since they may be consumed by an economic agent that has not paid for it ("free rider"), their supply tends to be less than optimal. This is the case, for example, of the output of basic research which is supposed to constitute the pool of available knowledge and information to which productive agents draw from to carry out their innovations. In these cases, individual rationality tends to generate collective inefficiency; therefore State intervention is needed to ensure optimal supply[25].

State intervention is advocated to ensure efficiency of markets. In the absence of perfect competition, State action is needed to guarantee the optimal provision of

[24] An additional argument in support of state intervention refers to ethical reasons; this is the case of "merit goods". These are goods whose consumption is promoted (or prohibited) by the state due to ethical and collective reasons, going beyond the sovereignty of the consumer, Nozick (1974).

[25] This position provides, however, no universal rationale for State intervention, since in sufficiently small groups, public goods may be provided without State intervention, due to the marginal benefit that accrues from individuals' offering them unilaterally (Olson, 1965).

goods and services, helping to establish the equilibrium as close as possible as the one that would have been determined by competitive markets[26].

When individual utility (or cost) functions are not independent from those of other agents, so that individual actions have spillover effects — which are not transmitted through prices— on others who have no control over the initial action, we are in the presence of an externality. As private and social cost and utility functions differ, optimal individual behavior may lead to suboptimal collective situations (under-production in the case of positive externalities, and over-production in the case of negative externalities). The State needs to provide regulations, as for example the introduction of compensation mechanisms and the definition of property rights to reduce the gap between individual costs (or benefits) and social costs (or benefits). In the case of STI policies the analysis of externalities has been at the core of the discussion about the importance of appropriability mechanisms (and especially on intellectual property rights[27]). The State should guarantee the legal framework to ensure the appropriability of intangibles to create the incentives to maximize the rate of innovation[28]. In presence of externalities, as in the case of investment in the generation of basic scientific capabilities, economic theory justifies the extension of the scope of government action beyond regulation and horizontal financing. Direct state intervention, or targeted subsidies, might be required to create public laboratories and to offer targeted subsidies to R&D in key technological areas.

However, even when a more proactive role of the state is advocated, the space for government intervention is limited by the fear of "government failures" (Krueger, 1990). It is reasonable to assume that governments can fail or act under pressures from lobbies and vested interests, thus making mistakes in policy sequencing, timing and management. In the early 1970s, a series of studies focused on analyzing the experiences of State intervention over the previous decades to detect its capacities to prioritize and select sectors, and to determine the correct amount of resources to be devoted to innovation. These analyses showed that the State was no more exempt from making mistakes than it was the market. The discussion first focused on the State's difficulty to obtain and process the information needed for decision making. Moreover, some authors note that uncertainty about the future undermined the rationality of planning (Richardson 1960; Williamson 1975).

[26] Lipsey and Lancaster (1956) criticize this argument as a founding assumption for state intervention, arguing that eliminating some price distortions does not always increase the efficiency of markets, if all distortions are not corrected.

[27] This issue is further discussed in Chapter 3 of this dissertation.

[28] However, defining the optimal level of ownership rights and the compensation mechanisms is complex, and sometimes impossible, due to uncertainty, high transaction costs, the difficulty of obtaining relevant information, and the costs of enforcing contracts, among other issues (Coase, 1960; Stigler, 1975; Dahlman, 1979).

More recent contributions have identified additional reasons for government failures, including: (i) limited ability to foresee the consequences of public policy; (ii) the state's limited control over the consequences of its actions, especially in democratic systems where the state is not the only *locus* of decision making; (iii) the lack of separation of policy design from policy implementation; and (iv) the existence of incentives for veiled and captured interests[29]. In the case of STI policies, one might include a fifth point relating to the fact that the timing of political cycles do not coincide with the cycles of the "real" variables that policy aims to affect. Generating knowledge and building production and technological capacities is a long-term process that goes beyond the horizons of democratically elected administrations. Often, the political dynamics create incentives that prevent the adoption of costly selective measures that can be expected to yield results only on a time horizon beyond that of the administration implementing them.

The discussion on "government failures" is useful when it helps molding institutions to overcome them. But in practice, the belief in self-regulating markets has induced to focus on the shortcomings of government myopia, underestimating the short-sight of markets in picking technological options that might have high social and economic externalities. There is no historical or empirical evidence showing that the private sector is better than the public sector in picking actors and technological avenues. History shows that there is a variety of strategies conducting to success. If a common denominator exists behind them, it is a mix of state planning and financing matched with private sector commitment to innovation.

However, in practice, orthodox analyses are appealing to policy makers, especially to Ministries of Finance and Treasury requiring "facts" and "demonstrations" about the efficiency of public actions. Often, *ex-ante* cost-benefits analyses of public investment profitability are required as preconditions for investments in areas, such as innovation, where the outcome is not deterministic, not predictable and highly affected by serendipity and externality effects. The standard argument usually goes as follows: since the market, in theory endowed with perfect capacities for orienting resource allocation, fails to do that in the specific case of knowledge, the State needs to come in to correct market failures and to re-establish the equilibrium that would have been achieved by a perfectly competitive economy. Therefore, the market failure approach frames the rationale for policy making in a reductive way (correction of "failures"). In addition, the threat of "government failures" and the potential capture of interest by certain actors lead the orthodox policy maker to privilege the reduction of policy spaces for state intervention, rather than to prioritize the design of institutions and mechanisms to avoid the potential capture of interests and the crystallization of policies into "old and slow" bureaucratic routines, which are, actually potential drawbacks of State action.

[29] North (1990) explores the role of institutions as safeguard mechanisms that make it possible to preserve the "policies of the State" despite the pressures from special interests.

Standard economics frames innovation policy in a constraining way. Even when the need for selective state intervention is recognized, for example when there is a need to orient technical change towards new areas, the conventional approach still defines a pretty limited space for government action. In the case of green technologies, for example, the state should intervene to help the economy to switch from one technological paradigm towards another one (Acemoglu *et al.* 2012); however, how can the State have the capabilities to do so if it is not highly involved in policy planning and management on a continuous basis?

The evolutionary approach: institutions, learning and capabilities

Heterodox approaches often renounce to the simplicity and elegant formality of orthodox models and develop different frameworks that try to deal with the complexity, uncertainty and multiple equilibria that characterize the economy. Understanding how a phenomenon occurs, under which conditions, which are the agents involved and the barriers to tis development are primary steps for informing policy decision making. One of the major heterodox contributions to innovation policy comes from the evolutionary approach. It includes a series of studies on the properties of information and knowledge and on how technical knowledge is generated, diffused and applied in contemporary economies (Rosenberg, 1976, 1982; Freeman, 1982, 1994; Nelson and Winter, 1982; Winter, 1987, 2006; Dosi, 1982, 1988a; Pavitt, 1987, 1999; Freeman and Soete, 1997; David, 1993; Dasgupta and David, 1994).

Beyond the differences between authors, evolutionary interpretations share some core principles regarding: a) the framework and the basic features shaping the functioning of socio-economic systems; b) the specificities and properties of knowledge, technology and innovation; and c) the characteristics of the process of knowledge generation, application and diffusion.

i) The heterodox approach assumes that innovative behavior is nested in complex institutional settings. It identifies institutions, networks and markets as co-acting mechanisms shaping the generation and diffusion of innovation.

One of the areas of major disagreement in economic theory regards the patterns of individual and social choices. The evolutionary approach does not consider self-regulating markets as the best mechanism to support innovation. It does not assume profit maximizing agents, nor perfect information and competition as underlying hypothesis for determining individual and collective choices. Market failures are considered as regularities. The whole world could be looked at as a big market failure considering that the market fails to optimize the allocation of resources in the absence of complete information, and under imperfect competition and limited appropriability, as Cimoli *et al*. (2006) ironically argue.

The rationale for State intervention is based on the recognition of the absence of automatic adjustment mechanisms. Evolutionary theory explains why the existence of a superior technique does not always imply its automatic dissemination among all agents (David, 1985; Arthur, 1989). The rationale for State intervention is also linked to motivations such as growth and competitiveness of nations and security issues. Support to technological development is justifiable on the basis of the need to master techniques and technologies for defense and national security and because industrial productivity depends on innovation and technological capabilities.

It is not only the existence of knowledge or technology that matters for countries (and for firms), its ownership and accessibility matter too. This issue justifies State support to R&D and innovation even when externalities and uncertainty undermine the possibility of calculating the costs and benefits of each policy choice. Support to science, technology and innovation is strictly linked with industrial policy choices. Airbus, for example, is probably a high cost and risky business, whose profitability in terms of public investment is hard to determine; however how to calculate the costs and benefits of having introduced an additional big player in such a strategic industry? And what about the effective and potential technological cross- sectoral spillovers?

In the evolutionary framework, institutions play a crucial role in shaping information, knowledge and know-how generation, application and transfer. Institutions are needed to shape socio-economic trajectories and to avoid lock-in phenomena induced by market incentives. As a response to the government failure argument, evolutionary economists observe that although it is true that nothing can guarantee, *ex ante*, that a government's decisions will be optimal, it is equally true that no one can guarantee that the market's decisions will be optimal, or superior to governmental ones. Market forces alone will not suffice to generate, apply and diffuse the knowledge at the rate and in the direction required by the society. The market will probably be reluctant in investing in uncertain mission oriented research projects with no direct industrial application or characterized by long and highly unpredictable rate of success.

In addition, the evolutionary framework underlines the fact that innovative firms are not "monads". To search for and apply technological and business novelties firms require -and are influenced by- the set of relationship with other firms, consumers, and the environment in which they operate. Market structure, institutions and networks shape, and are shaped, by the innovative behavior of firms. The systemic view implies a broad definition of technical change, which includes not only the generation and application of hard technologies, but also complementary innovation strategies, and changes in organizational structures, routines and business models.

ii) The specific features of knowledge, technology and innovation are characterized by tacit and explicit dimensions and are embedded in routines and agents' behavioral patterns.

Knowledge differs from information because it has tacit and non formalized components that influence its effective transferability (Polany, 1966). Starting from the classic analyses of the peculiarity of invention and its generation (Nelson, 1959a; Arrow 1962a; Usher, 1964), the evolutionary approach adds insights about the behavioral dynamics of agents, institutions and networks (Dosi *et al*. 1988; Freeman and Soete 1997). In the late 1970s and 1980s, a series of studies contributed to "open the black box" of innovation by identifying specific features of knowledge, technology and innovation (Rosenberg, 1982; Kline and Rosenberg, 1986). Technology is far more than a set of blue prints and it embeds the know-how and problem solving activities. Innovation, following the Schumpeterian framework, can be defined in a strict and in a broad sense; it includes new products, new processes, but also new ways of doing business and new forms of organization of production and service provision.

The literature also recognizes the existence of technological paradigms (Dosi, 1982) and techno-economic paradigms (Perez and Soete, 1988). They are cyclical and recurrent supra-dimensions of technology which affect the aggregate way of production and consumption in given socio-economic periods and which shape the organization of the economic activity, influencing not only innovation, but also labor market and skills requirements, as well as, the forms of interactions among different agents.

In their search for innovation, agents (firms, individuals, and institutions) rely on a complex set of external resources. Absorptive capacities of firms and institutions affect their capacity to identify learning opportunities and of benefiting from knowledge available outside the boundaries of the firm. There are minimal levels and sets of capabilities which are required to profit from the knowledge and opportunities available in the system. We could say that the capabilities of innovative agents perform as filters (with multiplier or reductive potential) with respect to existing opportunities (Mowery, 1983; Cohen and Levinthal, 1989; Teece 1986; Rosenberg, 1990).

Technological knowledge and learning patterns are sector specific. The impact of different production activities on aggregate performance is not equal; increasing returns and margins for innovation-based rents differ from sector to sector. Different rents, productivity and employment gains will accrue from being innovative and competitive in the banana industry, in mobile-applications or in the aerospace industry. A series of studies contributed to "unbundle" the view on technology highlighting its non neutrality and its sector specific dynamics (Pavitt, 1984).

iii) The process of search, application and diffusion of innovation is not linear or deterministic. It is cumulative, uncertain and influenced by routines, indivisibilities and externalities.

Uncertainty is a primary feature of discovery and innovation. Schumpeter has sustained that "No list of identifiable environmental elements will suffice to determine how a particular change actually took place. [. . .] Of all that can be said on this topic, only one thing is of interest here, the appearance of novelty as such always gives rise to indeterminacy".[30] Nelson has clarified the unpredictability effect originating by the crossing between the lack of technological determinisms and the bounded human rationality. "Invention still is a most uncertain business, chance still plays a crucial role, and often the clever and lucky individual inventor rather than the better equipped research team wins fortune's smile" (Nelson, 1959b, p. 112). "[. . .] "experience made it increasingly clear that research cannot be closely planned and scheduled, that the types of skills needed cannot always be forecast, and that often men from several disciplines are needed" (Nelson, 1959b). "Knowledge has often (usually?) being acquired in activities in which pursuit of knowledge was of no, or negligible, importance" (Nelson, 1959a, p. 299). Uncertainty reduces the incentive for incumbents to search for new opportunities given the limited capacity of anticipating future benefits; hence, usually new firms are carrier of inventions and knew knowledge, (Nelson, 1959b).

The recognition of the existence of uncertainty leads to take into account the high risk associated with innovative efforts. While it is true that the probability of innovating is an increasing function of the effort (Dasgupta and Stiglitz, 1980; Reinganum, 1989); it is even truer that not all increased efforts lead to more innovations, nor that more innovation is always better (think about the disastrous impacts of financial innovations during the last decade . . .). Nelson (1982) applies order statistics to define the expectation of a better performance as a function of innovative effort and others define the probability of innovation as markovian process (Dosi 1982; Nelson and Winter, 1982). Innovation is a risky business, and failures must be considered as ordinary events in the discovery process, not as outliers of a supposed linear innovation trajectory. Beyond uncertainty, demand and supply forces shape innovation trajectories. In fact, evidence shows that technological advances have been the result of technology push, demand pull or a mix of the two (Freeman, 1984; Georghiou *et al*. 1986; Mowery and Rosenberg 1979).

Learning is a dynamic process based on trial and error, and requires a certain dosis of "personal" effort. Transferring information is possible, however learning requires time and targeted effort by each learning agent; shortcuts might be possible, but they are not the rule. The literature highlighted different types of learning, "learning by doing" (Arrow, 1962b), "learning by using" (Rosenberg, 1982) which support increasing returns in technology adoption, "learning by interacting", "learning by sharing", and alike.

The process of technical change is localized, meaning that it is influenced by the accumulated capacities, routines and competences and that the substitutability of techniques is resistant to price changes due to indivisibilities (Atkinson and Stiglitz, 1969). On the other hand, technical change shows increasing returns to adoption.

[30] See Schumpeter "Development" as republished in Schumpeter, A., Markus C. Becker, Thorbjørn Knudsen (2005), *Journal of Economic Literature*, Vol. 43, No. 1, pp. 108-120.

Under certain conditions, turn it into a non-localized asset, quite sensitive to changes in relative prices once other options are available or when it enters the "commoditization" phase.

Various mechanisms explain the generation of increasing returns from technical change adoption and diffusion (Arthur, 1989). Rosenberg shows that the more a new technology is used, the more the agent using it acquires capacities of mastering it, thus increasing its performance ("learning by using", Rosenberg, 1982). Katz and Shapiro (1985, 1986) suggest that the more a technology, or a way of doing business, is adopted by a series of users, the more new types of productive uses might ensue, thus increasing the returns from technology adoption (network externalities). Arthur (1989) discusses that the more a technology is diffused in the system, the more it is possible to benefit from scale economies in its production, allowing increasing returns from technology adoption. The author also points to the increasing returns deriving from information. The more a technology is used and known, the more agents can profit from its adoption thanks to increased information available in the system. Frenkel (1955) showed the existence of increasing returns from technology adoption due to simultaneous adoption in related markets (technological interrelations). Arthur (1989) demonstrates that competition between technologies characterized by increasing returns to adoption leads to multiple equilibria. Potential systemic inefficiency is possible, when the technology that dominates the market is not necessarily the one with the higher pay offs to adopters and when lock-in might occur due to increasing returns to adoption. Path dependency, might lead to a system which is dominated by inferior technologies due to "small" events, in the absence of targeted policies (Arthur, 1989; David, 1985).

Knowledge and technologies show private and public good properties, due to their specific nature and to the types of regulations which place them in the private or in the public domain (see for example the changes in the US intellectual property regime which increasingly pushed during the 80s and 90s for shifting science from the public good domain to the private one. This issue is further discussed in Chapter 5 of this dissertation). Technological knowledge appears to be a peculiar type of good: the "club" good. It is non rival but excludable in consumption. And excludability in "use" is shaped voluntarily by regulations, but also by the accumulated capabilities of agents.

National innovation systems: focus on interactions

Within the heterodox approach a series of studies focuses on the systemic dimension of innovation. Starting from the premises that innovation is a "business affair" the National Innovation Systems (NIS) literature stresses the need to take into account the systemic and institutional factors that influence business dynamics and that shape the discovery and application of new knowledge (Freeman, 1987; Lundvall 1992; Nelson, 1993; Metcafle, 1995; Edquist 1997; OECD, 1997). Merging evolutionary and institutionalist contributions, these studies sustain that a network of formal and informal connections constitutes the NIS. The NIS approach conceives innovation as a systemic and cumulative process. The interaction of different agents (firms and research institutions, but also consumers, and the civil society) responding to different market and non-market incentives shape the process of generation and diffusion of innovation.

According to Freeman (1987) the NIS is "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies". Lundvall (1992) emphasizes the learning processes that take places in NIS, while Nelson (1993) focuses on the institutions that determine innovative performance of firms in a given country. Similarly, Metcalfe (1995) defines an innovation system as "that set of distinct institutions which jointly and individually contributes to the development and diffusion of new technology and which provides the framework within which governments form and implement policies to influence the innovation process".

The NIS literature has been prolific (See Soete *et al.* 2009 for a review of the literature on innovation systems). It encompasses a series of studies that have in common the focus on the interconnected and interdependent nature of innovation (Arora and Gambardella, 1990; Carlsson, 1997; Chesbrough, 2003; Tether and Metcalfe, 2004; Powell and Grodal, 2005). Some authors focus the sectoral differences that characterize innovation, thus analyzing sectoral systems of innovation and the specificities of linkages, institutions and interactions that affect innovation and technical change in different sectors (Malerba, 2004a, 2004b;). Others discuss the institutional dimension and the relevance of forms of interactions in determining patterns of learning and innovation (Lundvall, 1988; 1992).

Beyond the nuances, the NIS approach defines innovation as process molded by specific sectoral and local conditions. Innovation is the result of non deterministic and uncertain processes in which public and private agents interact through various, formal and informal, networks on the basis of explicit and implicit coordination mechanisms (Nelson, 1993). Social and institutional factors become determinant in explaining the innovative performance of firms. The NIS approach recognizes that the generation of new knowledge, the adaptation of existing techniques and their diffusion in the socio-economic system are part of a dynamic process of complex interactions which involve actors motivated by market and non-market incentives. The development of production and technological capacities depends on interaction between market and non-market mechanisms, and it advances through a trial and error process.

The NIS approach contributes to enlarge the scope of innovation policies by recognizing upfront the relevance of non market institutions in determining innovation. Universities and public research laboratories, as well as the general level of skills available in a given society and the quality and usability of infrastructure also contribute to shape firm's innovation trajectories and performance. Considering the "diffuse" nature of the relationship between science and technology and innovation

(Kline and Rosenberg, 1986; Rosenberg, 1990), the NIS approach sustains the linear policy approach falls short in setting the conditions for improving the functioning of national innovation systems. Both supply-side and demand-side incentives are needed. The rationale for State intervention is not based on market failures, but rather on the recognition of the absence of automatic adjustment mechanisms. Policies are needed to support institutional development and to foster the interactions and coordination required to promote innovation.

By recognizing that innovation is determined not only by agents' capabilities but also by the types of interactions and by the kind of environment in which agents behave, the NSI approach broadens the rationale for policy action. Policies encompass actions to influence the business and creative environment, to increase the absorptive capacities of firms and research institutes and to improve the quality of interaction between the agents of the innovation system.

The NIS literature has also contributed to introduce heterodox approaches into policy making in developing countries (Cimoli, 2000). In particular, the notion of NIS supports the fact that systems differ not only in stages of development. They differ because different features (technological, structural, sectoral, territorial, and cultural) of a production system induce different outcomes. In practice, this approach leads to recognize that general lessons do not apply, unless time, sectoral and local context conditions are taken into account.

The "territorial" approach: local systems and networks

The heterodox approach also includes the lines of research of some authors that have focused on the regional and territorial dimensions of innovation systems. Merging the studies on local industrial dynamics (Perroux, 1955; Becattini, 1979; Brusco, 1982) with the innovation literature, this line of research has centered on analyzing Regional Innovation Systems (RIS). These authors focus on the relevance of local, territorial and proximity conditions in shaping innovation (Asheim and Gertler, 2005; Cooke, 1992; Cooke and Morgan, 1998; Cassiolato and Lastres, 1999).

As in the NIS approach, in the RIS, the innovative outcome of agents depends on the performance of other agents (such as universities and research centers), on framework conditions (such as standards and regulations), and on forces shaping the demand side. The key determinant of the performance of the system is the intensity and quality of interactions that take place in a given territorial unit. The RIS approach underlines the relevance of geographic proximity, the sharing of cultural codes and social capital in determining the quality, frequency and intensity of interactions.

The RIS approach focuses on qualitative research by describing innovation dynamics at the local and regional scale. Several studies provide detailed micro-analysis of innovation dynamics in specific industries and territories. In Europe, the RIS concept has made his way in the policy debate in the late 1990s (European Commission, 1998) and it has contributed to highlight the relevance of regional and local governments in fostering innovation and production development; a dimension which was underestimated in the NIS framework. The EU has fostered empirical studies based on the definition of regional typologies. Nevertheless, regional innovation indicators are still few and biased towards technology-related indicators, which do not capture the non-technological and intangible assets of regional and local production systems (European Commission, 2009; Wintjes and Hollanders, 2010). This approach is contributing to expand the scope for policy by including in the policy mix the incentives for training, labor absorption of skilled workers, business services, as well as demand-side policies and support to research and industrial upgrading. However, this approach tends to underestimate the national dimension in which regions are nested.

In certain cases, this approach has looked at regions as "smaller nations", underestimating the relevance of economic and functional regions. Economic activities are indeed localized, but the organisation of production organization often goes beyond administrative borders. In addition, some policies have taken to the extreme the "local" focus of the RIS and have mostly praised for local collaboration. In practice, this has not worked since firms and researchers choose partners first for their competences, and then for their territorial proximity.

The "global knowledge society": ICT, international linkages and the rise of services

Since the 90s, some authors have started to focus on the changing environment and the challenges for innovation generated by the new global context and the shift towards the knowledge economy paradigm (Soete, 1991). Some authors have interpreted globalization and the information and communication technologies (ICT) revolution as major drivers of change in the process of generation and diffusion of knowledge (David and Foray, 2002; Dolfsma and Soete, 2006).

Globalization and ICT have opened unprecedented opportunities for innovation (at least for those with the necessary absorptive and technological capacities). Global open economies and ICT increased the speed at which knowledge and information can be transmitted, reduced the time and costs of connection and communication and increased the variety of partners with whom agents can enter in contact. In this new context, innovation increases its relevance as a source of growth, but it also goes beyond the "technology-centered" approach of the early evolutionary interpretations. R&D and technological innovation still matter, but there are several innovations that are generated through the recombination of existing knowledge or through new business models. ICT enable new forms of organization of work and new types of businesses which *per se* are source of novelty in the economic system.

David and Foray (2002) have highlighted the impact of the information society on learning processes and learning environments. They argue that the new paradigm contributes to shift the attention from individuals and firms to communities where knowledge is shared and transmitted, especially in the service economy. The users (i.e. demand) have always been relevant in the search for innovation, but the new context makes that interaction more rapid, less costly and more open.

Others have focused on the role of multinational companies (MNCs). MNCs account for the majority of R&D expenditures in global economies and are influencing the shifts in the global geography of innovation and production by their changing delocalization choices (Cantwell, 1989). MNCs might act as drivers of technological catching up in countries with domestic learning capabilities and huge markets, as it has been in the case of China, but also in small economies such as Costa Rica.

In the new context, knowledge networks and markets and the mobility of talent have grown in importance. ICT enables to manage growing datasets and facilitates the exchange of knowledge and research outcomes. The new context opens new opportunities for science to advance in faster and better ways, when appropriate regulations are put in place. The principle of open science (Dasgupta and David, 1994) becomes even more important in the new context, because several innovations are incremental.

The broadening of the sources of innovation beyond R&D-based processes and the importance of the knowledge embedded in individuals and systems are identified as major game changers in the innovation process. In this setting, the impact of skills and human capital on innovation increases. In addition, national boundaries become too narrow to promote innovation; innovative behaviors are increasingly influenced by trans-national factors. Innovation policies, which have been historically linked to national choices and priorities, are therefore challenged by this new setting.

Archibugi and Iammarino (1999) have reviewed the implications of globalization for innovation policy focusing on the changes in the exploitation of locally generated knowledge by international agents, the existence of global production alliances for innovation, mainly carried out by multinationals, and the existence of global scientific networks. According to them, these are three different problems, although sometimes overlapping, that require targeted solutions and specific policy changes. A key point in their analysis is the need to better understand the impact of globalization on the generation and diffusion of knowledge, and the need to broaden the scope of action for national public policy.

There is a need to increase our understanding of the sources and procedures of technical change at the firm and at the sectoral level in global open economies. The opportunities of the new context are "potential"; they will become effective for the individuals, firms and systems which will be equipped with the necessary capabilities to access them. The fact that the ICT revolution is impacting in different ways US, Chinese and Bolivian companies is self-evident. However, there is a need to better understand the implications of this epochal change on industrial and innovation organization to increase the effectiveness of innovation policies.

1.2 INNOVATION THEORY AND ITS CONTRIBUTION TO POLICY

The variety of heterodox approaches provides insights on the properties of knowledge and technical change, and on the regularities and irregularities that shape the process of innovation generation, diffusion and adoption. Table 1.1 summarizes the main characteristics of these processes.

The heterodox approach offers, at the cost of increased complexity and less appealing "shopping list" type of recommendations, what orthodox theory lacks: a theory of innovation as the underling basis for policy prescriptions. It could represent an appropriate reference for guiding policy since it assumes uncertainty, non linearity, serendipity and path dependency in technological and innovation trajectories.

Innovation policies would be more effective if they were designed to take into account the non codifyable and tacit dimension of knowledge, as well as the sectoral specificities of technical and scientific knowledge; they should take into account that agents have heterogeneous scientific and technological capabilities which shape their reaction to incentives. Policy schemes would be more effective if they could take into account the "club" good aspect of knowledge, both when excludability in access is filtered by prices or when it rests on the capabilities for accessing knowledge. Policies would be more effective if they could explicitly take into account how markets and networks for knowledge work in practice, since they shape knowledge access and diffusion.

Learning is localized and cumulative; hence systems advance by trial and error. Agents and institutions learn by doing, using and interacting. Learning capabilities are shaped by absorptive capacities. The recognition of these features supports investments in the generation of capacities, but also in mechanisms to foster learning. Policies need to consider failures and errors as integral parts of the innovative process. Learning is paramount; it is essential to create institutional strategic intelligence capacities and to preserve institutional memory.

Table 1.1 Innovation and technical change: a taxonomy of properties for orienting policies

Innovation and technical change	Main Properties	Relevant features for innovation policy				
		Agents	Institutions	Markets	Networks	Innovation Systems (National and Local)
Knowledge	Codified and non codified; Tacit Qualitative difference between sectors	Scientific and technological capabilities	Institutional and individual capabilities	Private and "club" good	Public and "club" good	Accumulated in routines and shared codes
Learning	Localized and cumulative	Trial and error; learning by doing, by using, by interacting and absorptive capacities	Strategic intelligence, institutional learning and "institutional memory"	Increasing returns	Network externalities Technological interrelations;	Collective, enhanced or hampered by systemic factors
Technology and knowledge transfer	Modernization and knowledge transfer bounded by endogenous capabilities and constrained by the learning process	Imitation, adaptation, Reverse engineering, Talent mobility	Policy dialogues, platforms	Markets for technologies and for ideas	Open vs. close; flat vs. hierarchical networks ; Cooperation and trust, knowledge communities	Formal and informal mechanisms
Uncertainty	Non linearity and lack of determinism in the generation and diffusion process	Bounded rationality, limited forecasting capacities	Political cycles	"Lottery ticket" (with double uncertainty-probability of winning and the amount of the prize)	Opportunistic behavior; legal infrastructure and appropriability of results	Systemic vulnerability; reinforcing mechanisms of lock in and lock out
Irreversibility	Indivisibilities, sunk costs and lock-in processes	Path dependency, lock-in and routines		Dominant positions; competition and concentration	Externalities, routines, sunk-costs in trust building	Sectoral, historical and cultural routines
Globalization	Intensification of international knowledge flows	Rising heterogeneity within and between countries Mobility/ Stickiness	IPRs regimes Trade and investment agreements	Rise of new industrial powers	Rising relevance of global and local networks	"internationalization" of national and local systems

Source: Author's elaboration based on Cimoli (2005).

Innovation generates increasing returns to adoption. At the same time, innovation benefits from network externalities and technological interrelations, requiring the existence of non-market mechanisms to allow learning by interacting. Market size also shapes the patterns of innovation generation and diffusion. What matters for innovation are not only individual efforts, but also the absorptive capacities and the dynamics of the external environment.

Heterogeneity between territories is a persistent feature of economic systems. Different production modes will coexist over time, each shaped by local and context specific factors. However, there are thresholds beyond which the heterogeneity is not socially tolerable, or could compromise aggregate performance. National innovation policies in the new global context will be more effective when they take into account the territorial dimension in planning, and not only in execution.

Innovation also requires access to existing technologies and practices already available. Technology and knowledge transfer are powerful means, however their effectiveness is bounded by the capacities of the recipient. Innovative agents innovate also by imitating, adapting, by reverse engineering and by fostering the mobility of talent to favor the acquisition of tacit practices. Technology and knowledge transfers require appropriately regulated markets for technologies (i.e. rules which shape the transfer of codified knowledge) and functioning networks and communities. Knowledge networks are of different types (they might be open or close and managed hierarchically or in a flat mode); they depend on trust and on the cooperative propensity of agents involved.

Innovation is characterized by uncertainty of outcomes and discontinuities. Agents act on the basis of bounded rationality and have limited forecasting capacities, institutions are affected by instability deriving from political cycles, thus contrasting with the need of mid and long-term oriented policies. Uncertainty influences the markets for innovation due to the indeterminacy of future dominant technologies. This engenders a peculiar lottery race where uncertainty affects not only the potential winner, but also the amount of prize that the market will be willing to pay for the innovation in question. Uncertainty also affects the functioning of networks via potential opportunistic behavior, the legal infrastructure and the various degrees of appropriability of the results of innovation. Path dependency, as well as institutional inertia towards change shape innovation trajectories of firms and countries. Irreversibility also means that markets for innovations tend to favor dominant positions and are affected by the type of competition and concentration. In networks, irreversibility contributes to increase the sunk-costs in trust building.

The global knowledge society has intensified the opportunities for international knowledge flows thus raising the importance of mastering skills to access to global networks. In the new economy, intellectual property regimes (IPRs) that regulate access and diffusion of codified knowledge, international trade and investment agreements determine incentives for business development and should be taken into account in innovation policy design.

The heterodox approach contributes to define more sophisticated policy models capable of dealing with multiple, and sometimes conflicting policy objectives (for examples the need of markets and networks for innovation). The recognition of the complexity of the innovation process requires a policy vision which includes a broad policy mix, beyond the traditional focus on R&D. The heterodox approach legitimizes policy action upfront, recognizing at the same time the need for markets and non market mechanisms to stimulate innovation. The resulting innovation "policy package" therefore isn't "soft", and it explicitly recognises the sectoral specificities of industrial dynamics[31].

The room for state action in supporting innovation goes beyond financing (through direct or indirect subsidies). The state can also be a knowledge producer, trader and buyer. The state can support innovation on the demand-side through public procurement schemes. At the same time, it can be the articulator of policy measures tailored to promote linkages between agents. In addition, this vision supports a broad view of innovation which requires more than R&D, and which needs support from the generation of basic knowledge to the development of capabilities for mastering existing technologies (Nelson and Soete, 1988).

STI policies act on several domains: the supply-side, the demand side and the creation of enabling conditions for innovation. On the supply side, there are the policies for human resources for innovation and R&D, the ones for the creation of infrastructure for R&D and the policies which target the expansion of scientific and technological opportunities. On the demand-side, there are the policies supporting the expansion and diversification of the production system and the actions targeted to create and guarantee the demand for innovation, such as public procurement (see Table 1.2). Policy analysis should help to design more pragmatic and effective mechanisms. There is a rising body of evidence on policies and instruments to support innovation. This literature describes the types of instruments, the conditionalities, the criteria for beneficiary selection and the type of offered support, as well as the impact of those different policies[32]

The objectives of innovation policies are multiple. Financial resources are often scarce and incentives to mobilize private sector are limited, especially in developing economies. Each country faces specific challenges in a given moment in time, however three major common questions are: i) how to prioritize actions? ii) What is the effective mix of instruments to be used? And iii) How to finance innovation policies? There is no unique response, but success stories in modern history (the US, Germany, but also more recently the Republic of South Korea and China) show that countries need to put in place a mix of instruments acting on the supply side,

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[31] Nevertheless, why is it that the "heterodox" approach, apparently so suitable for orienting innovation policy in theory, is not mainstreaming the policy debate in practice? Several reasons contribute to it; not least the capacity of orthodox theory to communicate and easily frame the recommendations. The heterogeneity between the different "heterodox communities" weakens the approach and makes it a complex point of reference to the community of policy makers and practitioners.

[32] From the second half of the 1980s a specific literature emerged devoted to the analysis of STI policies and instruments, also thanks to the creation of an *ad hoc* review "Research Policy". These studies focused mostly on the description of the functioning of instruments. For example, Folster (1991) studies the impact of government subsidies to test under which conditions they are crowding out investment which would have been made in any case by the firm. Various authors have analyzed the role of fiscal incentives with diverging results (Bozeman and Link, 1984; Mansfield, 1986; Hall and van Reenen, 2000). Others focused on the role of public procurement as a stimulus to private investment (Lichtenberg, 1984; Edler and Georghiou, 2007). Others have addressed regional innovation and the role and impact of S&T parks in supporting innovation (see among others, Wessner, 2009).

the demand side and on the framework conditions. Actions on one dimension only will not suffice, even if well planned and designed.

Table 1.2 A taxonomy of areas for policy intervention of STI policies

Type of policy	Areas for policy intervention	Actions and instruments	Some Contributions
Supply Side	Infrastructure for R&D and innovation	Investment and support in physical and web-based infrastructure; scientific and technological parks, etc.	Rosenberg (2002) Soete and Weel (2005) Wessner (2009)
	Creation and expansion of scientific and technological opportunities	Traditional science policy, mission oriented research, public-private partnerships for R&D and innovation, etc. Technology policy to support R&D, direct subsidies, funds, business incubators, support for modernization, technology transfer, etc. Financing for innovation: R&D credits, fiscal incentives, venture capital, etc. Cooperation for innovation: research-consortia, public-private partnerships for innovation, multidisciplinary and interdisciplinary training, platforms etc. FDI and knowledge transfer	Dasgupta and David (1994) Hall and van Reenen (2000) Bozeman (2000) David and Hall (2000) Cimoli *et al.* (2011)
Demand-side policies	Creation, expansion and diversification of the production system	Industrial policy (support to production agents) Support to the physical and institutional infrastructure of industrial development (creation of ad hoc institutions—industry groups, technical training centres, business universities, etc.). Support to clusters, business incubators	Soete (2007) Cimoli *et al.* (2009b)
	Support for market generation and demand for innovation	Innovation oriented public procurement	Edler and Georghiou (2007)
Enabling conditions policies	Skills development Human resources for R&D and innovation	Training (grants for PhD and research training, training of human resources for science, vocational training programs; incentives and definition of mechanisms for the recognition of the carrier of researcher, programs for fostering labor insertion of PhDs into firms, etc).	Dahlman and Aubert (2001)
	Business environment and entrepreneurship	Regulations and certifications schemes to supporting product and process upgrading in quality. IPRs regimes Innovation services to firms and business coaching	Teece (2006) Cimoli *et al.* (2009a)
	Market organization and structure	Competition policy	Shapiro (2002)

Source: Author's elaboration based on Dosi (1988b) and Cimoli *et al.* (2006).

CONCLUSIONS

As the relevance of innovation for growth rises, policies to support innovation assume a strategic relevance. Closing the gap between innovation theory and policy can help designing and implementing better policies, and getting rid of ideological "complexes". Innovation is not neutral nor in its impact on societies, nor in its diffusion trajectories. Innovation impacts agents and systems in uneven ways. Institutions and policies mold learning patterns and can induce virtuous (or vicious) structural changes depending on the intensity and direction of state intervention.

Polices require models which go beyond standard compensation approaches, since compensations are not usually possible to determine, especially in the case of innovation. The equilibrium and optimizing approach penalizes the innovation policy maker by creating a too stringent space for policy action. Innovation policy would be more effective if its design could be permeated by a renewed and enhanced understanding of how innovation occurs in the new global landscape and which are the implications for different sectors, activities and agents, also taking into account the different roles of large firms and SMEs (Small and Medium Enterprises).

Over the decades, countries have accumulated knowledge in managing, more or less pro-active, innovation policies. But future innovation policies will need more than "more of the same". They will benefit from contributions from different disciplines; social sciences, cognitive analyses, modelling of complex systems in order to better grasp the various facets of innovation in contemporary societies and the role of governments in supporting it.

Innovation policies will be crucial in shaping production and consumption dynamics of the 21st century. Clarifying the rationale for policy action taking into account how innovation takes place in the new global context could help in avoiding common traps in innovation policy design and could increase the capacity to effectively implement policies. Policy makers need to recognize that supporting innovation requires taking decisions, even if bounded by the constraints of localized information. But, innovation also requires "evolutionary" policy advisors, who conceive innovation policies as actions relating to power (within and between countries) and dynamic issues, which will face resistance and opposition from several types of "elites" or "groups of interest", and which need to be aligned with broader production development strategies, thus taking into account the international dimension and the challenges of globalization.

There is no presumption that the state is better endowed than the market to select technological avenues; but the state is (or should be) the negotiated expression of different voices of the economic system, with a view at inter-generational impact of present choices and with an institutional capacity to identify and create incentives in the sake of the "common good" of the society. For this, the State, meaning by it a democratic state which is the expression of negotiated interests between the market and the different constituencies of the society, is better endowed than the market alone to provide incentives for the generation and diffusion of knowledge for achieving sustainable and inclusive growth. Advanced countries had recognized this when they were developing; the question is if developing countries, and in particular Latin American ones, will recognize this today and will put in place the necessary actions to factor in the voices for change in the policy debate.

CHAPTER 2

INNOVATION POLICIES IN LATIN AMERICA:
A tale of a (slow) learning process[33]

This chapter presents an analysis of the evolution of innovation policies in Latin America taking a long-term perspective. It discusses how the countries of the region, albeit different in trajectories and approaches, evolved from a linear supply side policy model to a demand-side one and, more recently to a public-private partnerships model. It presents detailed, comparative country evidence on institutions and governance, strategies and policy tools, with a focus on the changes that took place over the last decade. It highlights the return of the new forms of selectivity in national innovation agendas, the broadening scope of innovation policies, the new linkages with trade and FDI policies, and the emergence of new priorities for innovation policies, as territorial and social inclusion. The chapter concludes assessing the learning in policy making of the countries of the region focusing on four government's capabilities: choice, coherence, consistency and control.

[33] This chapter updates and expands a series of studies on structural change and innovation policy published by the United Nations Economic Commission for Latin America and the Caribbean, including Cimoli and Primi (2003); Cimoli *et al*. (2005; 2006; 2009b) and Cimoli (2005).

INTRODUCTION

During the last decade the innovation agenda has grown in importance in Latin America. Beyond the differences between the countries of the region in endowments, specialization and participation to global trade, most of them have nowadays at least in the form of a plan, a national innovation strategy with functioning institutions and operating instruments. However, budgets are often very small, when compared to other emerging countries, and execution rates even lower.

The relatively strong growth pattern of Latin America of the last decade has increased the margins for active policies. But, on the other hand, it has reinforced the resistance against innovation policies in the Ministries of Finance and Economy, as well as in some of the regional business elites which are benefiting from the persistency of the *status quo*. Business as usual seems, despite the 2008 financial and economic crisis, extremely comfortable for many actors in Latin America due to skyrocketing prices of raw materials and the sustained demand coming from China. Promoting innovation in Latin America is not an easy option in this "*bonanza*" period (Cimoli *et al. 2012)*.

Most Latin American countries face two major challenges; they need to create a consensus for innovation, end especially get the private sector on board, even in a context where prices of natural resources are rising, making traditional sectors highly profitable without need to invest in innovation. And they need to overcome the detachment between the promotion of innovation and the support to production structure transformation. The lack of coordination between the two has emerged in the 1990s, and it has undermined the impact of innovation policies in the region.

Latin American countries have accumulated experience in innovation policy design and implementation since the 1950s. At that time, Latin American countries embraced industrialization strategies, matching the efforts to create domestic production capacities with the support of the generation of domestic scientific and technological capabilities. The reforms praised by the Washington Consensus induced a drastic rupture in these policy efforts. The 1990s have changed what was politically acceptable, slowing the policy learning process in most countries of the region. From the end of the 1990s, Latin America has seen a (slow) return of innovation policies. But industrial policies are still regarded with extreme suspiciousness by ministries of Finance and Economy in most of the countries of the region, thus forcing the innovation agenda to pick "soft" and horizontal issues. Brazil has been the exception, with the explicit resurgence of industrial policy in 2003. In the last years, new forms of sectoral approaches have emerged in many countries of the region, from Argentina, to Brazil, Chile and Mexico, opening new opportunities, but also challenging the governments' capacities to deal with the increasingly complex and global dimension of innovation.

This chapter analyzes the evolution of innovation policies in Latin America with a focus on the learning process. The first section analyzes the evolution of innovation policy models in the region. The second presents evidence on institutions and governance. The third discusses country innovation strategies, focusing on priorities and instruments. The fourth concludes discussing the policy learning process through four drivers: choice, coherence, consistency and control. The annexes to the chapter complement the discussion with stylized comparative facts on innovation, country innovation budgets and detailed information about the sectoral technology funds in Brazil, which is one of the most advanced schemes for financing innovation in the region.

2.1 THE EVOLUTION OF THE POLICY MODELS: FROM SUPPLY-SIDE TO DEMAND-SIDE

Since the 2000s, innovation policies have re-gained ground in Latin America's development agendas. During the import substitution phase, most Latin American countries have supported the creation of institutions and infrastructure for scientific and technological development in the sectors that were considered priorities for national development. During the 1990s, the Washington consensus has reduced the room for state intervention by rationalizing investments, but also by weakening domestic scientific and technological institutions and privileging foreign direct investment (FDI) and technology transfer as drivers for growth. Several factors have concurred to define new approaches in economic development models in Latin American countries and to shape a new policy model for science, technology and innovation (Table 2.1). Among them, the emergence of new political leaderships willing to promote a Latin American approach to development and less inclined to accept without conditionalities the "old" prescriptions of the Washington Consensus, the growing globalization and the diffusion of information technologies, the rise of China and the emerging concerns in western economies about their capacity to maintain their scientific and technological leadership.

During the import substitution phase, Latin American countries did not have any formal technology policy. The creation of domestic scientific and technological capabilities was considered a necessary step to support industrialization. Development was intended as a process of transformation from raw material exporters to generation of manufacturing capacities. Market signals would have discouraged investments in technology and knowledge because the region did not have a "comparative advantage" in these areas. Hence, there was a generalized consensus on the need for governments to intervene and to "distort" market incentives to favor the accumulation of scientific and technological capabilities.

In the 1950s and 1960s, the state played a major role in identifying national priorities, in fostering the development of human capital, in subsidizing infrastructure for research and development (R&D) and in carrying out directly scientific and technological development activities through state-owned laboratories and firms[34]. During these years Latin Americas countries created their main institutions for scientific and technological development which still constitute the backbone of the institutional infrastructure for innovation. Governments supported the creation of the main national scientific and technological agencies, including the National Council for Scientific and Technical Development (CNPq) in Brazil, instituted in 1951, the National Council for Scientific and Technical Research (CONICET) in Argentina, opened in 1958 and the National Council for Science and Technology (CONACYT) in Mexico in 1970 (Cimoli *et al.* 2005, 2009b)

Table 2.1 The evolution of technology policies in Latin America

	Linear supply model	Linear demand model	Public-private partnership model	Towards a new deal for innovation?
Period and prevailing national development strategy	Industrialization by Import Substitution	Washington consensus era, structural reforms and export-led growth	Post Washington consensus era, diffusion of new technological paradigms and natural resource led growth	Post 2008 crisis, search for new sources of growth and green economy with persistency in high prices of NNRR, rising attention to internal demand as a source of growth
Framing approach	Structuralist	Market failure	National Innovation Systems	Schumpeterian/Evolutionary/Neo structuralist
Core-idea	Public sector as main S&T provider	Private sector as main source of technical change and innovation	Public and private sectors as sources of technical change and innovation	
Sectoral approach	YES	NO	NO	YES
Assumed pattern of diffusion of knowledge	Top-down	Bottom-up	Bidirectional	Systemic
Main policy proposals	Selective and centralized supply-pushed S&T policies	Horizontal and demand oriented incentive schemes for technological development and innovation	Networking, partnership, multidisciplinary and technology transfer-oriented policies	Support to human resources & R&D Matching funds from private and public sector Sectoral innovation funds
Link with industrial policy	YES	NO	NO	YES
Institutional governance and management criteria of S&T institutions	Highly centralized model focused on the scientific production. Predominance of academic, scientific and public sector criteria	Minimalist governance structure, institutional rationalization. Predominance of market and efficiency criteria	Gradual shift to open management systems and participatory management approaches, incipient design of incentives for public-private collaboration.	Sophisticated governance approaches with rising participation of different stakeholders (horizontal and vertical)

Source: Author's elaboration. Draws and updates Cimoli *et al.* (2005; 2009b).

[34] See, among others: Capdevielle *et al*. (2000); Crespi and Katz (2000); Tigre et al. (2000).

The policy followed a selective and linear-supply model. Knowledge and innovation were supposed to flow from government and public institutions (supply-side) to production (demand-side). R&D activities were mainly carried out by large public enterprises operating in strategic sectors, including telecommunications and transport, and by public research institutes and universities specialized in agriculture, energy, mining, forestry and aeronautical (ECLAC, 2004). In those years, many countries in Latin America opened research institutes and commissions in strategic sectors[35]. The state financed most of the investment in science and technology (ECLAC, 2002). The public sector not only influenced scientific priorities; its logic also prevailed in the administration of scientific and technological institutions, which were run under hierarchical and non-flexible management practices that difficulted, when not inhibited, coping with the changing needs of the private sector. The linear supply model has contributed to the creation of the Latin American scientific and technological infrastructure; but it lacked coordination capacities between different sectoral agencies, as well as with the private sector, and in certain cases has led to the implementation of overlapping initiatives.

In the 1980s, the explosion of the debt crises diverted the attention from long-term development efforts to short-term stabilization and inflation targeting programmes. During the so-called "lost decade" the priority for Latin America was the recovery of macroeconomic stability. Policies to foster capabilities accumulation were labeled as "distortive" and inefficient and were banned. The free-market "out-of-crisis" recipe (proposed by international financial institutions, and well accepted by most of the governments of the region) delegitimized the role of the state as a development "shaper" stressing on the risks associated with government myopia in technology foresight, capture and potential failures of targeted interventions.

The faith in the capacity of the markets to pick the best options resulted in a minimalist approach to policy. Only few horizontal instruments for technological development were maintained[36]. Scientific and technology policies were marginalized and industrial policies were dismissed from the "desirable and accepted" poli-

[35] As stated in Cimoli and Primi (2008), in Argentina the National Atomic Energy Commission (CNEA) was set up in 1954, followed in 1957 by the National Institute of Industrial Technology (INTI) and the National Institute of Agricultural Technology (INTA). Both were responsible for the provision of technology services (Yoguel, 2003). In Mexico the National Institute for Nuclear Research (ININ), the Electrical Research Institute (IIE), the Mexican Institute of Water Technology (IMTA) and the Mexican Petroleum Institute (IMP) were set up to promote technological innovation and development in the respective industries (Casalet, 2003; ECLAC, 2004). Consistently with a selective industrial focus, Brazil created a series of sectoral institutions. In the early fifties was established the Aerospace Technology Centre (CTA), while almost twenty years later, in 1973, was set up the Agricultural Research Enterprise (EMBRAPA). According to the predominant logic of state intervention as an engine of growth, many public enterprises established their own research centres, like ELETROBRAS' Electrical Energy Research Centre (CEPEL) and the Leopoldo Américo M. de Mello Research and Development Centre (CENPES) run by PETROBRAS.

[36] See among others: ECLAC (2004); Casalet (2003); Jaramillo (2003); Pacheco (2003); Vargas Alfaro and Segura Bonilla (2003); Pacheco (2003); and Yoguel (2003).

cies. The free-trade agenda wanted Latin American countries to open up their markets and eliminate the protections for their industries to foster catching up. In this context of weakened industrial policies, and with a specialization in natural resources and labour-intensive activities, there was not much demand left for innovation (For an overview of comparative trends in specialization and innovation in Latin America, see Annex 2.A1- Stylized Comparative Facts on Specialization and Innovation in Latin America- at the end of this Chapter). But, paradoxically, innovation policy started to follow a "demand-oriented" model.

Trade was seen as the main driver of modernization[37]. Active technology policies were considered in most of the cases ineffective. Capital goods imports, technology licensing and the need to compete with foreign and more technologically advanced firms, were identified as the most effective incentives to induce domestic firms to modernize and innovate. As a consequence, during the 1990s several industries in Latin America modernized, but these improvements remained circumscribed to leading firms in few sectors and did not trickled down to the rest of the production matrix, contributing to increase the structural heterogeneity that characterizes the countries of the region (See Annex 2.A1 for empirical evidence on specialization patterns). Most governments in the region also updated their management procedures and created new institutions[38]. Beyond the countries' specificities, theses institutional reorganizations resulted in i) strengthening of institutions in charge of promoting private sector development; ii) incipient interest towards science and industry linkages and, iii) reforms in management of public administrations and introduction of performance-based evaluation criteria for resource allocation.

Since the mid 1990s, the concept of national innovation system (NIS) entered the innovation policy debate in Latin America. Policies started to focus on the role of networks and linkages for innovation. This has allowed overcoming the drawback of the assumption of linearity of the two previous policy models. Innovation was identified as the result of interaction and cooperation between the public and private sector. However, these new policies had little impact in many cases, because they were detached from industrial policy efforts and a neutrality in policy approach prevailed. In other words, the policies suffered of the lack of synchronization between industrial transformation and the development of technological capa-

[37] The degree of marginalisation of technology policies has been heterogeneous. Argentina and Brazil somehow maintained the support to S&T, while in most of the other countries in the region the support to technologicaldevelopment was legitimized only when it was linked to export promotion.

[38] For example, as noted in Cimoli *et al.* (2009b) "in Argentina the restructuring of S&T institutional infrastructure led to an increase in coordination among different bodies, partly overcoming what represented a structural limit of the previous period. In Mexico the priority was the decentralization of S&T institutional management, according to the different technological and specialization patterns of various Mexican regions. In Colombia the restructuring privileged the regionalization of the S&T system and greater emphasis on cooperation between universities and enterprises in technological upgrading. In Costa Rica the reorganization of S&T institutions focused on human capital formation".

bilities and a low recognition of qualitative differences between economic activities prevailed (Cimoli *et al.*, 2005; 2009b). This kind of "public-private partnership" innovation policy model operated in a context in which the growing exposure to external competition induced most Latin American countries to further specialize according to static comparative advantages. Argentina and Chile, for example, reoriented their production structures towards raw materials and natural resource processing activities, while Mexico and many Central American countries moved towards *maquila* type industries. These changes in the regional specialization patterns favored the generation of an industrial structure that, *"per se"*, expresses little demand for knowledge, thus implicitly limiting the potential positive stimuli effect towards technological catch up of liberalization and increased competition (Cimoli *et al.*, 2005; 2009b). In fact, as Cimoli *et al.* (2009b) note "in contrast, the South East Asian economies, like the Republic of South Korea and Taiwan, followed by Malaysia, Thailand and Indonesia, were successful in entering and expanding technology intensive industries or production stages, combining selective import substitution policies with aggressive, but gradual, export oriented strategies (Amsden, 1989; Sundaran, 1997; Wade, 1990)".

Since the mid 2000s, Latin America entered a new phase. The high growth, induced by the rise of China and by the deliberate strategies of promoting growth through mass consumption, as in the case of Brazil, and the rise in the prices of raw materials, has opened new fiscal spaces. In addition, the new political elites in some Latin American countries are more inclined to follow national approaches development in contrast with the Chicago approach of the past, are opening new spaces for policy action.

Innovation policies have risen up in the priorities of many countries in Latin America, even though budgets are still often pretty low. Some of the characteristics of the recent return of innovation policy on the development agenda of the countries in the region are: i) the return of the sectoral dimension, which goes hand in hand with the return of industrial policy; ii) a change in the policy model. Countries are implementing more pragmatic policy models that try to take into account the systemic dimension of innovation and follow a broad approach including to incentives for science and technology, targeted support for linkages and spillovers from FDI and for the creation of new domestic firms; iii) new priorities for the innovation strategy, including social and territorial inclusion as well as environmental sustainability. A key challenge for innovation policy in Latin America is the development of policy spaces and institutional capacities to engage the private sector in a constructive way. The following sections present detailed comparative evidence on: institutions and governance for innovation policy, as well as national innovation strategies and priorities and policy tools.

2.2 INSTITUTIONS AND GOVERNANCE FOR INNOVATION POLICY

Institutions, their organization, the articulation between them, and the criteria for their management, shape the processes of strategic decision making and influence how policies are designed, managed and assessed. There is no optimal institutional model for innovation policy. In each case it depends on the government' structure as well as on historical, local and cultural contingencies. However, there are some common features that shape the effectiveness of policies, including transparent mechanisms for priority-setting, incentives for vertical and horizontal coordination, and complementing tools on the "supply side" (i.e. the scientific production) with the ones acting on the "demand side" (i.e. entrepreneurial behavior and production structure), as well clear procedures for financing, monitoring and evaluation.

Variety of institutional models in Latin America

The institutionality for innovation policy in Latin America is varied. Most countries have an agency, a Ministry or a National Council or Secretariat, in charge of defining the policy and a series of institutions for policy implementation (See Table 2.2). The governance for innovation policy in the countries of the region differs in three major aspects:

i. **Variety in the type of institution responsible for innovation policy.** (i.e. A ministry, an autonomous agency responding to the Presidency of the Republic, or a decentralized body of a sectoral ministry, usually Economy, Industry or Education).

While in advanced economies it is common to have a Ministry in charge of science, technology and innovation, in Latin America only five countries have a Ministry in the area (Argentina, Brazil, Cuba, Costa Rica and Venezuela). In addition, the power and the execution capacities of these ministries differ sensibly across countries; for example, in Brazil the Ministry for Science, Technology and Innovation (MCT) was created in 1985 and since 2003 it has developed a strong alliance with the Ministry of Industry and Trade (MIDIC) and with the national development bank (BNDES) to implement the innovation policy in coordination with the new industrial policy, thus increasing its relevance in the government's hierarchy of powers.

In Argentina, the Ministry for Science, Technology and Productive Innovation has been created in 2008 as an expression of the renewed interest of the government to support knowledge-based and inclusive growth. Argentina has a longstanding tradition in supporting scientific research. The creation of the Ministry responded to need to increase the applicability and market impact of the national research[39]. In Costa Rica, the Ministry for Science and Technology was created as a spin-off of a program for scientific and technological development started in 1986. It has a small budget, but thanks to the recent partnership with the Ministry for Foreign Trade it is helping in strengthening the linkages between the academy and the business sector and the spillovers from FDI to domestic innovation[40].

Nevertheless, most Latin American countries do not have a Ministry in charge of innovation. In some countries, the responsible institution is a specialized autonomous agency responding directly to the Presidency of the Republic, as in Chile, Panama and Nicaragua (where actually, the agency responds to the Vice-Presidency of the Republic since 2002). In others, a decentralized agency of a sectoral ministry (usually education or industry) is in charge of innovation policy, as in Mexico where the CONACYT responds to the Ministry of Economy, or in Uruguay where the National Agency for Research and Innovation (ANII) responds, and is chaired, by the Ministry of Education and Culture. In Colombia, the agency responsible for innovation, Colciencias, has been created in the early 1970s and assigned to the Department of Planning in the 1990s; in 2009 the agency has been declared an autonomous department by law. Colciencias defines the national strategy for innovation and administers the government funds for innovation. In Peru there are two entities which deal with innovation policy, one responding to the Ministry of Education, the CONCYTEC (National Council for Science, Technology and Technological Innovation) and the other, the National Council for Competitiveness which depends from the Ministry of Economy and Finance. The two institutions set innovation strategies and operationalized specific instruments which are financed from different budgetary sources. Scant collaboration exists between them, thus undermining the synergy between policy actions.

ii. Differences in the strategic positioning of the innovation strategy in the national development agenda.

Albeit is it a rising priority in almost all the countries of the region, innovation is not yet a top priority in national development agendas. The relevance of the innovation strategy depends both on the commitment of high political spheres and on the budgetary capacities of the institutions in charge of innovation policy. In Brazil, for example, the President of the Republic chairs the Science and Technology Council (CCT) which is the body in charge of strategy setting and horizontal coordina-

[39] The SETCIP (Secretaria para la Tecnología la Ciencia y la Innovación Productiva) is responsible for the elaboration of the national plan for STI and, at the same time, for the creation and maintenance of the national information system about STI, which provides information about innovation trends in the eoconomy and policy implementation. Policy implementation is carried out by the ANPCYT Agencia Nacional de Promoción Científica y Tecnológica. The agency, desconcentrated body of the SETCIP, is responsible for policy implementation and management of instruments of innovation support and financing. The agency administers the two major funds for financing FONTAR and FONCYT.

[40] See OECD (2012).

tion. The council is composed by 13 sectoral ministries, 8 representatives of the business community directly indicated by the President of the Republic, and 6 members from the academy and research sector indicated by the national associations of science and by the academic institutions. In Mexico, the General Council for Research and Development (*Consejo General de Investigación Científica y Desarrollo Tecnológico*), created by the innovation law 2002, is composed by the Presidency of the Republic, who chairs it, the secretaries of the nine states, the general director of CONACYT, the coordinator of the *Foro Consultivo Científico y Tecnológico* and 4 members invited by the President of the Republic. In Colombia the President of the Republic chairs the National Competitiveness Commission, an institution created in 2006 to foster horizontal coordination among sectoral ministries. The commission is composed by 8 sectoral ministries, the presidents of the national departments related with science, technology and innovation, the national federation of municipalities and representatives from the civil society and the university, plus three members directly nominated by the president of the republic.

The direct participation of the President of the Republic in the process of setting the innovation agenda is not common. In most cases, the coordination between different sectoral ministries, or agencies, is guaranteed by interministerial committees. Chile, Costa Rica, Panama and Uruguay[41] have interministerial councils which foster horizontal coordination and that define the priorities of the national innovation strategy. In Chile, the Committee of Ministries for Innovation is chaired by the Ministry of Economy. It is composed by all the ministries with responsibilities in areas related with science, technology and innovation, including infrastructure, agriculture, education and mining. In Argentina, the Cabinet for Science and Technology (GACTEC), the instance in charge of policy coordination, is composed by all Ministries and Secretaries of States operating in areas related with science and technology that directly depend from the Presidency of the Republic. The GACTEC was created in 1996 and, since 2008 it is chaired by the Ministry for Science, Technology and Productive Innovation. The GACTEC proposes the annual budget for the innovation policy and, each year is responsible for the evaluation of the implementation of the National Plan for science, technology and innovation. At the same time, it fosters vertical and horizontal coordination, as the National Commission for Competitiveness does in Colombia. In Peru, the Presidency of the Ministerial Council is involved in the strategy planning. The National Competitiveness Council (CNC) is a multisectoral body in charge of the elaboration and implementation of the national competitiveness plan. The Council is chaired by the Ministry of Economy and composed by the President of the Ministerial Council, the Ministry of production

[41] In Panama the CICYT (Interministerial STI Council) is composed by the National Secretary for STI, the Ministry of Education, Health, Trade and Industry, Agricultural Development and Economy, as well as representatives from the presidency of the Republic. In Uruguay the Ministerial Cabinet for Innovation, created in 2005 is formed by the Ministry for Education, Economy and Finance, Industry, Mining and Energy, Agriculture and livestock, and the director of Planning and Budgeting.

(PRODUCE), the one for Trade and Truism (MINCETUR), a representative of the Municipal authorities and a representative on the national association of private firms (CONFIEP). However, the CNC does not require ministerial presidency and the ministerial participation is not mandatory The Ministry of Agriculture (MINAG) also contributes to the national competitiveness policy, but it is not a member of the CNC.

iii. Heterogeneity in the degree of complexity of the institutional setting.

In Latin America, countries differ for the level of complexity and articulation of the institutional governance for innovation policy. In addition, as innovation becomes a transversal issue in governments' agendas, the governance of innovation policies becomes more complex. Often, in addition to the institutions formally in charge of innovation policy, other ministries and agencies run innovation programmes, as for example the Ministries of Energy, Mining and Infrastructure.

Countries differ in the way in which they articulate the policy mix for innovation. For example, some countries have instances for horizontal and vertical coordination and separate strategy setting from financing and execution, while others do not. These differences depend on strategic country choices, on historical reasons, as well as on the size of the economy. In smaller economies the density of institutions is usually lower than in larger economies.

Brazil has the most "dense" institutional matrix for innovation in Latin America. The Ministry for Science, Technology and Innovation manages a system of institutions, including a center specialized in strategic studies, some centers for R&D and public companies, in addition to the institutions for policy financing, the CNPq (National Research Council) and the FINEP (Brazilian National Innovation Agency)[42]. In addition, in Brazil, sub-national levels of government have a high role in the promotion of science and technology; Each Brazilian State has a secretary for science, technology and innovation and a Foundation for Financing R&D. These state organizations are confederated in networks (the CONSECTI and the CONFAP, respectively) that support vertical dialogue, and should support horizontal coordination. In Brazil there are also several (and powerful) institutions involved with policy implementation. The Ministry for Science, Technology and Innovation manages the FINEp and the CNPq finance innovative projects and applied research. In addition, the national development bank (BNDES) offers credit for innovative projects though several lines. Other institutions that promote innovation are the large state-owned companies including Petrobrás, and several specialized bodies like Embrapa (the State company for agricultural research) and the Fiocruz (the state foundation

[42] The System coordinated by the Ministry of S&T (MCT) includes the Center for management and strategic studies (CGEE), the National Commission for Nucelar Energy (CNEN), the Brazilian Space Agency (EB), 19 R&D unuts, 4 public companies*: Indústrias Nucleares Brasileiras* (INB); *Nuclebrás Equipamentos Pesados* (Nuclep); *Alcântara Cyclone Space* (ACS) and *Centro de Excelência em Tecnologia Eletrônica Avançada* (Ceitec).

responsible for applied research in the bio-pharmaceutical sector responding to the Ministry of health).

Latin American countries also differ in their institutional capacity to create spaces for horizontal and vertical coordination. In Costa Rica, the Incentive Commission (which is the body in charge of selecting the beneficiaries of the national incentives for innovation) is chaired by the Ministry of Science, Technology and Innovation and it is composed by representatives from the Ministry of Treasury, Agriculture, Foreign Trade, the National Research Council and members from the academy, the National Chamber for Industry and Agriculture and the private sector.

Some countries have specific bodies in charge of federative issues, or relationship between levels of government. In Argentina, the COFECYT (Federal Council for Science and Technology) promotes vertical coordination and is composed by the highest provincial authorities in charge of science and technology issues. On the scientific side, the *Consejo Institucional de Ciencia y Tecnología* (CICYT) fosters coordination of provincial bodies involved in scientific activities[43]. In Colombia, the articulation between innovation policy and regional development is managed directly by the National Competitiveness Commission created in 2006. In Mexico, the national network of State Councils and entities for science and technology (REDNACECYT) promotes the dialogue between regional entities and fosters the alignment between the federal strategy set by CONACYT and priorities of the different States. Peru has two bodies for regional coordination; one fosters the dialogue between regional innovation councils (CORCYTEC) and the other supports the collaboration between regional entities in charge of economic development (CEPLAN). Smaller economies often do not have specific institutions in charge of vertical coordination, but some have identified specific institutional arrangements to take into account the territorial perspective. For example, Panama has Sectoral Commissions conformed by national experts to act as advisory bodies to define the national innovation plan; among them there is a commission dealing with territorial and regional issues representing the interests of local communities.

Countries also differ in their capacity to reach out to the civil society and with the "users" of scientific and technological innovations. The mechanisms to foster dialogue with the society are important because they allow smoothing the process of consensus generation on the innovation agenda. The capacity to negotiate with different stakeholders enables the innovation agenda to be an inclusive one. This aspect, even though quite new in the region, is extremely important for countries where the innovation agenda has to defend its legitimacy versus the policies target-

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[43] The CICYT is composed by CONICET (*Consejo Nacional de Investigaciones Científicas y Técnicas*), CNEA (*Comisión Nacional de Energía Atómica*), INTA (*Instituto Nacional de Tecnología Agropecuaria*), INTI (*Instituto Nacional de Tecnología Industrial*), CONAE (*Comisión Nacional de Actividades Espaciales*), SEGEMAR (*Servicio Geológico Minero Argentino*); INDEP (*Instituto Nacional de Desarrollo Pesquero*); INA (*Instituto Nacional del Agua*); CITEFA (*Centro de Investigación Tecnológica de las Fuerzas Armadas*); ANLIS (*Administración Nacional de Laboratorios e Institutos de Salud*).

ing social development and poverty reduction. Some examples in the region are: the Advisory Commission for the Plan in Argentina that conveys the voice of the society in the planning phase and the *Foro Consultivo Científico y Tecnológico* in Mexico which conveys representatives from the scientific community and the business sector to set national priorities in innovation.

Recent changes in the institutional setting

Institutions evolve over time, due to cumulative learning and restructuring; they also change due to reforms in other institutions that influence their performance. In Latin America, the institutionality for science, technology and innovation was created to support the industrialization strategy. Domestic scientific and technological capabilities were needed to shift the specialization from raw materials and commodities to specialized knowledge-intensive products and services.

The structural reforms of the Washington Consensus have induced changes in the institutionality for scientific and technological development. Many countries were forced to close some departments, rationalize the public support to scientific research, and rationalize functions, including extension services, thus interrupting a process of institutional learning.

With the slow return of the innovation (and industrial development) agenda in the 2000s, institutional reforms were needed to strengthen the institutionality for innovation policy and re-endow the state with the capacity to design, finance and implement policies for scientific and technological development. Latin American countries had not only to identify mechanisms to overcome the weakened institutional capabilities in the domain of science and technology, but also to endow the old and new institutions with new capacities in line with the changing global knowledge landscape. Latin American countries have followed different paths, but they have recently advanced in four areas:

i. **Institutional strengthening**. Most countries in Latin America have invested in strengthening the institutions for innovation policy since the 2000s. The institutional strengthening has taken different forms. Argentina has created the Ministry for Science, Technology and Productive Innovation in 2008. Uruguay has approved a new law and created the National Agency for Research and Innovation (ANII); Chile has instituted, but by decree and not yet by law, the National Council for Innovation and Competitiveness attaching to the Found for Innovation and Competitiveness, financed through the royalties on mining production. In Brazil, the institutional strengthening happened though the increased coordination and synchronization between the agenda of the Ministry for Science, Technology and Innovation (MCTI), the Ministry for Industry and Trade (MIDIC) and the national development bank (BNDES). The strengthening of the innovation agenda came from the renewed interest in industrial policy which stimulates the demand-side.

ii. **New sources of finance for innovation.** The introduction of new sources of finance has required institutional upgrading. Brazil has been a pioneer; it has introduced in 1999 a system of sectoral technology funds to finance innovation channeling rents for different production sectors (See Annex 2.A3 at the end of this Chapter). The management of these funds has required the creation of sectoral committees with participants from the private and the public sector[44]. In Chile, the introduction of the royalty on copper production represented a new source of finance for innovation; the new scheme has required an institutional upgrading and an improvement in the management of the relationship between the central government and the regions. In Argentina and Mexico the introduction of sectoral technology funds, on the basis of the Brazilian model, have also induced institutional reforms to handle the new financing schemes.

iii. **Increased role of regional governments in innovation and improved interaction between the regions and the central governments.** Many Latin American countries are pursuing inclusive growth and are recognizing the need to foster a more balanced territorial development. In line with this, some have introduced reforms to increase the capacity of the innovation policy to deal with territorial issues. In some cases, governments have created new spaces for discussion, like the National Conference for science and technology in Brazil, or the Competitiveness Commission created in Colombia 2006 to gather representatives of the sub-national governments, as well as sectoral ministries.

iv. **Improved legal framework for innovation policy.** Several countries have introduced modifications in the legal framework. Some have approved new innovation laws like Brazil, or simplified administrative procedures to create firms and access to innovation credits, as Chile and Mexico.

The institutional design matters for policy because it influences not only formulation processes (that can be more or less open to different stakeholders or more or less articulated with other governmental actions according to the types of institutions which conform the system and considering the redistribution of responsibilities across them), but also the positioning of the innovation agenda in the national development strategy. Countries with powerful institutions for science and technology and with effective mechanisms to ensure long-term financing for innovation are more capable to implement stronger innovation policies, than countries where the institutions responsible for innovation are "far" from the national strategic and budgetary decisions.

The institutional setting is highly country-specific. The same institutional setting can deliver different outcomes, in different contexts. However, there are some good governance principles that tend to be generally valid. The identification of clear responsibilities for implementation and evaluation, the establishment of mul-

[44] See Annex 2.A3 for a detailed description of the functioning of the sectoral technology funds in Brazil.

ti-annual budgets and of incentives for horizontal and vertical coordination are key ingredients for effective policies. The countries that are able to be at fore-front of innovation, often also support institutional learning and incentivize experimentation. In Finland, for example, the innovation fund (SITRA) includes in its mission the funding of research in experimental fields to propose new strategies and policy approaches.

An important lesson from Latin America is that when planning institutional reforms it is important to have mechanisms to reveal *ex ante* the complementarities between different policies and institutions in order not to undermine the functioning of the whole system, while reforming one piece. Institutional settings are usually conceived in specific contexts and over time they develop a *modus operandi* that includes formal and informal networks between their different agencies and functions. When they evolve, due to institutional learning or to reforms, it is important to have in mind a systemic perspective to maintain the capacity of the institutional system to accomplish is mission. For example, in Brazil the structural reforms have closed several rural extension services. These were supposed to transfer to local producers the scientific discoveries and innovations carried out by state owned companies and research centers, including the Corporation for Agricultural Research (EMBRAPA). Brazil preserved the operations of EMBRAPA, which had already attained global scientific excellence in his field, but the reforms by closing rural extension services have jeopardized the capacity of the system to transfer technological solutions to rural producers. Some of the local branches of EMBRAPA have, over time, developed internal rural extension services to accomplish the mission of the institution of improving productivity and sustainability of Brazilian agricultural production[45].

The institutional evolution is also slowed down by the structural inertia. Institutions learn how to perform their functions through trial and error and suffer of path-dependency in the processes of decision making. Institutions act on the basis of accumulated knowledge, shared practices and routines. Designing policies for innovation requires not only institutional memory and accumulated knowledge and capabilities, but also forward-looking thinking and the continuous generation of new competences to deal with "new" and emerging issues and to anticipate potential future scenarios. In Latin America, most institutions in charge of innovation have a long history; a major challenge is to strengthen and improve the existing

[45] The dismantling of national extension services in the 80s weakened the model and required EMBRAPA to identify alternative methods for technology transfer. For example, the Embrapa *Agro Industria Torpical* introduced a "Mobile Unit" which operates in the Nordeste as an alternative for traditional extension services. The "Mobile Units" reaches producers in remote areas in the region and delivers them technical assistance to apply research results to production. When States implement rural extension services like in the case of Ceará the effectiveness of EMBRAPA action on domestic and local production is much higher. The policy complementarities between research, capacity building and technical assistance necessary for technology transfer has been weakened during the structural reforms and need to be restored to increase the impact of investment in research.

institutional setting to enable it to foster innovation and dynamic change, avoiding incurring in the costs of truncating the processes of institutional learning. Often institutional evolution could be a better choice than drastic institutional reforms which might create diseconomies by disrupting institutional memory and learning processes.

2.3 INNOVATION STRATEGIES IN LATIN AMERICA

From a review of innovation policies in Latin American countries since the 2000s, five common issues emerge:

i. Almost all countries in the region have a plan for science, technology and innovation. The plans tend to be structured in a similar way. They identify the challenges and the opportunities for innovation in the country, set the government priorities and define the programs, or the lines of action to achieve them. In some cases the plan has measurable targets (Chile, Brazil, Panama), in others the objectives of the policy are more general (Argentina, Costa Rica).

ii. Countries differ in the "centrality" of the innovation strategy in the national development agenda. Beyond the rhetoric that innovation matters for development, in some countries more than in others innovation is at the core of the governmental action (Brazil and Costa Rica).

iii. The innovation plans tend to be similar in terms of main priority areas (nanotechnology, biotechnology, ICT, energies and health appear as key sectors/issues in almost all national strategies; an emerging priority for all countries are also environmental sustainability and social inclusion). But the plans differ in the policy implementation and in the priorities for actions; some countries privilege focusing on SMEs (Peru), others prioritize clusters (Chile) and others take a sectoral focus (Argentina, Brazil).

iv. Countries differ for the intensity of actions and the budgets for innovation. In certain cases the reduced amount of available resources weakens the impact of policies (Costa Rica, Panama), in others high budgets can challenge the capacity to implement and deliver effective results (Chile).

v. Most countries now include the territorial perspective in their national innovation strategies. In some cases this responds to the opportunity to tap into new sources growth (Argentina, Brazil); in others is the result of new sources of finance for innovation related with the exploitation of natural resources. These new funds require a rising involvement of regional authorities in public policies (Chile, Colombia, and Peru). Overall, this also derives from the willingness to promote inclusive growth and from the evolution of democratic systems, which often brings about growing articulation between levels of governments.

Priorities and budgets

Innovation strategies in Latin America differ in policy orientation (more or less interventionist), the degree and intensity of selectivity (sectoral focus, prioritization), instruments and budgets. On the basis of these characteristics it is possible to identify four main models of innovation policy in the region (Table 2.2).

Table 2.2 Institutions and governance for innovation policy in Latin America: variety in institutional settings

Institutional Model	Country	Strategy Setting	Horizontal Coordination	Vertical Coordination	Advisory	Implementation	Legal Framework
MINISTRY for STI	Argentina	Ministry for Science, Technology and Productive Innovation, created in 2008.	Gabinete Científico-Tecnológico (GACTEC)		Advisory Commission for Innovation Plan	ANPCYT (Agencia Nacional de Promoción Científica y Tecnológica) FONTAR (Fondo Tecnológico Argentino) CONICET (Consejo Nacional de Investigaciones Científicas y Tecnológicas) FONCYT (Fondo para la Investigación Científica y Tecnológica) Other Organisms (INTI, INTA, etc.)	Law 26.338 establishing competences for sectoral ministries Law 25.467, 2001 National Innovation systems (structure, responsabilities,etc.)
		SETCIP (Secretaría para la Tecnología, la Ciencia y la Innovación Productiva)	National Institutional Council for S&T (CICYT)	Federal Council for S&T (COFECYT)			
	Brazil	Science and Technology Council (CCT) President: President of the Republic Executive Secretary: Ministry of ST		Conselho Nacional de Secretários Estaduais de CTI (CONSECTI) CONFAP (National Council of State Foundations for RED)		MCT (FINEP and CNPq) CAPES BNDES Petrobrás State Foundations for R&D Other Organisms (Embrapa, Ministry of Health, Defense)	Innovation Law (2004) modified in 2010 Chapter III Lei do Bem (2006) State Innovation Laws (process started in 2006)
		Ministry of Science and Technology (MCT) and State Secretaries for S&T (created in 1985)	Articulation with PDP. Participation of MCT in the Management Committee for PDP.				
	Costa Rica	MICIT (Ministry for Science and Technology)				CONICIT (Consejo Nacional de Investigaciones Científicas y Tecnológicas) Comisión de Incentivos para la Ciencia y la Tecnología	Law 7169 Setting the guidelines for the national support to ST

Institutional Model	Country	Strategy Setting	Horizontal Coordination	Vertical Coordination	Advisory	Implementation	Legal Framework
Autonomous Body	Colombia	Colciencias (responding to the National Planning Department)	Comisión Nacional de Competitivdad (created in 2006)			Colciencias	S&T Law 1990. Law 344/1996 Competitiveness Program Law 643/2001 Heath Research Fund Law 1286/2009 which transforms Colciencias in an Administrative Department
Agency-responding to the Presidency of the Republic	Chile	National Council for Innovation and Competitiveness (CNIC)	Committee of Ministries for Innovation Presidency: Ministry of Economy			CORFO (support to firms) CONICYT (National Commission for Science and Technology) support to training and scientific research) Becas Chile FIA (Fondo para la Innovación Agricola)	The CNIC has been created by a Presidential Decree in 2005
	Nicaragua	CONICYT (Consejo Nicaraguense de Ciencia y Tecnología) (Responding to the Vice-Presidency of the Republic)				CONICYT (Consejo Nicaraguense de Ciencia y Tecnología)	Decreto Presidencial 14-2002
	Panama	SENACYT (Secretaría Nacional de Ciencia y Tecnología)	CICYT (Consejo Interministerial de CTI)		Comisión Nacional de Ciencia, Tecnología e Innovación (CONCYT) Sectorial Commissions	SENACYT (Secretaría Nacional de Ciencia y Tecnología)	Ley 13 de 15 de abril de 1997, modificada posteriormente por la Ley 50 de 21 de diciembre de 2005

Institutional Model	Country	Strategy Setting	Horizontal Coordination	Vertical Coordination	Advisory	Implementation	Legal Framework
Agency related to a sectoral Ministry	Mexico (Ministry of Economy)	CONACYT (Consejo Nacional de Ciencia y Tecnología)	Consejo General de Investigación Científica y Desarrollo Tecnológico	REDNACECYT Red Nacional de Consejos y Organismos Estaduales de Ciencia y Tecnología	Foro Consultivo Científico y Tecnológico	CONACYT (Sectoral and Mixed Funds)	Innovation Law 2002. Comisión de Ciencia y Tecnología de la Cámara de Diputados del H. Congreso de la Unión
	Peru (Education/Industry)	Consejo Nacional de Ciencia, Tecnología e Innovación Tecnológica, CONCYTEC (Ministry of Education)		Regionales de Ciencia, Tecnología e Innovación (CORCYTEC)		CONCYTEC (trough FONDECYT Fondo Nacional para el Desarrollo Científico y Tecnológico))	Ley Marco de Ciencia y Tecnología N° 28303, lo establecido en el Decreto Supremo N° 082-2005-PCM, referente a su adscripción al Ministerio de Educación, y la Ley del CONCYTEC N° 28613.
		CNC Consejo Nacional de la Competitividad (Ministry of Economy and Finance)	Presidencia del Consejo de Ministros. Centro Nacional de Planeamiento Estratégico (CEPLAN)	Centro Nacional de Planeamiento Estratégico (CEPLAN)		FINCYT (introduced in 2006 and financed by IADB)	
	Uruguay (Ministry of Education and Culture)	Ministerial Council for Innovation (Gabinete Ministerial de la Innovación GMI) created in 2005. Conformed sectoral Ministries			CONICYT (National Council for Research, Science and Technology) with representatives from academy and civil society	ANII National Agency for Research and Innovation	The ANII has been created by law, the GMI by presidential decree in 2005

Source: Author's elaboration.

Table 2.3 Variety in innovation policy models in Latin America

MODEL	EXAMPLE OF COUNTRY	FOCUS	MAIN PRIORITIES	PREVAILING TYPE OF INSTRUMENT	SECTORAL PRIORITY	LINK with INDUSTRIAL POLICY
COMPETITIVENESS	Colombia	Export-oriented	1. Innovation in the business sector 2. Regionalization of innovation policy	Demand-oriented support to firms (fiscal incentive; services to access private credit)	NO	Industrial policy mainly carried out through the innovation policy
CLUSTER-BASED	Chile	Export-oriented	1. Rising investments in R&D 2. Cluster development in priority sectors	Demand-oriented support to value-chain development by sector	Focus on clusters, not sectors	
SCIENCE AND TALENT BASED	Argentina (PENCTI Bicentenario 2006-2010)	Domestic scientific technological capabilities &Exports	1 Rising investments in S&T 2. Rising num. of researchers 3. improving regional distribution of resources	Demand oriented support to R&D and human capital development	YES	Weak
PRODUCTION DEVELOPMENT	Brazil (PACTI 2007-2010)	Domestic market and exports (focus Mercosur)	1. NIS modernization 2. Innovation in firms 3. R&D and I in priority areas 4. R&D and I for social challenges	Coordination between "demand and supply" in financial support (Sectoral technology funds) Credit for innovation through National Development Bank	YES	High

Source: Author's elaboration.

The "competitiveness model" is characterized by the absence of sectoral prioritization, strong export-orientation and a preference for demand oriented incentives, targeting SMEs. The preferred instruments are "less distortive", including fiscal incentives (e.g.: Colombia and Peru). The cluster-based model prioritizes actions, not sectors. It supports the development of specific activities following a cluster-based approach. The incentives are often oriented towards the demand and the priorities are upgrading in value chains and exports (e.g.: Chile). The science-based model prioritizes scientific and applied research, as well as talent development in key scientific and technological areas. Resources are channeled principally by traditional tools, including grants for human resources and R&D. To increase the impact of this policy model a higher articulation with the private sector is need, as well as new forms of financing for business development. Argentina has recently addressed this issue by introducing the sectoral technology funds. The production development approach links innovation with trade and industrial policies. The model is based on an articulated policy mix with a marked sectoral focus. It offers a mix of incentives for scientific development, industrial competitiveness and targeted support to SMEs. Due to its orientation towards the private sector it often needs high quality articulation with the financial sector, including with development banks (e.g. Brazil).

Since the mid 2000s, in line with the rising relevance of innovation policies in national government strategies, most countries in Latin America have improved access to information about government expenditures on innovation. The innovation budgets in the region are low, both in respect to their share over total government expenditures and in relation to the amount of resources devoted by more advanced countries to innovation. While investment in innovation in Latin America does not reach even 10 million USD in the top investing countries, in the US only the nanotechnology initiative receives annually around 1.8 USD billion from the federal budget. Moreover, on the total innovation budget the share of resources targeting business innovation is low, indicating the persistency of the “supply-side” policy model in budget allocations. The share of resources for business innovation in 2010 was 8.6% in Chile (over a total expenditure of 863 454 millions on Chilean pesos, 1 733 million US$), and 7.9% in Brazil (over a total of 14 483 million R$, approx. 7 200 million US$). The budget for innovation is distributed across several ministries. In Mexico the national council for science and technology (CONACYT) accounts for 34% and the Ministry of Education for 30% of the federal budget for science and technology. In Brazil the ministry for education accounts for 41% of total science and technology expenditures, while the ministry for science and technology accounts for 27% of the total budget (See Annex 2.A2 for detailed information about country innovation budgets).

A major challenge is the capacity to ensure multi-annual financial commitment. For example, in 2005, as a result of a complex and long negotiation process, Chile has approved a law (n. 20 026) on the royalty on mining production. In parallel, a decree has established the Innovation for Competitiveness Fund (FIC) to finance the innovation policy through the resources coming from the royalty. Despite this advancement, the allocation of resources from the mining sector to innovation is carried out on a yearly basis thus undermining the capacity to plan long term investments. In Chile the budget law (*Ley de Presupuesto*) has assigned approximately 84 USD million to the FIC in 2006, 154.5 million USD in 2008, and 240 million US$ in 2009. The FIC has also a targeted line to support innovation in regions; since 2008 25% of the FIC (i.e. the so called “Regional Assignment”) goes to regions and represents a mechanism to increase innovation capacities in the regions themselves. Different constituencies in the country recognize that mechanism for the allocation of resources to regions is in its early stages and requires improvements. As agreed by the government the priorities for the FIC were to support science and technology development in firms, to invest in human resource development and to internationalize domestic innovation efforts.

Traditional and emerging instruments in the policy mix

In terms of “inventory” the region has a quite rich innovation policy portfolio. The difference with frontier countries is in the budget, in implementation capacities and in the implemented policy tools. Some common elements in the recent innovation strategies in Latin America are the priority given to the grants for higher education and talent development. Some emerging trends are the return of the sectoral approach and the implementation of sectoral innovation funds, as well as the rising importance assigned to the recognition of the profession of researcher and the new interest in supporting the creation of new firms, including startups. An exhaustive inventory of innovation policy tools goes beyond the scope of this Chapter. The screening of major operating innovation policy instruments presented in the following paragraphs offers an in-depth panorama of the policy mix available in the region.

Innovation policy instruments can be characterized according to their targets in: i) support to human capital, ii) direct and indirect funding for R&D, including infrastructure for R&D, scientific research and innovation in firms; iii) services and iv) integrated support for innovation. The instruments differ according to their level of political "acceptability"; some are in fact traditional and have been used the region since a long time, such as grants for R&D. Others are emerging, including innovation services and the integrated support to innovation.

Table 2.4 The innovation policy mix: type of support and political acceptability

<table>
<tr><th rowspan="2"></th><th rowspan="2"></th><th rowspan="2">Human Capital
for R&D</th><th colspan="3">Direct and Indirect Financing</th><th rowspan="2">Innovation Services</th><th rowspan="2">Integrated support for R&D and Innovation</th></tr>
<tr><th>Infrastructure for STI</th><th>Scientific Research</th><th>R&D and Innovation</th></tr>
<tr><td rowspan="5">INSTRUMENTS</td><td rowspan="5">TRADITIONAL</td><td rowspan="5">Grants for higher education
All countries</td><td colspan="4">National S&T Institutes
in strategic fields
Agriculture
Argentina: INTA; Brazil: EMBRAPA; Chile: INIA
Health (all countries)
Manufacturing:
Argentina (INTI National Institute for Industrial Technology);
Brazil : INPE (National Institute for Spatial Research)</td><td rowspan="5">Cluster Support
S&T Parks
Innovation
Poles
Entrepreneurship and start-ups
Brazil:
APLs;
Biotech Pole
Minas Gerais
Chile: Cluster
Policy
Panama:
City of
Knowledge</td></tr>
<tr><td colspan="2" rowspan="2">Research Funds
Subsidies and matching funds for infrastructure upgrading
Grants and subsidies to researchers or research projects
Chile: FONCYT
Argentina: FONCYT</td><td rowspan="4">Technology funds
(demand-oriented)
Argentina: FONTAR
Chile:
Colombia
Peru
Panama</td><td>(Extension Services)</td></tr>
<tr><td>National Institutes for metrology, certification and measurement</td></tr>
<tr><td colspan="2" rowspan="2">NEW TREND: support to research groups and consortia
Chile, Mexico</td><td>Technical training and business coaching
Brazil: "Sistema S"
SENAI, SENAR,
SEBRAE</td></tr>
<tr><td>Technology transfer services
Argentina
Unidades de Vinculaicón Tecnológica</td></tr>
</table>

<table>
<tr><td rowspan="9">EMERGING</td><td rowspan="2">National System of Researchers
Mexico: SNI
Panama
Brazil: Lattes
Argentina</td><td colspan="3" rowspan="2">System of Sectoral Technology Funds
Brazil
(coordination between demand and supply and transversal actions for research infrastructure and science-industry linkages)</td><td>Networks for the provision of technological and extension services
Brazil: SIBRATEC</td></tr>
<tr><td>Platforms for access to knowledge
&
information exchange
Argentina: SICyTAR
Colombia
Access to scientific publications
Chile: SICTI
Costa Rica
Innovation System Map</td></tr>
<tr><td>Talent repatriation & retention
Argentina: RAICES
Panama</td><td rowspan="3">Access to ICT
(“intangible” infrastructure)
All countries</td><td rowspan="6">Support to cross-country scientific research
Argentina and Brazil: Nanotechnology Initiative</td><td>Sectoral Funds
Argentina
(FONARSEC
FONSOFT)
Mexico</td><td rowspan="3">Innovation
Exhibitions & Fairs
Brazil-States
Costa Rica</td></tr>
<tr><td rowspan="2">Attraction of forewing talents
Chile: CONICYT program for attraction of human capital</td><td>Fiscal Incentives
Chile
Colombia
Mexico
Brazil (Lei do Bem)</td></tr>
<tr><td>Support to access to finance
Brazil, Colombia</td></tr>
<tr><td rowspan="4">Promotion of Scientific and Innovation Culture
Chile:
Explora program from CONICYT targeting children and young people
Argentina:
CINECIEN Festival Cientific Cinema</td><td rowspan="4">Public Invesment in muli-funcional spaces:
Argentina
Polo Científico Tecnológico</td><td>Technological risk sharing
Colombia</td><td rowspan="4">Intellectual Property Management
Argentina, Chile, Mexico: incentives to IP protection
Brazil: incentives to IP protection + training INPI Academy</td></tr>
<tr><td>Science-industry links
Research consortia
Argentina; Chile; Mexico
Support to PhD employment in industry
Brazil</td></tr>
<tr><td>Venture Capital
Weak in all countries</td></tr>
<tr><td colspan="2">Public procurement
Brazil</td></tr>
</table>

Source: Author’s elaboration based on country information.

Fostering talent development and skills for innovation

Almost all countries in Latin America offer grants to pursue masters and especially PhDs, in the region and abroad. In some countries these grants are offered when students enroll in trainings in country priority areas. Brazil has prioritized the training of PhDs. In the 1980s the share of Brazilian PhDs over the PhDs delivered in the US was 3%; this share rose to 12% in the 1990s and to 19% in 2008. In parallel, the number of PhD degrees granted in Brazil rose from 5 000 in the mid 1990s to 10 705 in 2008. This catching up in the supply of qualified labor force has been supported by a rising public commitment to increase the quality and coverage of tertiary education[46]. Brazil, for example, introduced in 2006 a quite innovative scheme to support the incorporation of high skilled human capital in firms. The Ministry for science, technology and innovation (MCT) offers, through FINEP, contributes to the costs of hiring PhDs in firms. In 2008, the MCT/FINEP approved 33 operations for a three-year budget of R$ 10 million. The scheme offers a subsidy of maximum R$ 7 000 for each hired PhD and R$ 5 000 for master degrees for a maximum of three years. In Argentina, in 2008 the National Fund for Science and Technology (FONCYT) has invested 188 million of Argentinean pesos, 27% of which went to the human resource program. In Chile, the national council for science and technology (CONICYT) offers grants for human capital development; in 2006 the budget was around 5 billion of Chilean pesos, of which 70% was for PhDs studying in Chile, and 15% for PhDs abroad. However, less support has been given to vocational and technical training.

In addition to the traditional offer of grants for education, Latin American countries are also supporting the strengthening of human capital for innovation through other means:

i. The recognition of the profession of "researcher" and the mapping of national researchers.

Several countries have introduced systems to qualify the profession of "researcher". The pioneers have been Brazil with the "Lattes Curriculum System" and Mexico with the SNI (National Researcher System). These two have been used as a benchmark to set up the systems in Argentina and Panama. Ecuador and Uruguay also have national systems for the accreditation of the profession of researchers.

ii. Talent repatriation and retention.

A key challenge for Latin American countries is to retain talents and offer opportunities for productive employment. Argentina has introduced the program RAICES (Network of Argentinean Researchers Living Abroad) to subsidize the repatriation of national researchers. The program offers travel and a lump-sum for relocation. Small economies face the challenge of avoiding brain-drain. Panama, for example,

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[46] In 2009, the National Agency for High Level Training (CAPES), has delivered 24 657 grants for PhDs and Post-doc studies in Brazil and 3 200 grants for PhDs and post-doc studying in a foreign country. The CAPES investment for 2009 was of R$ 1.157 billion in higher education grants and R$ 291 million in incentives for training. The execution rate (i.e. the effective expenditures over the foreseen allocated budget) of CAPES resources tends to be very high indicating a good capacity of the institution to implement the planned strategy. The execution rate is 86%, and actually grants for Phds and post-docs show an execution rate of 100%, while the item which reduces the average is due to a newly introduced program offering training for future trainers which recored an exteremly low execution rate of 18.7%.

offers support to talent repatriation by sharing the employment costs with the hiring firm or institution.

iii. Attraction of foreign talents.

Attraction of foreign talent has been a common ingredient in the catching up strategies of South East Asian economies; in Latin America this has beenless common. Some countries are starting to attract foreign talent. Panama couples talent repatriation grants with a package to attract foreign talent by offering simplified administrative procedures and services to foreign researchers that have been hired by domestic companies and institutions. Chile has started to incentivize the attraction of foreign talent, both through grants offered by the national science and technology council (CONICYT) and by subsidies given by the national corporation for production development (CORFO) which has recently introduced a scheme for attracting foreign start-uppers to Chile.

iv. Promotion of scientific and innovation culture.

The support to human capital for innovation goes beyond direct subsidies for training and talent mobility. Latin American countries increasingly recognize the need to invest in promoting an “innovation culture”. In Chile, the national council for science and technology (CONICYT) sponsors the “Explora Project”, which supports the popularization of S&T among children and young people. In Argentina, the Ministry for science, technology and productive innovation (MINCYT) co-sponsors, together with the National Art Institute the festival of scientific cinema (CINECIEN) to increase awareness of the relevance and impact of science and technological development on the society as a whole.

Direct and indirect financing for science, technology and innovation

Latin American countries support science, technology and innovation through a variety of direct and indirect support mechanisms.

National technological institutes

These public scientific and technological institutes have been created during the import substitution phase to facilitate applied research and knowledge transfer to the business sector in priority fields in support of the industrialization strategy. These provide infrastructure for research, carried out R&D and favoured technology transfer.

Public research institutes have played, and in certain cases continue to play, a determinant role in supporting R&D for agriculture. Argentina, Brazil, Chile, Panama and Peru are among the countries in the region that have a technological institute in charge of agriculture[47]. Brazil has opted for a model in which the R&D and extension services were separated, EMBRAPA (*Empresa Brasilera de Pesquisa Agropecuária* /Brazilian Firm for Agriculture and Livestock Research[48]) was in charge of applied research to increase the competitiveness and sustainability of the domestic agricultural and livestock production, while national rural extension services were responsible for the dissemination of the research results to producers. Several countries also have public research institutes specialized in health and often attached to the ministries of health, including the *Instituto Nacional de Salud Pública* in Mexico, the *Instituto Nacional de Salud* in Peru, the *Fiocruz* in Brazil. Those institutes are major executors of research in the health sector[49].

Most countries in the region have public research institutes in key industrial fields. Brazil has the National Institute for Research in the Amazonia (INPA *Instituto Nacional de Pesquisas da Amazônia*, the National Institute for Space Research (*INPE Instituto Nacional de Pesquisas Espaciais*) created in 1971 after ten years of investment in the organization of a national space research agenda (the budget for 2011 is 200 million R$). In Argentina the National Institute for Industrial Technology (INTI *Instituto Nacional de Tecnología Industrial*), carries out R&D and offers support to firms for business development, technological upgrading and qualification of personnel with no sectoral target. The capacity of these institutes to interact with the business sector today is varied, but in certain cases their research agenda tends to be defined more by the scientific than the business community.

Demand-oriented funds

The majority of the resources for science and technology in Latin America are channeled to firms and researchers through technology funds. Countries often manage two funds: one targeting research institutions and individuals and the other targeting firms. Most of the funds are "demand-oriented", as in Argentina, Co-

[47] In Argentina, the INTA (*Instituto Nacional de Tecnología Agropecuaria*) was created in 1956 with the objective of carrying out R&D and providing extension services and technology transfer. The INTA budget for 2010 was 1 billion Argentinean Pesos. In Chile, the INIA (*Instituto de Investigaciones Agropecuarias*) was created in 1964 and it is the major research entity for upgrading domestic agricultural production. Other examples of this type of institute is the the IDIAP (*Instituto de Investigación Agropecuaria*) in Panama, created in 1975, and the INIA (*Instituto Nacional de Innovación Agraria*) in Perú. In Mexico the network of institutes includes both the research centers related to CONACYT and the sectoral ones related to State secretaries for innovation. Nicaragua the INATEC (*Instituto Nacional Tecnológico*) and INTA (*Instituto Nicaraguense de Tecnología Agropecuaria*).

[48] EMBRAPA is a state-owned applied research firm created in 1973 attached to the Ministry of Agriculture specialized in applied R&D. EMBRAPA is in EMBRAPA operates through a network of 45 Units, localized in almost all Brazilian states, focusing on thematic issues, specific products and main Brazilian challenges. Embrapa employes 8.944 people, of which 2.024 are researchers (21% master degree, 71% PhDs and 7% post-Phd training). The budget for Embrapa for 2010 is 1 billion 863 thousand R$. EMBRAPA receives resources from the federal government, but also from BNDES, BNB, and international donors.

[49] For example the budget for Fiocruz 2008 was R$ 76 million.

lombia, Peru, and Mexico. "Demand-oriented" means that beneficiaries need to present a request to access these funds[50]. These types of schemes can "generate adverse selection in the recipients: more pro-active agents, that could probably master technological innovation without recurring to public funds, will be more prone to submit projects for evaluation; while more technological backward actors will face higher barriers to access the resources" (Cimoli *et al.* 2009b). In addition, this scheme requires awareness campaigns to allow the potential beneficiaries to be aware of the existence of these resources. In fact, often these funds are under-utilised because potential beneficiaries are not informed about their existence, or find it too hard to comply with all the requirements (Cimoli *et al.* 2005; 2009b)[51].

Since the 2000s, several countries in Latin America have introduced collaboration and partnerships as conditionalities to access these funds. In many cases, potential beneficiaries were asked to submit joint proposal, by creating consortia of firms and research institutions. The support to research networks and "more ambitious" research projects, has found, however, serious limitations due to the lack of critical mass of excellent R&D partners in the countries of the region. More open collaboration conditionalities would have, in many cases, worked better than the strict requirement of collaborating with the local university, for example.

Sectoral technology funds

In addition to demand-oriented technology funds, several countries in Latin America have set up sectoral technology funds. The pioneer has been Brazil. In 1999, it has introduced a system of sectoral technology funds based on the coordination between knowledge demand and supply (Cimoli *et al.* 2005; 2009b). This system represents a step forward in policy design for how it channels resources to innovation and for its management scheme. Brazil has 16 technology funds; 14 of which are related to specific sectors, and 2 target science-industry links (FVA- *Fundo Verde Amarelo)* and S&T infrastructure upgrading (CT-INFRA). The first sectoral fund has been, with no surprise, the one for oil (CT-Petro). The more recent one focuses on Audio-Visual Arts. All sectoral technology funds belong to the FNCT (Na-

[50] As stated in Cimoli *et al.* (2009b, pg. 44), "for instance, the Argentine Technological Fund (FONTAR) prioritize 5 areas in S&T development: i) technological development of new products, services or production processes, ii) technological modernization, i.e. improvement of products and processes, training, iii) promotion of the technological services market, supporting research laboratories and business research centres activities, iv) training and technical assistance and v) technological advisory assistance programmes especially to strengthen small and medium-sized enterprises' technological performance. The fund allocates resources on the basis of a demand-pull mechanism. It is made up of national financial resources originating from national budget, fiscal credit law, credit lines of public banks and of resources originating from international loans (IADB loans according to the Argentine Modernization Plan). The FONTAR assigns financial resources to demanding beneficiaries principally in the form of non-repayable contributions, loans, subsidies and fiscal credit according to specific objectives and prospective beneficiaries".

[51] For additional country evidence on this topic see Casalet (2003); Jaramillo (2003); Pacheco (2003); Vargas Alfaro and Segura Bonilla (2003); Yoguel (2003).

tional Fund for Science and Technology) and are managed by FINEP, with the exception of the FUNTEL (Fund for Technological Development of Telecommunications) which is managed by the Ministry of Telecommunications, and the Audio-Visual fund which is managed by the authority for audiovisual industry.

Each sectoral fund is ruled by a law that establishes the operational mechanisms, the objectives, source of financing and the amount of resources to be invested in the fund. Each sectoral fund has a specific financing arrangement. In general, resources derive from the revenues of the exploitation of natural resources, taxes on industrial production (IPI *Imposto sobre Produtos Industrilizados*) or share of contributions paid for royalties on use or acquisition of technology from foreign countries. Since 2004, 50% of each sectoral fund has to finance "transversal actions" in line with the priorities of the national policy for industrial development. In addition, by law 30% of the resources of sectoral funds need to target priority regions (such as Norte, Nordeste and Centro-Oeste).

Each sectoral fund has its own rules and priorities; however they share some common rules:

- Resources are sector-bounded and activity bounded; i.e. it is not possible to transfer resources from one fund to another and resources must be used to finance R&D and technological development in the sector;
- Multi-annual budgeting; all funds allow for multi-annual actions;
- Shared governance; the management committees are composed by governmental, business, academy and civil society constituencies;
- Differentiated sources of finance: the funds are financed by different types of resources like royalties, financial compensation, licensing, etc.; integrated programs: the funds can support programs from basic to applied research. Beneficiaries can access resources through public calls often managed by the FINEP and the CNPq.

The system has been developed to increase the budget for technological development and innovation in strategic sectors and to favour private-public collaboration for innovation. Each fund has a Management Committee chaired by a representative of the Ministry of Science and Technology, and composed by stakeholders from relevant ministries, regulatory agencies, the business sector and the academy. The mixed management committee runs each technological fund according to a coordinated and consensual strategy. This mechanism, which has the advantage of promoting coordination between the private and the public sector, is also difficult to manage in practice, as observed in Cimoli *et al.* (2005; 2009b). During the first years of operation of this scheme, the management challenges have led to a sub-utilization of the resources and have contributed to the sectoral fragmentation of actions. However, the model has evolved and the management committees have gained practice in priority setting and in conflict management. In addition, in 2004 a new Committee for the Coordination of Sectoral Funds has been established to stimulate interaction among the different sectoral agendas. The Committee is chaired by the Minister of Science, Technology and Innovation and it is responsible for the implementation of the transversal actions. In the first years of operation, the execution rates were very low. More recently most funds have registered execution rates of around 90%.

More recently, other Latin American countries have introduced the sectoral technology funds, but in each country the model is different. Mexico has instituted sectoral technology funds and Argentina has introduced the FONARSEC (Sectoral Fund) receiving financial support from the IADB (Inter-American Development Bank) for its execution. The FONARSEC supports innovation for problem solving in strategic sectors, potential areas: health, energy, agro-industry, ICT, Nanotechnology and biotechnology and social development. For example, the FS-BIO supports the development of technological platforms to provide services to public and private agents for technological development in the biotechnology industry; the projects cannot exceed 30 million Argentinean pesos and require a 30% of matching grants. The FONSOFT supports the software industry and finances training, R&D projects and business coaching in the sector.

Fiscal incentives to firms for R&D and innovation projects

A common instrument to support business investments in R&D are the fiscal incentives. They can include: i) tax deductions and ii) tax credits to given categories (SMEs, firms in given sectors, research institutions, etc.) for R&D and technological modernization expenditures. Fiscal incentives enjoy higher political acceptability than direct financing since they are perceived as less interventionist and more "neutral". In practice, however, they are, as all policies, selective since different agents react in a different way to the same incentive. For example, SMEs usually lack the financial competences to manage the tax incentives schemes. In fact, it is often the large firms who take advantage of tax breaks.

Since the end of the 1990s some countries in Latin America have reformed their fiscal laws to shift towards a more pro-innovation tax system. In Argentina, the FONTAR offers a fiscal credit for innovation since 1998. In Mexico, firms can benefit of fiscal deduction for infrastructure development and maintenance. As part of its strategy to attract technology based firms, Colombia offers tax deductions for local software development, even if it is for export; it also offers 125% of tax deductions for R&D expenditures in the fields approved by Colciencias and tax-free exports of technological services developed in Colombia. In Chile, firms benefit of a tax reduction of 35% of R&D expenditures since 2008[52]. In Brazil, firms can deduce between 60% and 100% of the income tax and the social contribution tax and 50% of the tax on industrial products as established by the chapter III of the "*Lei do Bem*" approved in 2005), while reductions are between 50% and 250% when R&D projects are executed in collaboration with public S&T institutes (according to the provisions established by the *Lei do MEC Inovação* 2007). Brazil also has fiscal incentives

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[52] Law 20.241/2008.

for quicker depreciation of acquisition of machinery and specific incentives for the information and communication technology industry. In addition, in Brazil firms can benefit of premiums in fiscal incentives in proportion with the number of researchers employed and for obtained patents.

Notwithstanding the recent improvements in the regulatory framework, the use of fiscal incentives from firms remains low. This is due, not only to often complex legal requirements, but also to the fact that most firms are small and find difficult to use these *ex-post* innovation rewards. Tax incentives are also "demand-oriented" and therefore tend to underperform in a context of low entrepreneurial dynamism.

New forms of financing for innovation

In line with the rise of the innovation agenda, most countries in Latin America are introducing new mechanisms to finance innovation.

Development banks

Development banks are growing in importance as providers of long term finance for innovation. In Brazil, the national development bank (BNDES) has included innovation among its priorities since 2003, in parallel with the return of industrial policy in the country's development agenda. In 2010, the BNDES has channeled R$ 1.6 billion (funds, share participation, non reimbursable contributions and credits) to innovation. In Colombia, a key pillar of the innovation policy is the incentive to technological innovation offered by *Bancoldex-Colciencias* through a privileged credit line for SMEs[53].

Technological risk sharing

An emerging instrument is also a kind of public insurance for private investments in high risky technological development projects. These types of schemes are well known in the Republic of South Korea, for example, but are not yet common in Latin America. In Colombia, Colciencias has introduced a "shared technological risk" line for SMEs that offers 70% of the total amount upon project approval of 70% (up to 200 monthly minimum salaries) against a matching fund of 30% of the beneficiary. The support of *Colciencias* includes a reimbursable and a non reimbursable component; firms will need to reimburse between 20% and 60% of the support according to the success of the project.

[53] *Bancoldex* is the Bank for Foreign Trade of Colombia which operates both as a development bank in support of production development and as a second-tier bank though a wide network of financial institutions and corporations in the country.

Venture capital and business angels
The development of the venture capital industry is quite recent in Latin America[54]. In line with a growing willingness of countries to promote the creation of new firms, and especially technology based start-ups, many countries in the region are looking how to promote the creation of venture capital and business angels. These funds offer not only financing but also expertise to new entrepreneurs and can be of support in promoting firm development. Public policies are needed at the early stages of these industries to generate incentives for their development and to adjust the legal framework to make the operation of these funds possible. Brazil and Chile have the most advanced venture capital industries in the region, and yet their level of development is far below what their economies could achieve. In Chile, CORFO has acted as a convoy to channel private funds to create a national industry for venture capital. In Brazil, public and private agencies operate to promote risk capital development and train potential investors (OECD, 2013b).

Public procurement for innovation
In line with the resurgence of demand-side policies for innovation in OECD countries (OECD, 2011), Latin America has also seen the return of public procurement for innovation. This instrument was banned in the region as a consequence of the structural reforms of the 1990s. Brazil uses public procurement for innovation in strategic sectors, including the software industry (following the provisions of the *Lei da Informática*, 1991) and the health-care[55]. The country has improved the legal framework for public procurement by introducing a provision of preference for the domestic industry and preferential treatment for national products and services deriving from domestic technological innovation (when the costs are not superior to 25% to the price of similar foreign manufactured and services). The new legal framework also establishes a preference for Mercosur products and services, when Brazilian ones are not available. A pending challenge is to increase the agility of the system and augment the negotiation capacity to reduce the costs.

Science-industry linkages
An additional common feature of recent STI policies in Latin America is the promotion of public-private partnerships (Cimoli *et al.* 2005; 2009b). Most financing mechanisms include conditionalities to foster such cooperation through various channels. For example, the new Brazilian Innovation Law allows university researchers to temporarly undertake research at private institutions. These initiatives are, however, incipient. And often, their budgets remain too low to mobilize the engagement of the private sector. In addition, Latin American and Caribbean

[54] See OECD (2013b) for an overview of initiatives to promote risk capital and businsss angels in Latin American countries.
[55] The laws12.520/02 and 12.349/10 allow using public procurement as a tool for national development.

production specialisaiton leads domestic agents to seek mostly outward oriented linkages, privileging foreign companies and research laboratories that already have sound reputation and worldwide recognized experience in scientific and technological development" (Cimoli *et al.* 2005; 2009b). This charactheristic contributes to limit the effect of binding conditionalities on local cooperation between science and business.

Support to cross-border collaboration in research

With rising globalization and the new technological paradigms cross-border collaboration in R&D and innovation is growing in importance. Some Latin American countries are implementing new initiatives to foster international collaboration in science and innovation. Argentina and Brazil created in 2005 the Argentinean/Brazilian Center for Nano-science and Nanotechnology (CABNN)**.** The Center aims at: i) implementing joint R&D projects and to support infrastructure upgrading in areas of key economic and social interest for both countries; ii) supporting the creation of bi-national companies for development of nanotech products and processes; iii) developing a common stance towards intellectual property management in the nanotechnology sector and iv) training human resources for R&D in the nanotechnology area.

Access to ICT and "intangible" infrastructure

Since the 2000s, almost all Latin American countries have developed programmes to foster access to information and communication technologies (ICT). Several small countries have even witnesses a kind of "informatization" of the innovation agenda; most of the resources for innovation were in fact channeled to foster access to ICT. Most countries in the region have developed plans to favour access and application of ICT to service delivery in the public administration, education and health, and, even though in a smaller measure, to support production development (mainly SMEs exports)[56]. Some countries have identified ICT, not only as an enabling general purpose technology, but as a new industrial sector, implementing specific policies to foster innovation in ICT, as in Argentina, Brazil Chile, Costa Rica and Peru.

Multi-functional spaces for innovation

Some countries in the region are also experimenting new forms of "open" approaches to innovation policies and foster innovation by creative thinking. In Argentina, for example, the government is involved in the creation of the first scientific and technological pole in the country. The multi-functional space will host the Ministry for Science and Technology, the National Agency for Innovation as well as

[56] Several studies analyze the ICT agenda in the region and the policy impact. See Peres and Hilbert, 2009 for a complete review of the ICT policy impact and debate in the region.

national and international research laboratories, including the Max Plank institute of Biomedicine and Biotechnology. The pole will also host the first national science museum. These actions respond to the emerging “open” approach to science and to public polices in which spatial proximity between actors with different missions and expertise but with common interests is assumed to positively influence innovation and to promote the generation of a culture of innovation in the society.

Provision of innovation services

As a complement to financing schemes, the innovation policy mix also requires the supply innovation services in order to facilitate knowledge circulation. In Latin America, many countries have a national service for basic industrial technology, including Cuba, Costa Rica and Brazil[57]. In Argentina, as in some other countries, the National Institute for Industrial Technology provides these services.

Another traditional service is the supply of training and business coaching. In Brazil the “S system” (*Sistema S*) supplies these services; it has several agencies that offer specialized training and business development support to national firms, as for example the SENAI (National Service for Industrial Learning- *Serviço Nacional de Aprendizagem Industrial*), SEBRAE (Brazilian Support Service for Micro and Small Enterprises- *Serviço Brasilero de Apoio às Micro e Pequenas Empresas*) and the SENAR (National Service for Rural Learning- *Serviço Nacional de Aprendizagem Rural*)[58]. The SENAI was created in 1942 with the objective of offering specialized training and qualification to the national industry. The system offers training and specialized innovation services such as assistance and laboratories for applied R&D[59]. SEBRAE is an agency specialized in proving services to Micro and SMEs. It has been created in 1972 and it carries out training as well as support to associativism and formalization of micro-enterprises[60].

The paradigm shift in development policies of the 1990s has modified the policy mix for innovation services. For example, in Brazil, the “S system” survived but the extension services were closed. The shift towards a demand-oriented innovation policy model has contributed to create intermediaries and service providers and to facilitate private-public cooperation. Many countries in the region have created technology transfer services. In Argentina, for example, the Units for Technological Linkage (UVT *Unidades de Vinculación Tecnológica*) have been introduced by

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[57] The Brazilian national institute INMETRO is a reference in the region for its well developed functioning system.

[58] The SENAR was created in a later stage in 1992 following the SENAI model; it offers training and capacity building for rural entrepreneurs. In 2009 SENAR has invested R$ 1’102’293 in training activities for rural entrepreneurs.

[59] In 2010 the SENAI has invested R$ 2’996.778 billion in management, institutional business and training services to the national industry.

[60] SEBRAE invested R$ 2’468.482 million in 2010 and the budget for 2011 is R$ 2’777.420 million. In 2010 53.7% of the budget was devoted to project development, 17.5% to management services, 13.8% in knowledge and technology, 8.7% in financial services and 6.4% in institutional coordination.

the law 23’887/1990. UVT are certified institutions specialized in favoring the matching between university and business. They provide innovation services to firms, technical assistance in project development and facilitate access to public resources. The evidence on the performance and impact of these technological brokers is mixed.

The countries of the region are also providing new services to foster innovation in firms, including:

i. Web platforms for knowledge sharing

Most countries in Latin America have profited from the diffusion of ICT to develop web platforms for information sharing and knowledge exchange. In Colombia, Colciencias provides shared access to indexed scientific publications. Costa Rica has created an interactive innovation map in which the Ministry of Science, Technology and Innovation and the users can add and localize in the territory the agents of the innovation system (firms, public institutions, universities, etc.). Chile has introduced since 2005 the system for science and innovation information (SICTI), while Argentina has developed the science and technology information system (SICYTAR) which works as a database for the national science and technology personnel, scientific and innovation projects.

ii. Exhibitions and fairs

Holding innovation exhibitions and fairs is an “old” instrument to promote a country’s reputation, as well as to favour linkages and networks between the agents of the national innovation system. In Latin America this is an emerging trend. Since the 2000s, some Latin American countries have started to organize exhibitions to display locally generated technologies and business solutions. These activities contribute to raise awareness public opinion towards innovation and favour the creation of an entrepreneurial environment for innovation. Usually, these fairs are carried out in partnership with business associations and local authorities. In Latin America these exhibitions have started to target not only scientific and technological activities, but also the creative economy, as for example with the organization of the Brazilian Design Week and the Argentinean Design Exhibition.

iii. Intellectual property management

Latin American countries have increasingly incorporated intellectual property management in their innovation policy. The adoption of the TRIPS agreement in 1994 has required the countries of the region to modernize their patent laws to adequate them to international standards. This pressure towards raising intellectual property protection has been intensified by the bilateral trade and investment agreements signed by many Latin American countries with the US since the end of the 1990s. Since the end of the 1990s most countries in the region, including Argentina, Brazil, Chile and Colombia, have introduced in their financial incentives for innovation some targeted support for intellectual property protection. However, in most cases these incentives have been underutilized by domestic firms due to the lack of awareness, lack of corporate strategies targeted towards intellectual property protection and little critical mass of companies with the required capabilities to produce patentable products and/or processes.

In Brazil, in addition to the incentives to protect intellectual property, the National Patent Office (INPI) provides services to firms such as access to electronic databases related to intellectual property, as well as new services to increase the quality of patent examination process, including a platform for information sharing among patent examiners and targeted training to patent examiners. In Peru, the National Institute for Intellectual Property (INDECOPI- *Instituto Nacional de Defensa de la Competencia y de la Protección de la Propiedad Intelectual*) matches the function of intellectual property promotion with anti-trust regulation. This institutional setting allows coordinating intellectual property management with consumers' protection representing a quite unique configuration in the institutional setting in the region.

Integrated support to innovation: cluster policy, science parks and innovation poles

The innovation policy mix in Latin America also includes some "new generation" type of instruments that offer integrated support to innovation, matching financing, with provision of services, training and infrastructure in close linkage with the local communities and the territories. These instruments usually require a matching of public and private finance, investment in capacity building and in science-industry links and require the engagement of regional and local authorities in policy design and implementation.

In many countries, international financial institutions, including the Inter-American-Development Bank (IADB) as well as the Andean Corporation for Development (CAF) have financed competitiveness programmes through cluster development since a long time. Brazil has also a long tradition in promoting local production arrangements (APLs *Arranjos Produtivos Locais*). In Brazil APLs are defined as production systems anchored in a given locality and with a predominance of small and medium enterprises. Public support includes incentives to associativism and collaboration, as well as marketing and business planning. Several institutions are involved in supporting APLs like BNDES, the Ministry for Industry and Trade (MIDIC) and organizations like SEBRAE (specialized agency for training to micro and small entrepreneurs), as well as State Secretaries for Innovation.

In other countries, cluster promotion and the development of innovation poles and science parks are emerging issues in the innovation agendas. Chile is prioritizing cluster development in several areas including mining, agribusiness, global services and tourism. CORFO has fostered the development of national cluster councils composed of private and public entities and sectoral stakeholders to elaborate a strategy for business development in each cluster taking into account the requirements of the global production chain and the impacts on the local economy. In Chile, cluster development has been a way to re-introduce the sectoral dimension in the support to innovation and has served as a basis for dialogue with multinational companies operating in natural resource processing.

Many countries have promoted the creation of science and technology parks to foster innovation and to attract technology based firms. In Panama, for example the Government is prioritizing the development of the City of Knowledge (*Ciudad del Saber*) as a space for innovation and technological development in the country. In certain cases infrastructure costs overcome the innovation impact generated by the research centers and the firms. But when parks are well planned and managed they can play a major role in catalyzing innovation development efforts in the hosting community. Some successful examples are the Technological pole in Minas Gerais and the Tecnopuc in Porto Alegre.

2.4 CONCLUSIONS: LEARNING IN POLICY MAKING

Latin America is clearly not the first region that comes to mind when talking about innovation. However, an analysis of innovation policies in the region, shows that Latin American countries are recognising the importance of innovation for development. Most countries have functioning institutions and, a more or less articulated policy mix. The experience of Latin America can be interpreted as a process of policy learning. Over the years the countries have accumulated learning; the new global economic context opens opportunities for Latin America, to profit from the learning and to advance in achieving socio-economic transformation based on new sectors, activities and forms of organisation of production and service delivery. However, advancing requires new forms of consensus and more pragmatism in action, as well as a renewed role of internal demand, new and stronger alliances with the private and the financial sector. Four categories have come to my mind to synthesize this policy learning process: Choice, Coherence, Consistency and Control (Table 2.5):

- **Choice can be intended as the capacity of the policy to select objectives, sectors/activities and beneficiaries.** Innovation policy is more effective when it is capable of recognizing upfront that all policies are in practice "selective", no matter if they are designed as neutral or horizontal. Each policy intervention, even regulations, automatically discriminate beneficiaries due to differences in size, specialization, stage of development, *etc.* . The selectivity of innovation policies is auto-determined by the heterogeneity in the characteristics, behaviours and preferences of potential beneficiaries that shape, in practice, different reactions to equal policies. Therefore, policy systems are more effective when they take into account this aspect in policy design. In Brazil, innovation policy explicit the choices in terms of priority sectors and beneficiaries also thanks to the alignment with the new production development policy. In Chile, the cluster-based approach has helped re-introducing selectivity in a context in which the free market approach tends to dominate public action.

- **Coherence can be defined as the capacity to deal both with the cross-ministerial nature of innovation and with its diversified territorial impact.** Innovation policies need to create synergies with other policies to be effective; especially with government actions affecting the competitiveness of the business sector, including macroeconomic, trade and industrial policies, as well as with the policies influencing the innovation environment and the advancement of science, including education and skills policies. To facilitate horizontal coordination a strong political leadership is needed. In Brazil, the capacity to articulate innovation and production development policies is enhanced by the growing attention given to innovation by a powerful institution as the national development bank (BNDES).
  Policy "coherence" also has a vertical dimension; i.e. the capacity to consider territories as active players in policy design and implementation. In fact, innovation policies impact territorial development, and, at the same time, the territories define the assets and opportunities, as well as the barriers for innovation. Higher capacities of taking on board the voices of territory enable more effective policies. The co-existence of "islands" of technological excellence with marginalized areas is not a transitory stage in the development process; it can be a structural feature if not addressed by targeted policies. Latin American countries are increasingly concerned about the territorial dimension of their innovation strategies and they are advancing in designing territorially conscious innovation policies, as for example in Argentina, Brazil, Colombia and Peru.
- **Consistency can be defined as the capacity to ensure continuity in policy choices as well as fine-tuning as reality changes**. Policies are more effective when they are time and financially consistent. Time consistency refers to the capacity to implement policies "of the State" and not of "Governments" and to take into account the dynamic changes in the behaviours and preferences of agents over time. Time consistency is related to financial consistency, which refers to the capacity to guarantee continuity in financial support, as well as to the diversification of the sources of finance according to the policy objective. In Chile, for example, the fact that the innovation budget is submitted each year to the Treasury undermines the time-consistency in policy planning. The creation of the Fund for Innovation and Competitiveness (FIC) has represented an improvement in the financial consistency of the innovation policy. In Brazil the existence of sectoral technology funds guarantees a resource flow to innovation beyond yearly budget allocations. The national development bank (BNDES) ensures the government's commitment towards innovation even in fiscal consolidation periods. In smaller countries the financial consistency is challenged by the major role played by foreign resources in innovation policy financing, as it happens in Panama, for example.
- **Control can be defined as the capacity of the institutional setting to ensure policy accountability and monitoring** (policy control) **and to allow stakeholders' participation in the policy process** (social control). Improving poli-

cy control is paramount for Latin America. Some countries have advanced in this field by increasing the visibility of policy actions; for example, in Colombia the national observatory for innovation favours information dissemination, while in Brazil the National Institute for Applied Economic Research (IPEA) and the creation of the Centre for Management and Strategic Studies (CGEE) under the Ministry for Science, Technology and Innovation help to monitor policy implementation and increase visibility of actions.

Improving social control is also a major challenge for Latin America. This is part of the process of learning to design and implement policies in democratic systems. Some countries have advanced, but for many, much has to be done in this area. Costa Rica, for example, has introduced a web-based platform to map the national innovation system through an open and participatory approach through which the civil society, the business sector and the academia can signal their presence and share views on innovation issues. In Argentina, the Morula Network for social innovation managed by the National Agency for Innovation foster social participation in defining innovation programmes of the utility for the civil society, while in Brazil the yearly National Conference for Science and Technology offers a space for open policy dialogue between the central government, the States and the local communities. These events contribute to the popularization of science and technology and favour the participation of the local civil society to the policy debate.

Table 2.5 Choice, coherence, consistency and control: learning in innovation policy making in Latin America

	Choice	Coherence		Consistency		Control	
		Cross-Sectoral	Territorial	Time	Financial	Policy	Social
THEORY (Issues, mechanism and channels)	Prioritization Sectoral and agents' heterogeneity	National Development Strategy Industrial Policy, Intellectual Property Policy, Trade Policy Education, Health, Labour	Diversification and Complementarity Articulation Mechanisms for visibility ex-ante of territorial impact of sectoral choices	Continuity in choices matched with capacities to introduce novel priorities Policies of States and not of Governments Time factor when introducing reforms	Sustainability of support Consistency of type of financial support and policy choices Diversification and securitization of sources of finance	Accountability Monitoring and follow up	Participation of stakeholders in policy design and follow up Social Consensus for policy choices
PRACTICE (Examples from LAC countries)	Brazil: integrated policy approach (frontier-modernization and strategic sectors) Chile: Competitiveness model (Cluster approach) Argentina: science-led (biotech) and market niches (design)	Brazil: the coordination between industrial and innovation policy (MCT, BNDES and MIDIC)	Emerging topic. Still weak in the countries of the region. Advancements in regional dimension of policy, less in policy coordination. Chile: ARDP Brazil: State Innovation Laws and INCTI. Regional Conferences for S&T	Chile: weaknesses of a annually approved budget by the Ministry of Finance Brazil: sectoral technology funds	Chile: FIC on copper royalties Brazil: Sectoral Technology Funds and the role of BNDES Small countries: the high role of foreign resources for STI	Brazil: extensive and increasing amount of S&T indicators. Studies by strategic analysis bodies like CGEE and IPEA Colombia: OCyT	Costa Rica Atlas for S&T policies Brazil: National Conference for S&T

Source: Author's elaboration.

The governments of the region have improved their policies for innovation, especially in the last decade. With the exception of few countries, they have created stronger and more empowered institutions, increased the budgets for innovation, and improved, in part, the legal framework for carrying out innovative business activities. More importantly in certain cases they have re-launched new forms of industrial policies giving, therefore, more impetus to the innovation agenda and overcoming the mismatch between production transformation and innovation strategies of the 1990s. However, notwithstanding the advancements, public investment in innovation is still low and the private sector commitment to innovation is little.

The experience of Latin American countries in designing and implementing innovation policies shows that a set of well-designed instruments is not a guarantee of success on its own. Success requires matching industrialisation and structural transformation goals with multi-annual plans and budgets for science, technology and innovation. Path dependency and cumulative learning processes need to be taken into account while devising new initiatives, or revising existing ones. Innovation policies require explicit mechanisms to monitor and follow up implementation, as well as fine tuning capacities to keep up with a changing reality. Creating mechanisms to reveal success and failure factors in policy implementation helps in improving the policy process.

Latin American countries need to increase policy accountability together with strategic intelligence capacities to devise and anticipate change. And this is especially relevant in the changing global landscape and the rise of new technological powers like China. Soft innovation policies will not be enough to cope with the new landscape.

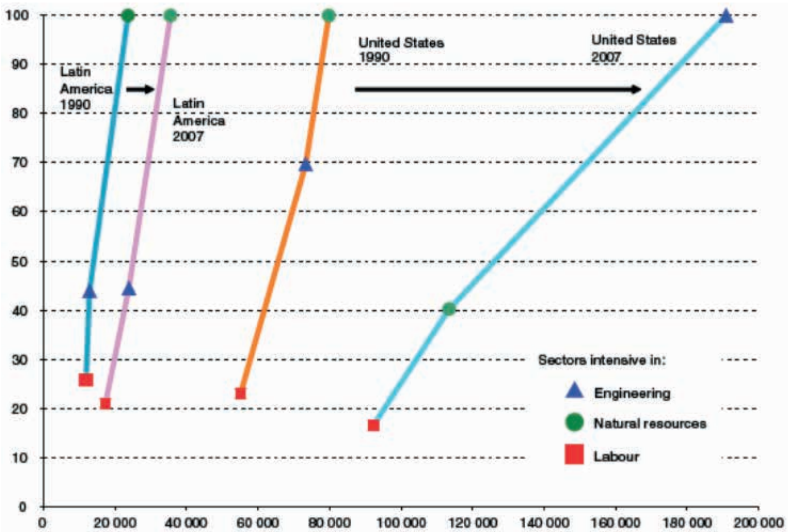
Latin American countries need to capitalize their learning in policy making and advance in implementing more effective and "ambitious" policies. Aligning innovation policies with production transformation efforts can open new opportunities for the countries of the region. It is only by matching the two that the policies for innovation will be effective and will help to achieve higher and more inclusive growth. Otherwise the risk is attaining only marginal improvements, confined to some actors of the system. While the objective is, on the contrary, the engendering of a systemic change, that permeates the whole economic structure.

ANNEX 2.1 INNOVATION IN LATIN AMERICA: STYLIZED FACTS

Latin America suffers of a "quantitative" and "qualitative" gap in manufacturing with respect to more advanced countries. Productivity is lower and it often grows at a lower rate. On average, the countries of the region are deepening their specialization in natural resources and labor-intensive activities, in contrast with more dynamic countries that are specializing in knowledge-intensive activities (Figure 2.A.1). The persistency in the specialization in natural resources and labour-intensive activities in Latin America has also started to challenge environmental sustainability. Natural resource intensive manufacturing is highly intensive in energy consumption (ECLAC, 2010). Therefore, Latin America is facing a double trap: rising productivity gap with the frontier and rising energy dependency to maintain its specialization pattern.

Figure A.2.1 Quantitative and qualitative structural change: LA and the US compared, 1990-2007

Constant $US 1985 (horizontal axis)
Cumulative share of sectoral value added on total manufacturing value added (vertical axis)



Source: ECLAC (2010) on the basis of PADI Database.

The lack of structural transformation in the region has been the result of a change in the economic model marked by the adoption of the structural reforms of the Washington Consensus. During the 1990s almost all Latin American countries have experienced a reduction in the share of value added generated by knowledge intensive sectors. After the year 2000, in certain countries, including Brazil and Mexico, these sectors have started to regain weight in the manufacturing industry (Table A.2.1, in Annex).

Table A.2.1 Technological specialization: Latin America (6 countries), 1970-2007
Share knowledge intensive sectors in total manufacturing value added

	1970	1980	1990	1997	2003	2007
Argentina	22.7	24.9	14.1	17.4	13.0	17.2
Brazil	22.0	32.3	27.8	33.7	33.2	39.6
Chile	16.6	11.0	10.2	12.4	11.3	11.6
Colombia	11.3	11.3	10.4	12.4	11.2	12.3
Mexico	20.2	26.9	26.3	30.5	33.0	41.3
Venezuela	9.0	14.2	9.4	13.5	10.3	12.9

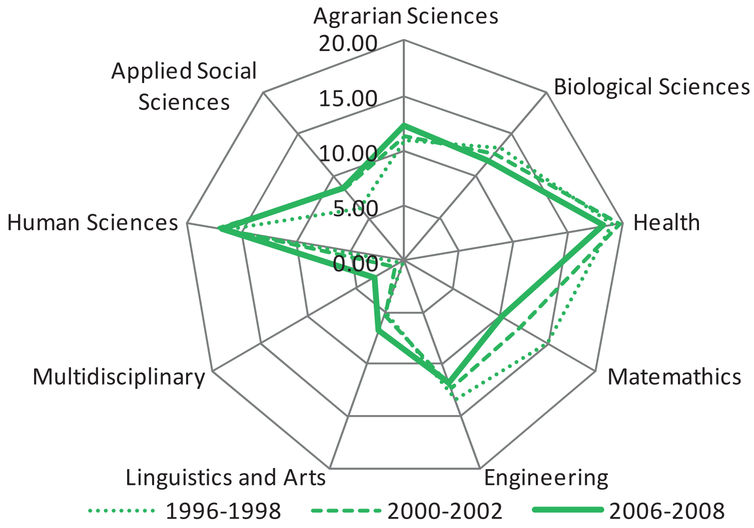
Source: Cimoli *et al.* (2009b) on the basis of the ECLAC-PADI database.

Given its specialization pattern, the scant innovation performance of Latin America at the aggregate level should come as no surprise. The innovation gap of the region can be observed from several angles; among them, three of paramount importance for innovation policy are: i) the quality and quantity of human resources for innovation; ii) investment in R&D; and iii) innovation strategies of firms.

Latin American countries face big challenges in terms of human resources for innovation; even the top countries fall short when compared to international standards. In Brazil, the share of PhD holders over 1000 population aged between 25 and 64 is 1.4% and in Argentina 0.2%; in Germany is 15.4%, and in the US 8.4%. In Latin America, PhDs are specialized in social sciences rather than in engineering and mathematics. Even in Brazil, which is the country of the region with the most diversified industrial matrix and that trains the highest number of PhDs in the region- more than 10 000 per year since 2007 (CGEE, 2010)- doctors are specialized in human sciences and health[61] rather than in mathematics of engineering (see Figure A.2.2).

[61] The relative specialization of Brazil in the health sector can be also explained by the articulated governmental strategy for the health care system which matches a Unified public system for delivering public health care to citizens (SUS *Sistema Unico de Saude*) with an articulated industrial and technology policy in support of industrial development and innovation in the health care production sector, coupled with a major public foundation linked to the Ministry of Health (FioCruz) which provides drugs for the national public health system.

Figure A.2.2 Brazil: specialization of human resources by fields of science 1996-98 and 2006-08
Share of PhD degrees by area of science over total PhD degrees for each period.

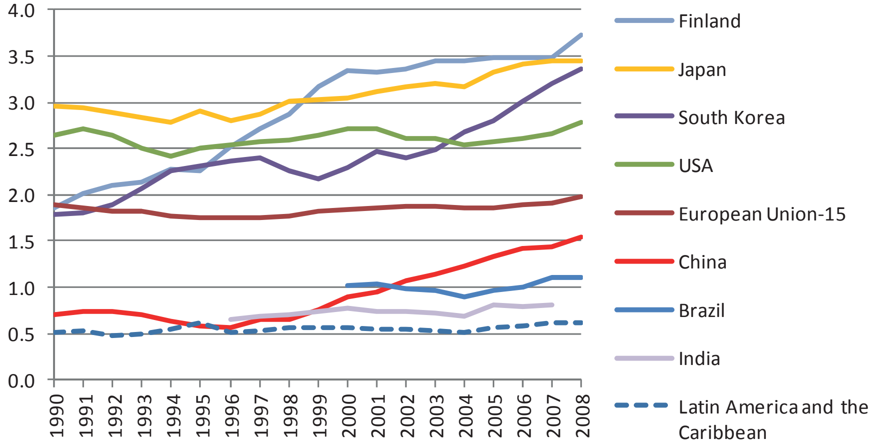


Source: author's elaboration based on data from CGEE (2010).

Latin America invests little in R&D and its gap with advanced and emerging countries is rising. While Latin America has been investing average 0.5% of its GDP in R&D over the last twenty years, China increased its R&D intensity from 0.7% in the 1990s to 1.54% in 2008 Figure A.2.3). In addition, in Latin America, the private sector commitment to innovation is very low. To increase in aggregate R&D expenditures and results more public investments as well as higher private sector investment are needed (Figure A.2.4)

Figure A.2.3 The global R&D gap, 1990-2008

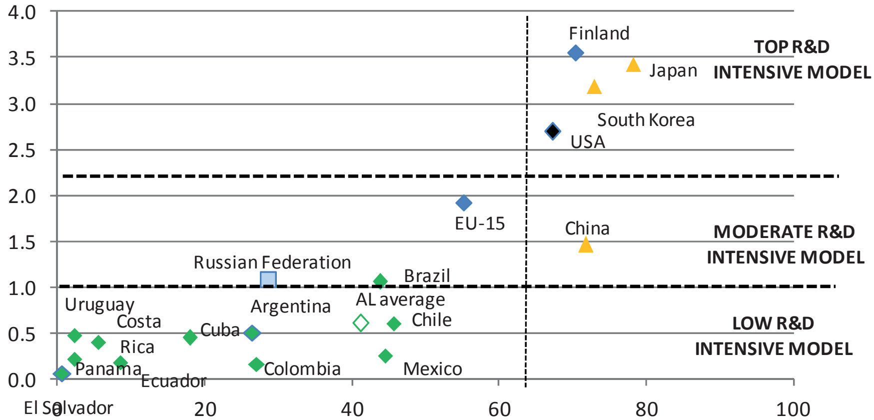
R&D expenditures as % of GDP, selected economies



Source: own elaboration on the basis of OECD MSTI (Main Science and Technology Indicators), RICYT, World Bank and Ministry for Science and Technology, Brazil.

Figure A.2.4 Variety of R&D models: R&D intensity and business sector participation

Latin America and selected world countries, R&D over GDP (vertical axis) and share of R&D financed by the business sector (horizontal axis) average 2006-2008



Note: dashed line between moderate and high is OECD average. Dashed line between moderate and low is the 1% threshold.
Source: author's elaboration based on OECD MSTI database, UNESCO and RICYT.

Innovation in Latin American is mostly adaptive in nature and rarely encompasses world break through innovations, in addition companies have only recently started to develop an innovation and intellectual property culture; therefore international protection of intellectual property rights is low. For example, Latin American countries in 2008 accounted for only 0.3% of total patents granted by the USPTO to foreign economies and for 5.22% of total foreign registered trademarks. Brazil is the top patenting country in the region, accounting for 41.29% of total USPTO patent grants to the countries of the region (Table A.2.2). Mexico is the leader for trademarks; it accounted for 45.81% of total trademarks registered by Latin American countries at the USPTO in 2007-08 (Table A.2.3).

Table A.2.2 Who patents in USPTO from Latin America and the Caribbean?

	Patent grants by USPTO to LAC countries					
	Share over LAC total			Number		
	1987-98	19997-99	2007-2009	1987-98	19997-99	2007-2009
Brazil	28.86	35.47	41.29	99	227	294
Mexico	38.48	27.81	23.88	132	178	170
Argentina	15.74	19.06	16.01	54	122	114
Chile	4.37	5.16	8.29	15	33	59
Colombia	3.21	3.13	3.09	11	20	22
Costa Rica	1.17	2.50	2.67	4	16	19
Uruguay	1.17	1.41	1.40	4	9	10
Ecuador	0.58	1.09	1.40	2	7	10
Panama	0.87	0.16	0.70	3	1	5
Peru	1.75	1.41	0.42	6	9	3
Guatemala	0.87	0.78	0.42	3	5	3
Bolivia	1.17	0.31	0.28	4	2	2
Honduras	0.58	0.94	0.14	2	6	1
El Salvador	0.58	0.31	0.00	2	2	0
Haiti	0.58	0.31	0.00	2	2	0
Nicaragua	0.00	0.16	0.00	0	1	0
LAC	100	100	100	343	640	712

Source: author's elaboration based on USPTO.

Table A.2.3 International trademarks registered at USPTO owned by LAC countries

	Trademarks registered in USPTO by LAC countries			
	Share over LAC total		Number	
	2004-2005	2007-2008	2004-2005	2007-2008
Mexico	39.36	45.81	829	1,541
Brazil	15.81	11.86	333	399
Argentina	11.11	9.27	234	312
Chile	8.64	6.87	182	231
Colombia	6.84	6.09	144	205
Panama	4.04	4.79	85	161
El Salvador	1.47	2.56	31	86
Venezuela	3.18	2.23	67	75
Peru	1.80	2.23	38	75
Dominican Republic	2.52	1.81	53	61
Guatemala	0.76	1.34	16	45
Costa Rica	1.14	1.19	24	40
Uruguay	1.66	1.13	35	38
Ecuador	0.85	1.01	18	34
Cuba	0.19	0.56	4	19
Honduras	0.14	0.42	3	14
Paraguay	0.14	0.33	3	11
Nicaragua	0.28	0.27	6	9
Bolivia	0.05	0.24	1	8
LAC	100	100	2,106	3,364

Source: author's elaboration based on USPTO.

Carrying out innovation surveys is a recent trend in Latin America[62]. Some countries have a longer tradition in firm-level data collection and analysis (Argentina, Brazil, Chile, for example), while in others it is a recent phenomenon (Costa Rica, Panama and Peru). The body of evidence from innovation surveys in Latin America confirms that few firms invest in innovation and that they face high obstacles to innovate, especially due to lack of finance and demand for innovation. Most innovations are new to the firm, or to the domestic market, but few are new to global mar-

[62] Available studies on innovation surveys tend to focus on performance, market structure and the role of multinationals (Crespi and Katz,1999; Quadros, et al., 2001; Arza, 2005; Benavente, 2006; Chudnovsky et al., 2006; Marin and Bell, 2006). Other studies focus on descriptive analysis of innovation patterns (De Negri et al., 2005; López and Orliki, 2005) and on exploring the determinants of innovative efforts and on the impact of innovation on productivity and export performance (Benavente, 2002; 2005; Chudnovsky et al., 2006; 2004; Arza, 2005).

kets. Firm-level data helps to analyze innovative behavior and could therefore contribute to better design innovation policies. For example, since the late 1990s and the 2000s, several innovation policies in Latin America have focused on strengthening collaboration for innovation. In one of the first comparative studies on innovation surveys in Latin America, Primi and Rovira (2011) show that the scale and quality of skills influences the willingness and capacity of firms to collaborate, and that the quality of the environment stimulates firms' openness; if fact firms are more willing to collaborate once they recognize that external agents and institutions are repositories of relevant knowledge. There are sectors in which firms require more interaction and linkages to innovate, than others. In Chile, Brazil and Mexico innovative firms tend to cooperate more with other firms (client and/or suppliers), while in Argentina and Uruguay the preferred partners are research centers and technological institutes. Foreign firms tend to cooperate more than domestic ones, and larger firms show a higher propensity to cooperation with respect to small ones.

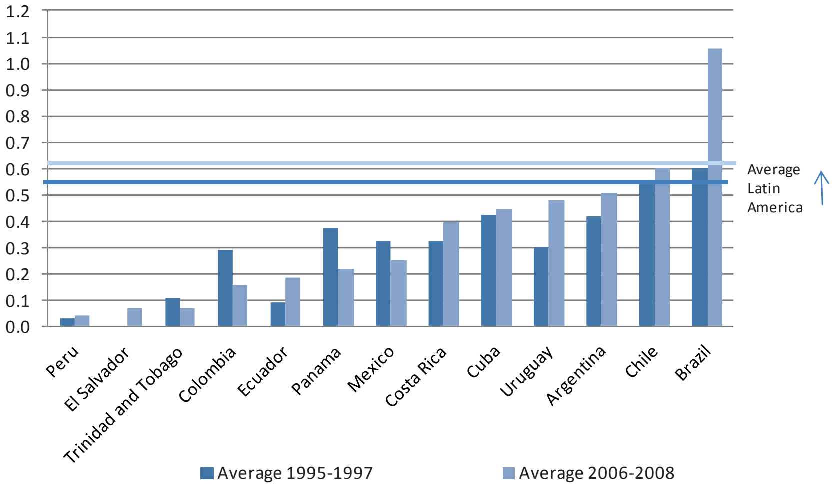
Table A.2.4 R&D intensity, selected LAC and world countries, 1990-2008

Countries	1990	1995	1998	2000	2002	2004	2006	2008
LAC	**0.49**	**0.58**	**0.45**	**0.56**	**0.64**	**0.53**	**0.63**	**0.62**
Argentina	0.36 [1]	0.42	0.41	0.44	0.39	0.44	0.49	0.52
Bolivia	..	0.36	0.29	0.28	0.26	..	..	..
Brazil	0.76	0.87	..	1.04	..	0.83	1.02	1.09
Chile	0.51	0.62	0.54	0.56	0.58	0.67	..	..
Colombia	..	0.29	0.21	0.18	0.1	0.18	0.18	0.15
Costa Rica	..	0.21	0.21	..	0.21	0.41	..	0.4
Cuba	0.7	0.47	0.54	0.52	0.62	0.56	0.41	0.49
Ecuador	..	0.08	0.09	..	0.1	..	0.15	0.25
El Salvador			0.09			..	..	0.11
Honduras	..	..	..	0.06	..	0.06	..	..
Jamaica	..	..	..	..	0.08	..	..	..
Mexico		0.31	0.38	0.37	0.34	0.36	0.36	0.38
Nicaragua	..	..	..	..	0.07	..	..	..
Panama	0.38	0.38	0.34	0.4		0.24	..	0.21
Paraguay	..	..	..	..	0.1	0.08	0.09	0.06
Peru	..	..	0.1	0.11	0.1	0.15	..	..
Trinidad and Tobago	..	..	0.13	0.11	0.14	0.15	0.22	0.04
Uruguay	0.25	0.28	0.23	0.24	0.22	..	0.36	0.64
Venezuela	..	..	0.35	0.34	0.29	..	..	..
OECD countries	2.25	2.06	2.13	2.21	2.22	2.19	2.26	
USA	2.65	2.50	2.60	2.71	2.62	2.54	2.61	2.79
European Union-15	1.89	1.76	1.77	1.84	1.88	1.85	1.89	1.98
Germany	2.61	2.19	2.27	2.45	2.49	2.49	2.53	2.68
Finland	1.85	2.26	2.88	3.35	3.37	3.45	3.48	3.72
Israel	..	2.96	3.42	4.88	..	4.41	4.74	
Japan	2.95	2.91	3.00	3.04	3.17	3.17	3.40	3.44
South Korea	1.79	2.30	2.26	2.30	2.40	2.68	3.01	3.36
China	0.71	0.57	0.65	0.90	1.07	1.23	1.42	1.54
Singapore	..	1.15	1.81	1.88	2.15	2.19	2.17	2.61
Russian Federation	2.03	0.85	0.95	1.05	1.25	1.15	1.07	1.03
South Africa	..	..	..	..	..	0.85	0.93	0.92
India	..	..	0.71	0.77	0.73	0.69	0.79	0.80

Source: updates Cimoli *et al.* (2009b). Data from RICYT (2008) and OECD MSTI (Main Science and Technology Indicators, 2008).

Figure A.2.5 R&D expenditures in Latin American countries 1995-97 and 2006-2008

R&D expenditures as % of GDP



Source: Author's calculations based on RICYT, UNESCO and national data sources.

Table A.2.5 Investments in R&D by financing sector, LAC and world selected countries, 2008

	Government	Enterprises	Higher Education	Non-profit organizations	Foreign
LAC	**54.18**	**41.18**	**3.18**	**0.23**	**1.23**
Argentina	67.6	26.5	4.4	0.9	0.6
Bolivia (2002)	20.0	16.0	31.0	19.0	14.0
Brazil	54.0	43.9	2.2	0.0	0.0
Chile (2004)	44.5	45.7	0.8	0.3	8.7
Colombia	39.3	27.1	26.5	2.8	4.4
Costa Rica	78.7	5.6	0.0	4.7	11.0
Cuba	69.0	18.0	0.0	13.0	0.0
Ecuador	89.6	8.5	1.4	0.0	0.5
Guatemala	22.7	0.0	28.9	0.0	48.4
El Salvador	50.0	0.7	44.7	0.1	4.5
Mexico	50.7	44.6	3.2	0.1	1.4
Panama	48.1	2.3	3.2	1.0	45.5
Paraguay	76.2	0.3	9.2	2.1	12.3
Uruguay	60.2	2.3	12.9	0.0	24.7
Trinidad and Tobago (2002)	48.2	34.5	17.3	0.0	0.0
Venezuela (2006)	62.3	14.3	23.4	0.0	0.0

	Government	Enterprises	Other sectors	Foreign
United States	27.1	67.3	5.7	0.0
Germany	28.4	67.3	0.3	4.0
EU-15	33.3	55.1	2.7	8.8
Finland	21.8	70.3	1.2	6.6
Japan	15.6	78.2	5.8	0.4
Korea	25.4	72.9	1.4	0.3
China	23.6	71.7	0.0	1.2
Singapore	19.9	63.5	1.3	5.3
Israel (2007)	14.3	79.5	2.8	0.0
Russian Federation	64.7	28.7	0.6	5.9

Source: updates Cimoli *et al.* (2009b). Data from RICYT (2008) and OECD MSTI (Main Science and Technology Indicators, 2008).

Table A.2.6 R&D investments by sector of performance, LAC and world selected countries, 2008

	Government	Enterprises	Higher Education	Private non-profit
LAC	**20.26**	**38.78**	**38.93**	**2.03**
Argentina	41.8	27.4	29.0	1.7
Bolivia (2002)	21.0	25.0	41.0	13.0
Brazil (2004)	21.3	40.2	38.4	0.1
Chile (2004)	23.0	26.6	41.8	8.6
Colombia	5.7	23.2	51.5	19.5
Costa Rica	16.8	30.2	47.9	5.1
Ecuador	90.0	8.6	1.4	0.0
Gutemala	13.4	0.0	80.9	5.6
Mexico) (2007)	25.1	47.5	26.0	1.4
Panama	47.1	0.2	8.7	43.9
Paraguay	28.3	0.0	59.9	11.8
Peru (2004)	25.6	29.2	38.1	7.1
Trinidad and Tobago	75.7	1.9	22.4	0.0
Uruguay	64.3	18.2	17.5	0.0
United States	10.6	71.6	12.9	3.9
EU-15	12.0	63.5	23.2	1.2
Germany	14.1	69.3	16.7	0.0
Finland	8.0	74.3	17.2	0.5
Japan	8.3	78.5	11.6	1.6
Korea	12.1	75.4	11.1	1.4
China	18.3	73.3	8.5	0.0
Singapore	7.6	71.8	20.5	0.0
Israel	4.5	80.5	12.1	2.8
Russian Federation	30.1	62.9	6.7	0.3
South Africa	21.7	57.7	19.5	1.2

Source: updates Cimoli *et al.* (2009b). Data from RICYT (2008) and OECD MSTI (Main Science and Technology Indicators, 2008).

ANNEX 2.2 COUNTRY BUDGETS FOR INNOVATION POLICY, SELECTED LATIN AMERICAN COUNTRIES

Table A.2.7 Chilean budget for innovation policy: 2005-2010

Areas of Investment	2005	2006	2007	2008	2009	2010
Advanced Human Capital	2.5	2.2	3.1	3.8	6.5	9.9
Basic Science	10.0	12.3	13.1	11.7	10.5	10.3
Precompetitive research	6.5	5.4	6.0	6.1	6.6	5.6
Public goods for innovation	9.3	8.0	8.0	7.2	8.2	7.5
FIC, regional assignment	--	--	--	3.2	3.4	3.3
Human Capital	22.2	25.6	26.1	27.4	28.9	29.3
Direct and Indirect Fiscal Contributions (AFD-AFI)	37.5	32.3	28.7	25.3	22.9	20.3
Business Innovation	8.4	8.8	8.5	8.6	7.5	8.6
Innovative Entrepreneurship	0.6	1.0	1.1	0.8	0.7	1.0
Other	0.3	0.4	0.8	0.4	0.3	0.3
Indirect Costs	2.8	3.9	4.5	5.5	4.5	3.9
Public Investment in science, technology and innovation + human capital	100	100	100	100	100	100
(millions of Chilean pesos, 2009)	458,517	538,657	608,983	677,677	755,573	863,454

Source: OECD (2010) on the basis of CNIC, 2010.

Table A.2.8 Brazil R&D expenditures by socio-economic objective 2000-2009

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total public expenditures in R&D (R$ million)	4,007.7	4,563.4	4,828.3	5,802.4	6,418.3	7,085.2	8,483.5	10,444.8	12,069.1	14,483.3
Share by socio-economic objective (% of total)										
Graduate and post-graduate institutions	59.4	54.9	58.1	54.5	55.4	54.1	55.2	55.7	55.0	55.8
Agriculture	14.4	13.9	13.2	12.6	13.0	13.2	12.3	11.5	11.8	13.0
Health	7.1	7.4	7.7	7.7	10.3	9.4	10.3	9.9	8.6	8.4
Industrial Technological Development	2.6	3.1	4.1	4.4	4.1	4.0	4.1	6.4	7.5	7.9
Non targeted research	3.6	4.6	3.6	4.7	3.5	3.9	4.2	3.3	4.8	4.5
Infrastructure	0.7	3.6	4.5	5.4	4.3	4.5	4.9	5.6	4.3	3.4
Civil aviation	3.7	3.0	2.3	2.1	2.4	2.3	1.9	1.6	1.2	1.3
Defense	2.6	2.6	1.8	1.6	1.7	1.8	0.9	0.8	0.9	1.2
Energy	3.5	3.6	2.2	2.6	2.3	2.3	2.5	2.0	1.7	1.2
Environmental protection	0.9	1.8	0.9	1.9	1.0	1.5	1.3	1.2	1.0	0.9
Exploration of Hearth and Atmospheres	1.5	1.4	1.5	1.4	0.9	0.6	0.6	0.5	0.5	0.6
Social development and services	0.1	0.2	0.1	0.5	0.2	1.5	0.7	0.5	1.6	0.4
Non specified	0.1	0.1	0.2	0.6	0.8	1.0	1.2	1.1	1.2	1.5

Source: author's elaboration on the basis of MCT data

Table A.2.9 Brazil: expenditures in S&T by Ministry 2000-2009

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total (million R$)	5,795.4	6,266.0	6,522.1	7,392.5	8,688.2	9,570.2	11,476.6	14,083.4	15,974.5	19,496.6
Min. of Education	36.01	36.23	40.07	39.25	38.52	37.95	38.35	40.06	41.17	41.12
Min. S&T	21.67	25.75	23.21	27.07	25.65	28.11	27.82	25.89	27.52	26.94
Min. Agriculture	12.08	11.99	10.79	10.24	9.99	10.02	9.26	8.69	9.03	9.97
Min. of Health	5.55	7.10	7.40	7.39	8.30	8.02	8.40	8.21	7.36	7.02
Min. of Planning and Budgeting	13.94	7.20	6.77	6.15	6.30	5.55	7.14	8.64	6.09	5.60
Min. of Inudstry	3.52	4.00	4.09	3.62	4.09	3.90	3.76	3.46	3.48	3.37
Min. of Defense	3.83	3.79	3.18	1.74	2.63	2.32	1.62	1.25	1.79	2.01
Min. of Mining and Energy	2.00	2.27	1.91	1.64	1.76	1.84	1.43	1.50	1.41	1.56
Presidência da República	0.03	0.03	0.17	0.21	0.17	0.20	0.13	0.11	0.29	0.96
Min. of National Integration	0.59	0.13	0.07	0.01	0.11	0.13	0.08	0.03	0.57	0.51
Min. of Environment	0.32	0.37	0.36	0.50	0.61	0.54	0.50	0.41	0.30	0.27
Min. for Agrarian Development		0.00			0.03	0.03	0.06	0.10	0.17	0.21
Min. o Communications		0.76	1.63	2.08	1.21	1.10	1.14	1.34	0.55	0.20
Other Ministries	0.45	0.39	0.36	0.11	0.62	0.29	0.30	0.31	0.27	0.26

Source: author's elaboration on the basis of MCT data

Table A.2.10 Mexico: Federal expenditures for S&T by national entity, 2002-2008

SECTOR	2002	2006	2007	2008
Education	30.9	36.2	30.9	30.1
CONACYT	31.5	31.4	34.1	34.6
Energy	19.4	15.0	16.8	16.6
Agriculture	7.6	6.4	6.8	8.7
Health	4.2	6.2	6.3	5.7
Economy	2.3	2.0	2.8	1.7
Environment	1.7	1.7	1.7	2.2
Others	2.4	1.1	0.5	0.4
Total (%)	100	100	100	100
Total (Million 2006 MXN)	31,335	32,792	33,624	38,083

Source: OECD (2009), Innovation Policy Review, Mexico, on the basis of CONACYT Data.

ANNEX 2.3 THE SYSTEM OF SECTORAL TECHNOLOGY FUNDS IN BRAZIL

Table A.2.11 The system of the sectoral technology funds in Brazil

Funds	Objectives	Origin of financial resources	Beneficiaries	Activities
CT-PETRO (1999) Sectoral fund for the oil and natural gas sector. Law No. 9487 of 1997	Sectoral development through promotion of research and development and human resources training	25% of value of royalties exceeding 5% of production of oil and natural gas	Public research institutions. Public and private firms are called to contribute technically and financially to project executions. Projects presented in partnership with firms or groups of firms will receive preferential treatment.	Collaboration in the definition of policies and the implementation of specific programmes. In 2001, the CNPq approved 144 projects worth 7 million reales. Expenditure between January and November 2003: 16,431,002.70 reales Budget in 2010: 122 million (execution 119,2 million).
CT-ENERGIA Sectoral fund for the energy sector. Law No. 9991 of 2000	Sectoral development through promotion of research and development. Focus on energy efficiency in final use.	Between 0.75% and 1% of the net income of enterprises with concessions for the generation, transmission and distribution of electricity	Public research institutions certified by MCT and Education institutes certified by MEC. Public and private firms are called to contribute technically and financially to project execution.	In 2001 the CNPq approved 132 research and development projects involving the investment of 8 million reales by the fund. In 2001 an association agreement was signed between the National Electric Power Agency and the CNPq to promote cooperation between research centres and enterprises. Total expenditure between January and November 2003: 8,397,738 In 2010, R$ 32.4 million through FINEP for 53 actions and 33.6 million to CNPq.
CT-HYDRO Sectoral fund for water resources. Law No. 9993 of 2000	Reduction of disparities between regions through investments in science and technology activities of importance for the sector. Strengthening of water resource sustainability	Made up of 4% of the financial compensation of electricity generation enterprises		Financing of scientific and technological development projects and programmes designed to improve water quality and use. In 2002, 28.6 million reales were invested, of which at least 4 million were for the training of specialized personnel. Expenditure between January and November 2003: 3,735,635.85 reales Reduced availability of resources for new actions. R$ 14 million for Water management through FINEP. (proposal of 24 million for research networks).
CT-MINERAL Sectoral fund for mining. Law No. 9993 of 2000	Promotion of sectoral technological development through support of science and technology activities	Made up of 2% of the financial compensation of mining sector		Financing human capital formation, maintenance of science and technology infrastructure and support installation of high tech research and development laboratories
CT-TRANSPORTE Sectoral fund for land transport Law No. 9992 of 2000	Strengthening of competitiveness of the sector through research and development programmes and	Made up of 10% of the National Roads Department (DNER) income coming from contracts with telephone or communication companies which use transport infrastructure		Financing incorporation of new technologies in the sector. A minimum of 30% of the resources is devoted to support projects in the Northern, North-western and Centre-West regions In 2010, R$ 481'000, of which only 3% has been executed. Evaluations singles that the reduced

Funds	Objectives	Origin of financial resources	Beneficiaries	Activities
	projects			amount of resources limits the capacity of proposing relevant projects.
CT-ESPACIAL Sectoral fund for aerospace industry Law No. 9994 of 2000	Sectoral development through promotion of research and development	Total income coming from licensing and authorizations of the Brazilian Aerospace Agency and 25% of income derived by the commercialization of orbit positions, 25% from income derived from launchings, and 25% of income derived from commercialization of space data and images.		Subsidizing research and development to create new products and services
FUNTTEL Sectoral fund for telecommunications Law 10052/ 2000	Promotion of sectoral technological development through innovation and human capital support	0.5% of gross income of firms providing telecom services; 1% contribution from gross income of events organized though phone-calls and an initial budget of R$ 100 million from the Telecommunication Fiscalization Fund (FISTEL). The fund is administered by the Ministry of Communications.	Research and teaching institution S Brazilian firms specialized in the offer of telecom services Brazilian firms offering goods and services for the telecom sector when engaged in supporting the development of the sector in the country.	Financing of sectoral innovation. SMEs benefit from privileged access to financial support
CT-INFO Sectoral fund for information technology. Law 10176/2001	Promotion of the competitiveness of the sector through research and development programmes	At least 0.5% of gross income of firms which benefit from fiscal incentive under the law to promote the IP industry		It is estimated that over 50 million reales are spent each year on the promotion of research and development activities in this sector. Expenditure between January and November 2003 was 9,971,983.70 reales 35 million committed in 2010 (25 million to CNPq for training which have not been assigned yet).
CT- SAUDE Sectoral fund for health Law 10332/2001	To increment the performance of the sector by supporting capacity building in priority areas for SUS (public health, biotech, drugs, etc), support private investment in R&D in basic industrial technology for medical equipments and diffusion of technologies for increasing access to health care	17.5% of the Contribution of the Intervention in the Economic Domain (CIDE) which derives from the 10% over payments to foreign countries for technical assistance, royalties and specialized technical services as established by the Law No. 10168 of the year 2000.		Financing of research and development activities to promote technical characteristics of equipment and to increase technical expertise of professionals. In 2010, R$ 87.1 million for 64 projects (99% of execution rate). Three transversal actions: Machinery acquisition for anti-yellow fever 1) million (50% National health Fund and 50% Transversal Actions) Machinery acquisition for vaccine production 12 million (50% National health Fund and 50% Transversal Actions) Pre-clinical trials network of research 5.2 million transversal actions

Funds	Objectives	Origin of financial resources	Beneficiaries	Activities
	system.			
CT-AGRO Sectoral fund for agribusiness. Law 10332/2001	To consolidate international competitiveness of the sector. Priority in diffusion of new technologies and biotech development for tropical agriculture.	17.5% of the Contribution of the Intervention in the Economic Domain (CIDE) which derives from the 10% over payments to foreign countries for technical assistance, royalties and specialized technical services as established by the Law No. 10168 of the year 2000.		Financing of research and development and science and technology activities. Expenditure between January and November 2003: 2,140,277.92 reales
CT-BIO Sectoral fund for biotechnology Law 10332/2001	To strengthen the technological and scientific capabilities in the sector by promoting human capital development, expansion of technology based firms and infrastructure upgrading.	7.5% of the Contribution of the Intervention in the Economic Domain (CIDE) which derives from the 10% over payments to foreign countries for technical assistance, royalties and specialized technical services as established by the Law No. 10168 of the year 2000.		It promotes ongoing cooperation and networking among research institutes like EMBRAPA, Sao Paulo Biology Institute and Osvaldo Cruz Foundation R$ 68.1 million for 2010-2012. R$ 35.8 million executed in 2010 (99% of execution rate on total budget).
CT-AERO Sectoral fund for aeronautics Law 10332/ 2001	Increasing R&D to strengthen international sectoral competitiveness	7.5% of the Contribution of the Intervention in the Economic Domain (CIDE) which derives from the 10% over payments to foreign countries for technical assistance, royalties and specialized technical services as established by the Law No. 10168 of the year 2000.		Promotion of production of scientific and technological innovations In 2010, 34 million budget (which is 94% of execution rate).
CT-Acquaviario Funds for Water Transport and Shipbuilding industry Law 10893/2004	Technological innovation and human capital development for Water Transport and Ship building industry	3% of the share of the tax on Renovation of merchant navy from the Fund for Merchant navy (FMM)		31.8 million in 2010 budget (applied 31.4 million 99% of execution rate).
CT-AMAZONIA Law 10176/2001	Promotion of research and development in the Amazonian region	At least of 0,5% of income of enterprises specialized in the production of informatics goods and services localized in the free trade area of Manaus		The sectoral fund is part of the project for supporting research and development of the Brazilian informatics enterprises localized in the free trade zone of Manaus. 5 million for new actions in 2010 in total 8 million (which is 58% of assigned budget).
CT-AUDIOVISUAL Law 11437/2006 The Fund is a specific line of the national Cultural Fund (FNC)	Promotion Support to increase the value added and international competitiveness of the audio-	Contributions for firms operating in the sector, mainly from the CONDECINE and the FISTEL (Fund for the Fiscalization of Telecom).		FINEP was selected in 2008 as the financial agent for managing the sectoral fund. The budget for 2008 has been R$ 54.5 million

Funds	Objectives	Origin of financial resources	Beneficiaries	Activities
	visual industry. The fund is managed by the ANCINE- National Agency for Cinema			
FVA- Fundo Verde Amarelo "Green and Yellow fund". Law 10168 /2000 and 10332/2001	Promotion of technological cooperation between universities, research centres and enterprises. Beneficiaries: public research institutions	50% of CIDE (Contribuiçào de Intervenção no Dominio Econômico) which derives from the 10% tax on payments to foreign countries on royalties for user licenses and/or acquisition of foreign know how; 43% of the fiscal contribution of the IPI over goods benefiting from fiscal incentives as indicated by the informatics law.		Expenditure between January and November 2003: 58,071,768.19 reales. In 2010, 38 projects though FINEP for 119.7 million. i.e. 32% of physical objective and 99.7% of planned budget. This is due to the increase in the amount of resources for projects.
CT-INFRA (2002) Infrastructure fund. Law No. 10197 of 2001	Maintenance and modernization of the technological infrastructure of public universities and research centres, in order to improve the competitiveness of the production sectors Beneficiaries: public research institutions	20% of the resources of all funds for financing science and technology activities.		In 2002, 100 million reales were provided to create suitable conditions for the execution of science and technology activities in science and technology bodies. Expenditure between January and November 2003: 70,284,331.74 reales In 2010, 309 contracts for R$ 344.9 million though FINEP, 31.4 million for CNPq and R$ 2.6 million to MCT. Execution rate 99%.
Transversal Actions	Support transversal actions in line with priorities of the production development policy	50% of the resources of all sectoral funds.		740 million in 2010

Source: draws and updtates Cimoli *et al.* 2005.

Table 2.A.12 Brazil: Evolution of Sectoral Technology Funds, 2006-2010

Sectoral distribution (%) and resources (R$ million)

	2006	2007	2008	2009	2010
CT-PETRO	41.17	37.35	42.41	30.47	35.72
CT-ENERG	8.91	9.94	7.15	15.62	7.69
CT-AGRO	4.01	4.47	4.10	4.87	4.85
CT-SAUDE	4.01	4.47	4.10	4.87	4.85
CT-AERO	1.72	1.91	1.75	2.09	2.08
CT-BIOTEC	1.72	1.91	1.75	2.09	2.08
CT-HIDRO	2.43	2.39	1.93	2.00	1.97
CT-INFO	1.73	1.83	1.72	1.59	1.82
CT-AQUA	0.95	1.32	1.76	1.10	1.62
CT-MINERAL	0.41	0.44	0.55	0.45	0.62
CT-AMAZONIA	0.90	0.89	0.86	0.56	0.58
CT-ESPACIAL	0.77	0.48	0.40	0.49	0.53
CT-TRANSPORTE	0.01	0.00	0.00	0.00	0.01
FVA	11.46	12.78	11.70	13.91	13.86
CT-INFRA	19.82	19.82	19.83	19.89	21.74
TOTAL	1850.5	2016.1	2510	2639.4	2798.2

Source: own elaboration on the basis of data from MCT (2010), Relatório de Gestão 2010- FNDCT, Rio de Janeiro 2011.

CHAPTER 3

WHAT DOES INNOVATION THEORY SAY ABOUT KNOWLEDGE APPROPIABILITY AND DIFFUSION?

And How Can It Help In Defining Better Policies?[63]

This chapter discusses how the transferability and appropriability functions of the patent system can be re-examined taking into account the properties of knowledge, technology and learning as defined by the literature on innovation. Knowledge appropriability and diffusion go well beyond legal mechanisms. The capabilities of innovative agents and the strategic use of legal frameworks shape the impact of patent policy on innovation trajectories. The patent system should balance the conditions for knowledge appropriability, diffusion and access to preserve the capacity of our societies to foster the generation and diffusion of knowledge. Intellectual property policies need to be included within the broader industrial transformation and innovation strategies. Often, developed countries manage this aspect quite strategically, while developing countries often lack a pragmatic approach to this issue and are trapped in dogmatic discussions on intellectual property as "good" or "bad" for development.

[63] This chapter draws from Cimoli and Primi (2008), "Technology and Intellectual Property: a Taxonomy of Contemporary Markets for Knowledge and their Implications for Development," *LEM Papers Series* 2008/06, Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy. A modified version of this chapter has been published in Primi, A. "From Intellectual Peroperty to Knowledge Goverance: a Micro-founded Evolutionary Explaination", in Burlamaqui, L., A. C. Castro and R. Kattel (*Eds.*) (2012), *Knowledge Governance: Resurrecting the Public Interest*, pp. 27-48, Anthem Press.

INTRODUCTION

Intellectual property has been, for a long time, out of the radar of development policy analyses. It was mainly a domain of lawyers and legal specialists that little had to do with "economics". And when it did, it was mostly a framework condition which needed to be "in place" and "right" in order not to hamper innovative entrepreneurial activities.

Patents have been seen as mechanisms to guarantee excludability in the use of knowledge, and the appropriability of intangibles. In theory, patents confer a temporary monopoly on the exploitation of the patented technology, in exchange of the disclosure of the relevant information necessary to replicate the technology. The information protected by the patent is supposed to be available for use in production by others than the patent owner, immediately upon patent expiration. In practice, things work quite differently.

The rationale for intellectual property protection roots in the recognition of the difference between knowledge, information and standard tangible commodities. Due to the specificities of knowledge, its appropriability needs to be guaranteed to support investments in its generation. Some discretional excludability is needed to incentivize economic agents to engage in efforts that would lead to the generation of new concepts and "intangibles" that otherwise would easily be appropriated by others.

In parallel, access to information and knowledge is essential to create new knowledge and to innovate. Intellectual property systems have been introduced to balance the interests of innovators and of users (see among others, Machlup, 1958; Kitch, 1977; Besen and Raskind, 1991; Besen, 1998). Intellectual property systems need to create the conditions both to reward innovators, by guaranteeing rights on intangibles, and to favour the diffusion of knowledge and innovation by facilitating the disclosure of technical knowledge and know-how embodied in technological discoveries with industrial applicability.

The seminal contributions of Arrow (1962) and Nelson (1959a, b) reflect the double need to address appropriability and diffusion conditions to promote innovation. Both authors were concerned about identifying the conditions to allocate scarce resources to the generation of new knowledge and invention in market economies under the framework of the welfare economic approach. The non rivalry and partial excludability in consumption of knowledge would lead to an under investment in its generation. Therefore, mechanisms to guarantee the appropriability of the returns deriving from innovative efforts were needed. In fact, in the absence of targeted legal appropriability mechanisms the incentive to invest in innovation would be inadequate form a social welfare point of view, and the amount of innovation introduced would be inferior to the optimal level, due to the eventuality of free-riding and to the potential erosion of the advantages of innovation induced by imitation.

State intervention, regulations (Arrow) and financing and direct participation to basic research (Nelson) was justified by the high risks and uncertainties associated with the process of invention. The market (i.e. private profit motivated agents) would spend less than what would be socially desirable on the generation of new knowledge, given the risk and uncertainty associated with its creation. Therefore, the state should financially support the generation of knew knowledge to correct the imbalance between private and social marginal benefit (Nelson, 1959a). At the same time, the state should also intervene to guarantee the appropriability of knowledge rents, because in absence of adequate mechanisms for protection, the economy would face an underinvestment in invention, due to the fears of undesired spillovers and free-riding (Arrow, 1962).

Since the 1950s and 1960s, the challenges that our societies face, as well as our understanding on the variety of innovative behaviors, have changed. In particular, since the end of the 90s several changes have contributed to make intellectual property an issue of rising concern for a growing number of stakeholders, including economists, policy makers and civil society, in developed and in developing countries.

Globalization and trade openness, matched with the diffusion of information and communication technologies (ICT) have shown that their impact on learning and innovation trajectories differ from what was predicted by the standard economic approach that prevailed in the 1990s (i.e. free trade is "good" -or "bad"- for developing countries). The rise of China and the emerging new geography of production and innovation, where markets, research and production are growing in multiple locations, have contributed to increase the complexity of the landscape where countries and firms compete and innovate. Despite the accumulation of production and innovation capabilities in developing economies, at the aggregate level the asymmetry with advanced economies in terms of specialization and knowledge capacities persists. The centrality of knowledge capabilities in the development process increases the importance of setting appropriate conditions to define knowledge generation, access and transfer in the new global economic landscape.

Globalization, matched with the diffusion of ICT, has opened new frontiers and forms of knowledge circulation. On the one hand, science is becoming more global and it is defining new forms of knowledge sharing and open access. On the other hand, businesses are developing new forms of knowledge appropriation and trading (see Chapter 5 of this dissertation). Multiple international and national reforms of intellectual property (IP) regimes have modified the incentives to protect or disclose new ideas creating a system where open and proprietary approaches coexist.

Regardless the stance that each has regarding open versus proprietary knowledge models, it is undeniable that the rules that define the conditions for excludability and diffusion of knowledge are increasingly important for our societies. However, the "popularization" of the intellectual property issue (which is evident not only in the rising number of academic articles and official reports about it, but especially in the rising attention given to the IP issue by the media and the press) went hand in hand with "polarization" of the points of view: stronger protection, is "good" or "bad" for innovation and industrial development. This polarized controversy is not helping much in advancing towards better IP regimes. The complexity and the multidimensionality of the contemporary challenges require more sophisticated approaches (Basheer and Primi, 2009).

The creation of institutions and mechanisms that take into account, at the same time, the need to support investment in the generation of knew knowledge, to guarantee appropriability of "intangibles" and to secure access and diffusion of knowledge and technologies in the new global economic landscape is a pending challenge. Given the rising relevance of knowledge and technology for inclusive and sustainable growth this is not only a major challenge, it is a pressing need. However, there are not blue prints or easy answers in this field. The existence of lobbies, power groups and diverging interests, between countries, and especially within countries themselves, contributes to make this field a particularly challenging one from the point of view of public regulation and policies.

This chapter contributes to the ongoing debate on improving intellectual property systems for development by advocating for pragmatism in policy approaches. Innovation theory can help in highlighting the variety of innovative behaviors and therefore helps in better understanding the functioning of patent system in practice. Clarifying how innovation happens and how technical knowledge is transferred can help in envisaging more effective patent policies. The first section summarizes the properties of technology and learning and clarifies why knowledge can be defined as a "club" good. The second specifies why the appropriability issue goes beyond legal mechanisms. The third discusses why the patent systems works in practice quite differently from what the theory prescribes; the fourth focuses on the variety of functions that patent-holders assign to patents. Recently patents are in fact increasingly considered as strategic assets and not as innovation incentives or rewards. The last section concludes drawing some policy recommendations.

3.1 THE PROPERTIES OF TECHNOLOGY AND LEARNING (AND WHY KNOWLEDGE IS A "CLUB" GOOD)

Evolutionary theory explains how novelty is generated, produced and diffused by clarifying the main properties of knowledge, technology and learning (see Chapter 1 of this dissertation, as well as Pavitt, 1987; Dosi *et al*. 1988; Cimoli and Dosi, 1995; Metcalfe, 1995, among others).

As noted in Cimoli and Primi (2008), technology, as defined in standard economics textbooks, is identified with a set of blueprints –i.e. techniques- required or used to produce artifacts. The choice of production techniques rests mainly on relative prices, given that information regarding the existence of such alternative blueprints is assumed to be available -and equally decodifiable- by all agents. However, this is hardly the case in practice. In fact, technology cannot be reduced to a set of pre-defined blueprints (Dosi, 1982; Pavitt, 1987). Rather, "it can be defined as the means, the methods, and the know-how through which agents 'do things'. It concerns problem-solving activities involving -to varying degrees- also tacit forms of knowledge embodied in individuals and organizational procedures, the means and the interfaces through which knowledge is produced, codified or transformed in 'transferable' artifacts ", Cimoli and Primi (2008, pg. 3). See also, Rosenberg (1976; 1982); Dosi (1988); Freeman (1982; 1994); and Freeman and Soete (1997).

"At the micro level, technologies are incorporated in particular institutions, the firms, whose capabilities are fundamental in shaping the rates and direction of technological progress. But firms are not the sole repositories of technologies. More ample socio-economic and institutional settings shape the availability of existing technologies, such as universities and institutions devoted to support technological development and innovation (Nelson, 1993). Learning is local, cumulative and embedded in organizations and their routines. Local means that the exploration and development of new techniques is likely to occur in the "neighborhood" of the techniques already in use (Atkinson and Stiglitz, 1969; Antonelli, 1995). Cumulative means that current technological development- at least at the level of individual business units- often builds upon past experiences of production and innovation, and it proceeds via sequences of specific problem-solving activities (Arthur, 1989; David, 1985). Learning can be enhanced by collective experiences and it is fostered -or jeopardized- by the density and quality of the environment. But, at the same time, requires non-substitutable individual efforts and processes", Cimoli and Primi (2008, pg. 3).

These characteristics of knowledge, technology and learning contribute to define the "transferability" and "appropriability" of innovation. As stated in Cimoli and Primi (2008) we can affirm that:

i. The transferability of knowledge results segmented, limited by its tacit and non-codifyable nature and enhanced by the proximity of capabilities between firms, systems and countries. The appropriability of knowledge overcomes the set of legal and strategic appropriability measures available to firms. Likewise, the tacit, non-codifyable and non-transferable component of knowledge embedded in procedures, routines and organizations guarantees its appropriability beyond any direct legal effort to protect it.

ii. Transferability of technologies is constrained (or enhanced) by "technological proximity" of producers and users, by their absorptive capacity, and by quality and density of networks, partnerships and routines. There is no guarantee of automatic substituibility between obsolete, less efficient technologies and improved ones. The impact of technology transfer and licensing depend on the specific characteristics and capabilities of agents (firms, universities, etc.).

iii. The transferability of learning is limited; however certain practices can help transferring expertise, for example through reverse engineering and interchange of personnel.

Knowledge encompasses tacit components and it is both codifiable and non-codifiable (Arrow, 1962; Polany, 1967). It is non-rival, but it is excludable. Its excludability can derive from regulations (for example patent law) and/or from the lack of capacities of agents to access, decodify and use knowledge. Assimilating knowledge to a public good stresses its non rivalry and non excludability. Once it is available in the system –for example after patent expiration- it can be freely "used" -or referred to- by different agents at the same time. However, in many cases, knowledge can be assimilated to a "club" good; i.e. non-rival but excludable. Defining knowledge as a "club" good helps to stress that regardless the legal conditions that define its appropriability and access, only those who have certain capabilities (positioning in network hierarchies, scientific base, specific know-how, production capacities, etc.) will be able to decode it and use it productively (Cimoli and Primi, 2008). This is a key preliminary issue to keep in mind when discussing intellectual property regimes and their impact on innovative conducts.

3.2 APPROPRIABILITY GOES BEYOND LEGAL ISSUES (I.E. WHY IT IS NOT ALWAYS TRUE THAT HIGHER APPROPRIABILITY GENERATES HIGHER INNOVATION)

"Firms do not always adopt frontier technologies and asymmetries in technological capabilities (between firms and countries) are likely to persist over time" (Cimoli and Primi, 2007, pg. 1 and Atkinson and Stiglitz, 1969; Freeman, 1982, 1994; Dosi, 1982; 1988; Nelson and Winter, 1982; Dosi *et al.*, 1990; Cimoli *et al.*, 2006).

"Appropriability" refers to the capacity of innovating agents (individuals, firms, institutions) to capture the value generated by innovations. "Firms use a set of complex (and sometimes complementary) mechanisms to appropriate the rents deriving from innovations. Industrial secrets, lead-time advantages, complementary manufacturing or technological capacities, branding and costumer fidelization are different means, among others, that firms might use to appropriate rents deriving from innovations"(Cimoli and Primi, 2007, pg. 13; see Nelson, 1959; Arrow, 1962; Teece, 1986; Dosi *et al.* 2006a; Winter, 2006; among others).

The generation of new (valuable) knowledge suffers from indivisibilities in production and uncertainty regarding outcomes. The time lag between the innovative effort and the generation of rents through the commercialization of innovation increases the costs of innovating and pushes firms to develop and use mechanisms to protect the result of the innovative effort. The uncertainty regarding the outcome of the innovative effort and the fact that the costs for innovation are sustained in a given moment in time, while the benefits could accrue in the form of a flow of resources for an undetermined period of time, transform the "prize" for innovation into an issue which suffers from multiple uncertainties. There is no clarity about the potential success of the innovation, nor on when it will be successful and for how long.

Firms rely on a combination of mechanisms to protect their innovative efforts. Each appropriability mechanism addresses different aspects of the intangibles and respond to different strategic functions. Patents, for example, are legal mechanisms that grant the inventor a temporary monopoly use of the patented innovation in exchange of the disclosure of the procedure to obtain or realize the innovation. National laws define the patentable subject matter, which include a non obvious inventive step with industrial applicability. Trademarks, on their turn, are meant to protect names and signs indicating a product, a process or a service.

"The choice between using one -or a combination- of those appropriability mechanisms rests upon different structural factors including the kind of innovation the firm is willing to protect, the capabilities of the innovative firm in terms of legal, financial and human resources dedicated to the enforcement of the entitled property rights" (Cimoli and Primi, 2007, pg. 13). See also Levin *et al*. (1987); Cockburn and Grilliches (1988); Coehn *et al.* (2000); Dosi *et al.* (2006a); and Winter (2006).

While firms deploy various strategies to secure their innovative efforts, the analyses of appropriability have been biased towards patenting. This is due to several factors. On the one hand, there has been a tendency to focus on R&D efforts and technological innovations which are the forms of innovation most subject to patenting. On the other hand, the deep institutional changes in global patent regimes have also contributed to shift the attention towards patenting, forgetting, too often, the relevance of other appropriability mechanisms.

Two major works have contributed to shift the focus from patent to the broader appropriability approach: the one by Levin *et al*. (1987), which analyzes the results of the Yale Survey, and the one by Cohen *et al.* (2000) based on the results of the "Carnegie Mellon Survey". The "Yale survey" (Levin *et al*. 1987) "describes the results of an inquiry into appropriability conditions in more than one hundred manufacturing industries", (ibdm. p. 785). The premise of that study was the recognition that "because technological advance is often an interactive, cumulative process, strong protection of individual achievements may slow the general advance" (ibdm p. 788). The document advocated that "it should not be taken for granted that more appropriability is better [and that] better protection necessarily leads to more innovation" (ibdm p. 787). The Yale survey gathered empirical evidence on the basis of interviews to high level R&D managers of firms in the US manufacturing industry. The study collected information on the effectiveness of alternative methods to protect the introduction of new products and processes. The results confirmed the hypothesis of limited effectiveness of patents with respect to other appropriability mechanisms. The only exception was the drug industry in which the majority of respondents considered patents as the most effective mechanism.

In 1994, the Carnegie Mellon Survey collected information regarding the use of different appropriability mechanisms on a sample of 1 478 R&D labs in the US manufacturing industry (Cohen *et al.* 2000). Starting from the recognition that, in practice, patents were not considered an effective protection mechanism for innovation, the survey aimed at gathering information regarding why firms patent or not patent their innovations, considering the sustained increase in patent applications and grants. Even though the results of the Carnegie Mellon Survey are not strictly comparable to those of the Yale Survey, the study confirms that patents are not the primary source of appropriability for US manufacturing firms, and that there are strong sectoral differences in preferences and effectiveness of different appropriability mechanisms[64].

Empirical evidence on patenting behavior of firms shows that:

i. Patents are not the preferred mechanism to protect product and process innovation; the preference for patents varies substantially across sector and by firm size.

ii. Some innovations are technically easier to protect by patents, while others are better securable through secret or other mechanisms. This depends both on the type of innovation, its codificability, and by the innovative strategy of the firm.

iii. Firms use a combination of appropriability mechanisms. For example, trade secrets can be complementary to patents, rather than substitutes (See Chapter 4 of this dissertation).

The heterogeneity between agents in terms of capabilities and preferences shapes the impact of intellectual property systems on innovation trajectories. As discussed in Cimoli and Primi (2007 and 2008), the assumption that changes in relative prices and the availability of information primary affect the innovative behavior is, in fact, not entirely consistent with reality. The rate and direction of research and imitation are shaped by a set of factors that go beyond legal frameworks, and that include:

- Technological capabilities of agents (including, absorptive capacities, resources and management capabilities);
- Production capacities (i.e. the stocks of resources, the nature of capital-embodied technologies, labor skills, product and input specification and organizational routines);
- Sectoral specificities of the technology in question (e.g. phase of development, level of diffusion in the markets, etc);
- Path-depended trajectories of firms -or countries (which shape the collective knowledge shared by agents in each socio-economic system and that define the *entourage* where firms and innovators operate);

[64] Recently, the literature on appropriability and patenting has been enriched by firm level analyses based on national innovation surveys. See Chapter 4 of this dissertation and Arundel (2001); Cincera (2003); Laursen and Salter (2005) and López and Orliki (2006).

- Non-rational perceptions of innovative opportunities, irrespectively of whether relative prices change or not, which might lead to the discovery of intended and unintended new techniques.

In fact, "even if all patent information would be freely available and disclosed, the direction of innovative search and the resulting firms' and countries' innovative and imitative trajectories would remain bounded within some relatively narrow paths determined by the nature of the underlying knowledge base, the structural characteristics of systems in which every particular activity is embodied" (Cimoli and Primi, 2007, pg. 12)[65]. There is no linear or deterministic relationship between the intensity of patent protection and the rate of innovation (David, 1993; Heller and Eisenberg, 1998; Mazzoleni and Nelson, 1998; Dosi *et al.* 2006b; Eisenberg, 2006; Gosh and Soete. 2006).

Firms can appropriate innovation rents beyond legal attempts. They can do it through the complexity and the embeddedness of technology and knowledge in their organizational procedures and technical know-how, or through lead-time advantages. "The availability of a set of diverse appropriability conditions and of a given knowledge base is not irrelevant in shaping the search for novelty and entrepreneurial endeavors in innovation. However, explanations about the willingness of firms (and to a broader extent of countries) to explore new paradigms, to carry out experimental research or to engage in reverse-engineering or imitative efforts, and about differences in the rate of introduction of new products, processes or creation of new firms, require a comprehensive understanding of specific social, institutional and corporate characteristics, which go beyond the prevailing legal framework governing access and transferability of knowledge" (Cimoli and Priim, 2007, pg. 22).

3.3 THE APPROPRIABILITY AND DISCLOSURE FUNCTION OF THE PATENT SYSTEM WORK DIFFERENTLY IN PRACTICE THAN IN THEORY[66]

Taking into account that technology is highly specific, that it is embedded in routines and procedures, that knowledge has a strong tacit component and that learning is a trial and error process which entail non-substitutable experiences, leads to shift the question from whether patents are "good" or "bad" for innovation, towards a more pragmatic approach that aims at identifying under which different appropriability mechanisms interact and shape innovation influencing development tra-

[65] See also Kitch (1977), Machlup and Penrose (1950); Arrow (1962); Scherer (1977), and Dosi *et al.*, (2006a).

[66] This section drwans on Cimoli and Primi (2007; 2008).

jectories. In fact, the appropriability and the disclosure function of the patent system work differently in practice than in theory.

The appropriability function. "The capacity of agents to appropriate the advantages and the rents deriving from innovation goes beyond the regulatory framework and the set of established (intellectual) property rights. Firms, and in wider perspective countries, use a set of complex (sometimes complementary) appropriability mechanisms in order to capture the rents stemming from innovation"(Levin *et al*., 1987; Cockburn and Grilliches, 1988; Coehn *et al*., 2000; and Dosi *et al*., 2006a). The choice between using one -or a combination- of these mechanisms rests upon different structural factors which include the kind of innovation or technology the firm is willing to protect, the size of the firm which influences the legal, financial and human resources the firm can dedicate to the enforcement of the entitled rights and the strategic management of the firm's technological and intangible assets" (Cimoli and Primi, 2007, pg 12).

At the same time, patents play different roles according to structural characteristics of firms and their appropriability strategies, which, in general, have a strong sector specific component (Scherer, 1965, 1983; Mansfield, 1986; Levin *et al.*, 1987; Cockburn and Griliches, 1988). As stated in Cimoli and Primi (2007), "Patent propensity is affected by the size of firms and the differences in the value assigned to the disclosure of information to users or consumers, features which, again, have a strong sectoral component related to the replicabilty and usability of disclosed information for agents others than the "inventor" (Scherer, 1965, 1983; Mansfield, 1986; Horstman *et al*. 1985; Levin *et al*. 1987; Harter, 1993; Harabi, 1995; Arundel and Kabla, 1998; Cohen *et al*. 2000). Patents are, therefore, one but not "the unique" appropriability mechanism".[67]

In addition, the legal recognition of the intellectual property right conferred by the patent is not automatically translated into effective capacity to guarantee the control. Patents confer the right to defend a temporary and exclusive right through legal action. Effective appropriability is a function of the capacity and the willingness of the owner of the right to "enforce" the right. Following Shapiro (2003) and Lemely and Shapiro (2005) patents can be defined as probabilistic rights. Litigation costs, the expertise of legal advisors, the bargaining power, the capacity of monitoring the market and the competitors are some of the factors that influence the possibility of the "legal entitlement" to be converted into "effective entitlement". For patents to perform as effective appropriability mechanisms the legal entitlement should be matched by the capacity -and the willingness- to enforce the right (Cimoli and Priim, 2007; 2008).

Certain interpretations tend to emphasize the role of patents in favoring incremental innovation and technical change through the increase in the amount of

[67] See chapter 4 for an analysis of the determinants of patenting in the Brazilian manufacturing industry, on the basis of the National innovation survey (PINTEC).

knowledge available in the public domain. Patents are seen as mechanisms to disseminate (relevant) information into the economic system. Patents incentivize the disclosure of technical information so that any person “skilled in the art” should be able to reproduce the invention, in exchange of a limited exclusive right of exploitation. However, the disclosure function is constrained by the nature of technology and learning and by the structural and organizational characteristics of firms and research institutions.

The temporary monopoly conferred by patents is justified by the disclosure function. In exchange of temporary exclusive rights, patents require the diffusion of technical information that otherwise would be kept secret. However, in practice this function is limited since the information disclosed in patents is often inadequate or opaque. In many cases, even when the disclosed information is complete, this does not guarantee the disclosure of what is needed in order to reverse-engineer, copy or reproduce the technology in question. Mastering technology and learning involve organizational and tacit knowledge embedded in routines that is not provided by the disclosure of information. In the case of generic drugs this limitation is evident. “Why do not all firms in every country produce them? Because most firms are simply not able to do it. Even if they are informed about the existence of a certain technique or technology, they might not have the capabilities for developing or using it. Even if firms were given all the blueprints, i.e. assuming the perfect disclosure of patent information- (and supposing in an extreme case also the availability of equal production capacities), performances might still differ due to asymmetries in capabilities and learning, just as having the best cook book doesn’t make us the best cook (we would still need to good ingredients, the tools, and the know-how to interpret and execute instructions, etc.)”(Cimoli and Primi, 2007, pg. 14).

Patents, in theory, should foster knowledge dissemination by disclosing relevant information, helping therefore to focus R&D on new issues. However, duplication of R&D efforts is not always inefficient. Often firms require internal capabilities to be able to decodify and productively use the technical information revealed in patents; therefore there is an economic rationale for carrying out internal R&D efforts even on issues which are of public domain when they allow to develop organizational capacities, routines and tacit codes that will enable first to catch up with existing knowledge (Cohen and Levinthal, 1989; 1990).

3.4 THE IMPORTANCE OF THE “USER SIDE”: THE PATENT SHIFT FROM INCENTIVES TO STRATEGIC ASSETS

Intellectual property regimes interact with other non-legal mechanisms in influencing innovation trajectories. They are not the unique determinants of innovative conducts but they have a strong influence on the patterns of search and diffusion of knowledge. The number and quality of patents, the enforcement capacities of patent owners, patent length, breath and quality shape innovative behavior in several ways. Patents influence the perception of what is freely available and what is proprietary. They can favor or discourage the entrance in specific research fields and they can mergers and acquisitions strategies (Cimoli and Primi, 2007). At the same time, they act as "reputation signals" and are increasingly used in legal settlements. In short, they are becoming 'assets" in firms' portfolios, often valued beyond the effective value of the patented technology (Cimoli *et al.* 2009a).

In fact, the rationale behind patenting goes beyond the logic provided by the standard approach of markets for technologies (i.e. patent licensing). Patents have been transformed in peculiar strategic assets, whose relevance is increasingly disentangled from the subjacent technology, being more and more dependent on non-rational expectations regarding possible future technological scenarios. The transformation of patents from incentives and rewards for and to innovation, into strategic assets for rent management can be explained by the concurrence of two major phenomena as described by Cimoli and Primi (2007; 2008):

i) The emergence of new technological paradigms entails a redefinition of what is innovation, how it is generated and through what means it can be diffused and appropriated). In new technological paradigms, mainly ICT, biotech and nanotech, innovation is more and more incremental and cumulative, intensive in interrelations between firms (countries and institutions), and it entails an increasing relevance of science. The concepts of replicabilty, usability and copying are being constantly re-defined, the potential technological interrelations are multiple, and uncertainty regarding future possible outcomes is even higher than in past technological paradigms.

ii) The re-shaping of world intellectual property systems[68]. Intellectual property regimes are regulatory infrastructures embodied in evolving socio-economic system; they are therefore subject to change and transformation. In fact, history shows that IP systems have evolved over time from a regulation of national scope to supra-national management regimes (Machlup and Penrose 1950; David 1993). This transformation went hand in hand with the increase in relevance of international trade and networks[69] (Dasgupta and David, 1994; Mazzoleni and Nelson, 1998; Cimoli *et al*. 2006).

The re-shaping of IP regimes towards an (upward) harmonization of standards has advanced hand in hand with increased trade liberalization. In the US a series of court-rulings have allowed an unprecented expansion of the patent subject matter

[68] See Cimoli *et al.* (2009a) for an analysis of the re-shaping of global IP systems.

[69] The Paris convention of 1883 on industrial property protection and the Berne Convention of 1886, which regulate the protection of original forms of expression like artistic or literary works, represented the first phases of the internationalization of the protection of intellectual property rights.

and have favored, since the early 80s with the adoption of the Bayh-Dole act[70], a transition towards a more capitalistic approach to science, in contrast with the previous open science model.

The ratification of the TRIPS agreement in 1994 within the GATT represented the baseline for worldwide harmonization of IP laws. However, since the mid 2000s, a multiplicity of trade and investment agreements are redefining on bilateral basis the policy spaces settled by the TRIPS (Fink and Reichenmiler, 2005; Moncayo, 2006).

The changes in patent regimes and in innovative behavior contributed to generate new markets for technologies. In these new markets the value of patents is increasingly independent from the subjacent technology and from the utilization of the patented technology in production. The value of patents is increasingly associated with expectations regarding: i) the possibility that the patent becomes relevant for production in the future; ii) the potential role of the patent in M&A, legal settlements and company negotiations; iii) the potential value of other patents to which the patent might be associated to, like in patent pools or patent portfolios. The new sets of rules and the evolving technological scenarios are transforming patents from “simple” legal mechanisms of potential and temporary exclusive rights into strategic assets for firms. In certain cases patents can be “traded” not because they are the carrier of a technology that is needed in production today, or potentially tomorrow, but because they might be a source of revenues without implying the need to carry out production. This changes the rules of the game, the barriers to entry, the rationale and the characteristics of the actors in the markets for knowledge. The new markets for knowledge include markets for science, especially in the areas in which scientific output is closer to business application such as ICT and biotech and “derivative” markets in which firms carry out transactions of patent valuating patents beyond the effective industrial utility of the patented technology, like in M&A and in litigations (Cimoli and Primi, 2008; Cimoli *et al.*, 2009a; this issue is further discussed in Chapter 5 of this thesis).

CONCLUSIONS: SOME IMPLICATIONS FOR POLICIES

The role of patents in shaping innovation trajectories has been extensively studied. However, several changes occurred in the last decades that modified the behaviour of agents and the role of patents in firms’ competitive strategies. As knowledge and innovation become more and more relevant sources of sustainable and inclusive growth, it is important to increase our understanding of the impact of intellectual

[70] See among others, Adelman (1987); Merges (1992); Mazzoleni and Nelson (1998); Jaffe (2000); Cohen and Lemely (2001); Hunt (2001); Hall and Ziedonis (2001); Gallini (2002); Graham and Mowery (2003); Hall (2003); Bessen and Hunt (2004).

property regimes on innovation trajectories to improve the effectiveness of policies.

Innovation theory can contribute to understand the role of IP regimes in influencing the rate of generation, adoption and diffusion of knowledge by providing hints on “what is technology” and “what is innovation”. If technology, as we have seen, cannot be reduced to the standard view of a set of well-defined new blueprints, and it actually encompasses the means, the methods, the know-how, and the problem-solving activities through which agents “do things”, it is clear that information available in patent documents is not enough for all firms to make productive use of it. Knowledge is partly tacit and embodied in complex organizational practices, technological lags within and between firms, industries and countries may persist, beyond the opportunities and limits established by legal appropriation mechanisms. In fact, “asymmetries in technological capacities (between firms and countries) are likely to persist over time, beyond the legal mechanisms defying the appropriability and transferability conditions of technologies (because of the capacities of agents. But, the opposite also holds: if firms show similar technological capabilities, imitation might occur very quickly, patent protection notwithstanding, by means of “inventing around” (Cimoli and Primi, 2007, pg. 5).

IP regimes influence behavioral choices of innovative agents, but isolating their effect is not possible, and not desirable. The search and diffusion of novelty are influenced by a series of factors in addition to legal intellectual property regimes, including direct incentives to innovation, regulations, market structure, competition policy, and firms’ strategic choices.

Table 3.1 Mechanisms for knowledge generation, appropriability and transferability

	GENERATION	APPROPRIABILITY	TRANSFERABILITY	**MECHANISMS FOR KNOWLEDGE AND TECHNOLOGY**		
				GENERATION	APPROPRIABILITY	TRANSFERABILITY/ CIRCULATION
KNOWLEDGE (public, private or club good)	Requires absorptive capacities, original individual and collective effort and builds up on the available existing stock.	High due to the tacit dimension of K. Influenced by the regimes which define the nature of K as a public or private good (ex. Open science)	High for codified K. Low for tacit knowledge/know how Limited by the absorptive capacities of agents	Policies: -Education, Training and Human Capital -STI policies (R&D and fiscal incentives, infrastructure for S&T, R&D.). -Industrial policy Corporate/ Institutional strategy: - investment in R&D; training, organization of production, etc.	Corporate/ Institutional strategy: - Lead time advantage - Trade secret - Exclusive clause for managers/workers Policies Industrial policy **IPRs**	Corporate/ Institutional strategy: -Fairs/exhibitions -Talent mobility Policies Human capital (training/ mobility of talent) Competition policies (M&A) Labor market (mobility) Science and technology policy (networks, collaboration) **IPRs** (licensing, patent pools)
TECHNOLOGY (Embodied or disembodied)		Varied. Shaped by institutional/business strategies and by regulations (IPR regimes, competition policy, standard setting).	Varied. Constrained (or enhanced) by "technological/cognitive" proximity of agents.		Corporate/ Institutional strategy: - Complementary manufacturing capacities/Bundling - Lead time advantage - Trade secret Policies **IPRs**	Corporate/ Institutional strategy: Reverse engineering Inventing around Technology Transfer Policies Competition policies (M&A) **IPRs** (Licensing, patent pools)
LEARNING		Very high. Embedded in individual/ institutional routines.	Limited. It can be enhanced by sharing processes.		-restrictions to mobility of talent/personnel	Fostering mobility of talents/personnel Collaborative projects

Source: Authors'elaboration.

The challenge for contemporary economies is to define the conditions for knowledge generation, diffusion and exploitation (i.e. the knowledge governance), in a comprehensive way. The interaction between different legal and non-legal issues shaping innovation needs to be taken into account, as well as the interaction between different policy fields when designing innovation policies (see Table 3.1).

The mechanisms for knowledge appropriability and transferability are only in part shaped by policies; they are also strongly influenced by the business and institutional strategy of firms and institutions. They are also influenced by several issues beyond IP, including competition policy, labor market regulations, science and technology policies and industrial policies. "Getting the IPRs right" is far from being the solution. Also because there is too much of uncertainty about what might "right" mean in terms of intellectual property regimes across firms and countries with profound differences in technological and production capacities. Legal appropriability mechanisms, i.e. prevailing intellectual property norms, classify as second order effect factors, with respect to production capacities and technological capabilities embodied in socio-institutional systems in shaping innovative and imitative conducts of firms, and countries (Cimoli and Primi, 2007, pg. 21).

As affirmed by Cimoli and Primi (2007), innovativeness is partly the result of a random process concerning something new and not-expected; it entails a degree of stikiness shaped by existing scientific, technological and production capabilities. Firms and countries do not depart from the same line. They suffer of deep asymmetries in terms of production capacity and technological capabilities. It is reasonable to assume that these differences will tend to persist over time, unless tailored and sustained efforts (mainly industrial and innovation policies) are taken in order to foster structural change and to induce transformations in production structures and allocation of inputs. Hence, patent policy should be defined taking into account industrial and innovation policy objectives.

"The existence of unexploited technological opportunities, the available knowledge base and the set of appropriability conditions, define the boundaries of the set of potential innovations: the ones that are actually explored depend socio-economic traits of production, organizational and institutional systems" (Cimoli and Primi, 2007, pg. 25). Hence, it is not about "getting the IP right", but about clarifying the required conditions and incentives for the creation of new knowledge, and for the diffusion and transfer of existing one. This requires defining the conditions that shape the governance of knowledge creation, diffusion and exploitation at several levels, including science, competition, industrial and technology policies (Cimoli and Primi, 2007, 2008 and Cimoli *et al.* 2009a).

Intellectual property should be discussed within the framework of innovation strategies of firms and countries. IP policy needs to be planned in coordination with innovation policies and should be framed under a broader concept of "knowledge governance" meaning by it all the rules and norms defining the conditions under which knowledge is created and diffused in economic systems.

Intellectual property policy is highly complementary with other policy domains (including, competition, trade and science policy). IP policies need to be defined taking into account local and global scientific and production development challenges. This means bringing at the table a varied group of constituencies. But it also means better defining the policy questions. Up to know too much of the discussion has implicitly assumed that more innovation is always better for our societies (while this might not be always the case; in fact in certain cases it is more the direction, rather than the rate of technical change that we should influence) and that stronger intellectual property systems are conducive to more innovation. We should shift the debate on how to create the conditions for addressing the major challenges of our societies and on how to generate and diffuse knowledge in a better way. This could be done by nesting the IP debate in this broader, "knowledge governance" framework. This approach could help in rebalancing the discussion from the "appropriability" dimension to the "disclosure" aspect; thus, better responding to the evolving needs of our societies.

CHAPTER 4

WHO IS PATENTING IN BRAZIL?

A firm level analysis of appropriability strategies in the manufacturing industry*

This chapter presents an empirical analysis of determinants of patenting of innovative firms in the Brazilian manufacturing industry. The chapter is based on firm-level data from the national innovation survey (PINTEC). As in advanced countries, innovative firms in Brazil tend to use multiple appropriability mechanisms to protect their innovations. In particular, trade secret and patents are used as complementary mechanisms rather than substitutes by innovative firms. A major difference between Brazil and more advanced countries is the low share of innovative firms over total firms and the specialization in sectors with low patent propensity.

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INTRODUCTION

The patent boom of 1990s has been extensively analyzed by the literature (Kortum and Lerner, 1999; Hall and Ziedonis, 2001)[71]. The available evidence shows that the increase in patent applications and grants has been leaded by the US and by some emerging economies, including Republic of South Korea, and more recently China. Latin America is still at the margins of global patenting, but patent applications and grants have been rising there too. Brazil is the country in Latin America that registers the higher patenting activity. The number of patents granted by the USPTO to Brazilians increased from 41 in 1990 to more than one hundred in 2009. Since the 1990s, the number of patents granted by the Brazilian patent office (INPI) has almost doubled. In addition, while non-residents account for the highest share in granted patents, residents have been presenting more and more patent applications, exceeding the non-residents since 2002.

In Brazil, firms are applying (and obtaining) more patents and intellectual property is an issue of rising concern for the government. The Brazilian industrial policy includes intellectual property management as a target since 2008[72]. For example, the policy aimed at doubling the number of patent applications in Brazil by domestic firms by 2010 and to triple the number of patent applications in foreign patent offices. The policy has also introduced some sector-specific targets, for example increasing patent applications in the biofuel industrial complex and in the automotive, leather and cosmetic sectors, (Government of Brazil, 2008). However, the Brazilian production structure is highly heterogeneous and the response of firms to IP incentives varies deeply according to firm size and sectoral specialization.

Why do Brazilian firms patent (or why they do not)? And what can policies do about it? While in advanced countries *ad hoc* surveys (Levin *et al*. 1987; Cohen *et al*.

[71] Several issues have contributed to the global rise in patent applications and grants. The rise and diffusion of new technological paradigms, including information and communication technologies, biotech and nanotech have entailed: i) new ways of doing business and of innovating, ii) a reshaping in the boundaries between science and business, and iii) rising opportunities for incremental innovations, thus opening new opportunities for patenting. Moreover, during the 80's and 90s there has been a political upturn in favor of patent protection. This has been reflected in institutional changes in intellectual property management within the US (the creation of the Court for Federal Circuit and the Bayh-Doll Act are two examples) and at the international level (due to the inclusion of IP provisions in multilateral and bilateral trade agreements- including the TRIPS agreement, and the BITs and FTAs between the US and numerous developing countries). See Cimoli and Primi, 2008; Cimoli et al. (2009a) and Chapter 5 of this dissertation for an analysis of the reshaping of global IP systems, and an interpretation of emerging markets for knowledge and their implications for developing economies.

[72] In 2008, Brazil launched a new industrial policy which merged horizontal fiscal incentives with selective policies, bringing back industrial competitiveness in the national development agenda. Since 2011, Brazil is deepening the efforts to support industrial and technological development, making IP management a key issue in national policy. In 2011 Brazil launched the new industrial policy (Brazil Plano Maior) which has a stronger international focus and keeps including patenting as a key target.

2000) and national innovation surveys have been carried out an analyzed to address these questions, this issue has not yet been analyzed deeply in Brazil. Knowing which firms are more likely to make use of patents, and understanding their preference for using other appropriability mechanisms, can help in clarifying the potential implications of national and international patent policies and can contribute to improve policy design and implementation.

Brazil has a fairly long tradition, when compared with other Latin American countries, in carrying out innovation surveys and analyzing them to get feedback for policy design. However, it is only recently that the country has started to analyze the results of innovation surveys under the intellectual property management angle. The national innovation survey of Brazil includes questions about the appropriability strategy of innovative firms and represents an underexploited source of information to clarify the appropriability strategies of innovative firms and to contribute to the policy debate on intellectual property and innovation.

Following the literature on national innovation surveys (Arundel, 2001; Cincera, 2003; López and Orliki, 2006) this chapter analyzes the factors that affect the probability that an innovative firm in the Brazilian manufacturing industry uses patents to protect its product or process innovation. It then contrasts this decision with the one of opting for trade secret. This chapter contributes to the existing literature on appropriability strategies of firms in three ways. It generates new evidence regarding the appropriability strategies of innovative firms in emerging economies. Up to know most of the studies focus on advanced countries. It provides hints to improve innovation and patent policies in Brazil by helping to clarify the variety of preferences of innovative firms in Brazil. And, in addition, it contributes to identify ways to improve the national innovation survey design by highlighting the limitation that the current questionnaire has in addressing the appropriability issue.

After this introduction, the first section briefly reviews the literature on appropriability strategies of firms, focusing in particular on patenting. The second describes the data used for the analysis; the third presents some basic descriptive statistics on innovative firms and appropriability mechanisms in Brazil; the fourth section presents the model and the results. The conclusions clarify the limitations of the study and sketch out some policy implications.

4.1. THE "APPROPRIABILITY PROBLEM" AND THE FIRM-LEVEL LITERATURE

The term "appropriability" refers to the capacity of innovating agents (individuals, firms, institutions) to capture the value generated by innovations and investment in "intangibles". It refers to the different mechanisms used by firms to secure the ownership of innovation related rents. The need to guarantee the appropriability of knowledge needs to be counterbalanced by the need to guarantee knowledge circulation and diffusion which are also essential for innovation. This tension between "openness" and "appropriation" was already present in the seminal works on innovation (Nelson, 1959 and Arrow, 1962; see also Chapter 3 of this dissertation).

Starting from the late 1980s, several studies have analyzed the behavior of firms in protecting their innovations. Evidence shows that firms use a set of complex (and sometimes complementary) mechanisms to secure the appropriability of rents deriving from innovative efforts. "Industrial secrets, lead-time advantages, complementary manufacturing capacities, branding and costumers' fidelization, are some of the means used by firms to appropriate the rents deriving from intangibles" (Cimoli and Primi, 2007, pg. 13). Firms deploy various strategies to secure their innovative efforts. However, in the analyses of the appropriability strategies there has been a bias towards patenting. This can be explained by the predominant interest in technological change and investments in R&D for innovation as key drivers for international competitiveness of firms, as well as by the reshaping of global IP systems (within the US and at the multilateral and bilateral level) which fostered the development of a patent intensive environment.

The Yale Survey (Levin *et al*., 1987) and the Carnegie Mellon Survey (Cohen *et al*., 2000) have contributed to deepen the understanding regarding patenting behavior of manufacturing firms, by showing that the decision to patent is often taken in the frame of a broader appropriability strategy. Recently, the literature on appropriability has been enriched by firm level analyses based on national innovation surveys (Harabi, 1995; Arundel, 2001; Cincera, 2003; Laursen and Salter, 2005; Lopez and Orliki, 2006). In Europe, the Community Innovation Survey (CIS) includes a module regarding the appropriability strategy of firms. Firms are asked to declare the number of patents applied for during the period covered by the survey and to declare the relative importance of formal and strategic methods to protect innovations. On average, surveys' results show that patents are not the preferred appropriability mechanism for innovative firms (Levin *et al*. 1987; Cohen *et al*. 2000; McLennan, 1995; Arundel, 2001). According to Cincera (2003) the share of firms with zero patents is 79%, while Bound *et al*. (1984) find that in the United States 60% of firms do not apply for any patent, and this share rises to 73% in the case of French firms according to Crépon and Duguet (1997). In the case of Brazil, the innovation survey of 2001-2003 shows that more than 90% of innovative firms do not make use of patents to protect innovations.

This literature focuses on the factors that affect the probability that an innovative firm patents its product or process innovation (Cincera, 2003, Brouwer and Kleinknecht, 1999; Lopez and Orliki, 2006). Different econometrics techniques are used to estimate the patenting behavior of innovative firms according to data availability, and to the type of hypothesis to test. R&D intensity, firm' size, capital ownership, export orientation, firm's openness to external sources, skilled labor force and some control for sectoral specialization are among the included factors in the estimations of the probability that a firm patents its innovations. Some authors explore the relationship between patenting and the use of alternative or complementary strategies, especially focusing on the relationship between the use of patents and trade secrets (Arundel, 2001; Laursen and Salter 2005).

Cincera (2003), for example, assesses the impact of R&D, and of other technological determinants on the number of patent applied by Belgian R&D performing firms, focusing on multinational companies. The author distinguishes between type of R&D effort and source of R&D financing finding that there are slightly decreasing returns to scale of R&D on patenting. His estimates show that public subsidies to R&D do not impact the number of patents applied for. In addition, Cincera finds that a high concentration of foreign subsidiaries in a given sector decrease the probability of patenting by domestic firms, and that foreign firms seems not interested in patenting in the host country.

Brouwer and Kleinknecht (1999), analyze manufacturing firms' propensity to patent in the Netherlands on the basis of the results of the Community Innovation Survey (CIS). Through a logit model with fixed effects, they find that firms that participate in collaborative R&D are more likely to apply for a patent than firms that do not participate in collaborative R&D, and that patent propensity varies by firm size and by sector. Arundel (2001) uses data from the 1993 CIS for 2 849 R&D performing firms to determine the relative importance of secrecy *versus* patenting as appropriability mechanism. Arundel (2001) finds that "a higher percentage of R&D performing firms in all size classes find secrecy to be a more effective means of appropriation than patents" (*ibid* p. 621). Laursen and Salter (2005) analyze the use of legal and "first mover" appropriability mechanisms in the case of UK manufacturing firms. According to their estimates, in all sectors firms have a preference for first mover mechanisms, including lead time advantages and complexity in design.

In Latin America, collecting and analyzing data form national innovation surveys is a recent phenomenon. Existing studies focus on the determinants of R&D investment, on the profitability of innovation and on science-industry linkages[73]. An analysis of the use of different appropriability mechanisms in Latin America can be found in López and Orlicki (2006). The study shows that the most used protection mechanisms by Latin American manufacturing firms are trademarks, followed by patents. The authors highlight that residents prevail in trademarks application and registrations, while foreigners file and obtain a higher number of patents than residents, suggesting that domestic innovators tend to realize less radical innovations than foreigners.

On average, firm level studies, both in advanced countries and in Latin America, suggests that:

[73] On the analysis of innovation surveys in Latin America see, among others, Crespi and Katz, 1999; De Negri and Salerno, 2005; Benavente, 2006; Chudnowsky *et al.* 2006 and Cimoli *et al.*, 2011.

i. Patents are not the preferred mechanism to protect product and process innovation. The preference for patents varies substantially by sector of specialization and firm' size.

ii. Some innovations are easier to protect through patents, while others are more easily securable through secrets or other strategic mechanisms, depending on the type of innovation, its codificability, and by the innovative strategy of the firm.

iii. Firms tend to use a combination of appropriability mechanisms to secure advantages deriving from innovation.

Improving the understanding of the behavior of firms and of their appropriability strategies can help to design better policies. This is a key issue for European and advanced countries; it should also be a priority for emerging and developing economies as they face the challenge of supporting innovation and fostering its diffusion to sustain growth and achieve social equity.

4.2. THE DATA: THE PITNEC 2001-2003

The PINTEC 2003 is the second innovation survey carried out by the National Statistical Office of Brazil, (IBGE)[74]. The objective of the survey is to collect information to compute indicators about innovation in industrial firms. It is structured to allow international comparability of results. It covers the mining sector and the manufacturing industry[75]. Its universe of reference includes all active formal firms with more than 10 employees[76].

The PINTEC starts from the assumption that innovation is a rare phenomenon. Traditional random sampling methods are considered inadequate because they would induce a sub-estimation of the innovative activities carried out by the firms. Therefore, a peculiar sampling method is adopted to identify *ex ante* the firms which have the higher probability to be innovative in order to increase the share of these firms in the sample[77]. The universe of analysis of the PINTEC 2003 is around 84 262 firms. The sample included 11 337 firms, of which 10 624 answered the interview (obtaining a response rate of 94%). 10 377 of the sampled firms belong to the manufacturing industry.

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[74] The data from the PITEC has been extensively analyzed. See De Negri and Salerno (2005) for a comprehensive analysis of technological trajectories and performance of Brazilian firms. These analyses, however, do not include the discussion of the determinants of patenting, or the use of appropriability mechanisms.

[75] The sectoral classification of economic activities follows the NACE at three digits (classes C and D).

[76] For a detailed description of the methodology and for a presentation of main results see IBGE (2005).

[77] For additional details regarding the sampling methodology of the PINTEC see IBGE (2005).

Considering that the term "innovation" might mean different things to different respondents, and taking into account that in Brazil most innovative efforts are adaptive in nature, and that that often R&D activities are carried out in informal way, it was supposed that the majority of firms would not have been familiarized with the concepts included in the survey. Therefore, a peculiar method for collecting information has been adopted (IBGE, 2005). The national statistical office identifies the person working in the R&D department, or in the industrial production section, that is best suited to answering the questionnaire. The survey is carried out through in-person interviews for firms with more than 500 employees located in federal districts with more than 15 sampled firms, and by computer assisted telephone interviews (CATI) in the rest of the cases.

The PINTEC 2003 follows the Oslo Manual[78]. It collects information about the firm's innovative behavior and efforts, the impacts of innovative activities and the incentives and obstacles for innovation. The survey covers a triennial period[79]. The PINTEC is structured in 13 different thematic blocs, each one focusing on a specific issue affecting, or resulting from, the innovative efforts of the firm. All sampled firms are asked to report information regarding their basic characteristics (like, number of employees, sector of activity, if the firm belongs to a group or not, main market, etc.). Firms are then are asked to declare if they have carried out a product or a process innovation during the period covered by the survey.

According to the Oslo Manual, the PINTEC defines technological innovation as the implementation of a new or substantially improved product (good or service) or process. An innovation is considered "implemented" when the product is introduced into the market, or when the process is being used by the firm. Firms which qualify as innovative (i.e. those who had introduced a new or significantly improved product or process in the period covered by the survey) are required to go fill the whole questionnaire, which includes 10 thematic modules. Non innovative firms need only to reply to the two final modules focusing on problems and obstacles to innovation and on organizational innovations.

The thematic modules consist of several questions regarding the different aspects of innovation, including the degree of innovativeness (i.e. if the innovation is new for the firm, for the domestic market or for the international market), who has carried out the innovation, etc. Innovative firms are required to provide information about: the kind of innovative activities carried out during the period of the survey (these are classified in two broad categories: R&D and other kind of activities, such as licensing and technology transfer), sources of financing for innovation, details regarding in-house R&D activities (including if they carry out R&D activities

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[78] The model of reference for the PINTEC 2003 is the one used by EUROSTAT for the third version of the CIS (Community Innovation Survey), 1998-2000.

[79] In the case of the PINTEC 2003 the survey covers the innovative activities carried out between 2001 and 2003. Usually, qualitative variables refer to the activities carried out during the whole period, while quantitative variables refer to the last year of the survey.

on a continuous basis and how many employees dedicated to R&D they employ by qualification, etc.), impact of innovations, sources of information, kind of cooperative agreements for innovation[80], government support for innovative activities and the use of appropriability mechanisms.

The survey also collects information on appropriability strategies. Firms are asked to specify if they have used at least one of the listed appropriability mechanisms to protect their process or product innovations between the year 2001 and 2003. The survey classifies appropriability mechanisms as written (patents, utility models, industrial designs, trademarks, and copyrights) and strategic (complexity in design, industrial secret and lead time advantages over competitors)[81].

4.3. APPROPRIABILITY STRATEGIES IN BRAZILIAN FIRMS: DESCRIPTIVE STATISTICS

According to the PINTEC 2003, Brazilian firms do not innovate as much, and when they do, they are not radical or break-through innovators. The majority of implemented innovations consist of incremental innovations, which are not new to the global market. Of the 10 377 responding firms, 43.1% qualify as innovative. Table 4.A.1 (in Annex) shows the composition of the sample and the share of innovative firms by industry.

The scant innovation dynamism of the Brazilian manufacturing industry can be explained, in part, by its sectoral composition[82]. The Brazilian industrial structure is specialized in low and medium low technology intensive sectors, which account for the 52% and 23.7% of total sampled firms, respectively. In general, sectors like pharmaceutical, chemicals, electronics are more R&D intensive and account for higher shares of innovative firms. In Brazil, around 60% of firms in high-tech sec-

[80] The PINTEC considers as cooperative agreements those with an active involvement of the firm in R&D projects with a series of given partners, the objective of this module of the questionnaire is to offer a measure of the intensity and the objectives of the relationship of the firm with the so called national system of innovation.

[81] Firms are also asked to specify if they have used another method not presented in the list. It is important to note that, the PINTEC is the only innovation survey in Latin America which asks firms to give details regarding the appropriability strategy (the other surveys only collect information regarding patents and trademarks). However, in the PINTEC firms are not asked to report the number of obtained and applied for patents, as in the case of the Argentinean survey. In addition, the Brazilian survey does not asks to rank the relative effectiveness of each mechanism in terms of the capacity to capture innovation rents, as the CIS does, limiting the kind of analyses that it is possible to carry out.

[82] Beyond the sectoral specificities in the propensity to innovate, the sectoral pattern of innovation in each country is also shaped by the production structure specialization and by the accumulation of capabilities in given sectors, such is the case of the food, beverage and tobacco sectors in Brazil, where the share of innovative firms is higher than the national average, even though those are sectors which are usually considered to be less innovation and R&D intensive.

tors and 50.5% of medium-high tech firms are innovative[83], while less than 40% of medium and low tech firms are innovative.

According to the PINTEC 2003, 63% of innovative firms carry out product innovations, 81% process innovations, and 44% carry out both of them. Among product innovators 39.7% of firms only introduced a significantly modified product, while 44.2% introduced a product which is new for the firm, 13.8 % a product which is new for the domestic market and 2.3 % a product new for the international market. 55.6% of firms introduced a significantly modified process, while 36.9% firms implemented a process which was new for the firm, and 6.5% and 0.9% introduced a process new for the national and the global market, respectively. The survey also reveals that firms make a scant use of appropriability mechanisms (see Table 4.A.2 in the Annex). Appropriability mechanisms are used to protect innovations from imitation; hence, the prevalent incremental and adaptive nature of the innovative effort of Brazilian firms contributes to explain the low level of use of appropriability mechanisms.

The low patent propensity of Brazil firms partially derives from the prevailing specialization pattern (i.e. the majority of firms specialized in low-tech sectors that tend to have a low patent propensity) and by the prevalence of incremental and adaptive innovations. However, beyond these differences, we can identify some common patterns in the use of appropriability mechanisms between innovative firms in Brazil and in more advanced countries:

i. **A generalized non preference for patents.** In Brazil, only 7.6% of innovative firms have declared to have made use of patents between 2001 and 2003, while 23.7% of firms have declared to have applied for a trademark, 14.3% have used trade secret, and 6.5% lead time advantages (Table 4.A.2). The preference for trade secret and trademarks is similar to what empirical studies have found in more advanced countries, but in the case of patents, the percentage of innovative firms in Brazil that applies for them is sensitively lower than what can be observed in more advanced countries. For example, in the EU 16% of firms patents, according to the Third Community Innovation Survey (CIS). The CIS estimates that 17% of innovative firms in Germany and in Sweden have applied at least for one patent during the years covered by the survey; the share lowers to 14% in the case of Finland and to 10% in Belgium.

[83] The sectors with the higher share of innovative firms, with respect to the total number of firms in each sector are: telecommunication equipments, sector in which 68.7% of the sampled firms qualify as innovative, computer and office machines, with 63.9% of innovative firms, and precision instruments, and pharmaceuticals with 61.4 and 60% of innovative firms, respectively. The other sectors in which the concentration of innovative firms is higher than the national average are: electrical machinery, chemicals, (excluding pharmaceuticals), machinery and equipment, motor vehicles, oil and transport equipment, and food beverage and tobacco in which 56.9%, 55%, 54.4%, 53.4%, 48.6%, 45.5% and 44.1% of total sampled firms are innovative. See Table 4.A.1 in Annex.

ii. **The propensity to use the appropriability mechanisms varies with firm size.** In general large firms tend to rely more on legal appropriability mechanisms, than SMEs. Data from the PINTEC 2003 show that only 3.1% of small innovative firms (between 10 and 49 employees) make use of patents, while this share increases to 8.7% of firms having between 250 and 499 employees (see Table 4.A.2 in Annex).

iii. **The preference for patents increases in the case of product innovations.** In Brazil, according to the PINTEC 2001-03, around 10.7% of product-innovating firms and 6.9% of process-innovating firms have used patents (Table 4.A.3 in Annex)[84]. The propensity to use appropriability mechanisms increases in the case of firms which introduced both product and process innovations.

iv. **The higher the degree of novelty of the new product (or process), the higher the use of appropriability mechanisms.** This is quite tautological: the more radical the innovation, the more valuable and higher the need for protecting it. As Table 4.A.4 (in Annex) shows, in Brazil on average, around 7.6% of innovative firms have declared to have used patents; however, when we take into account the degree of novelty, this share rises up to 50% in the case of the firms that have introduced an innovation new for the international market.

v. **The use of appropriability mechanisms, and especially of patents, varies across industries and sectors** (see Tables 4.A.5 and 4.A.6 in Annex). Patents are the most relevant appropriability mechanism only in few sectors, including pharmaceutical and electronics[85]. According to the PINTEC 2003, the sectors with the highest patent propensity are: precision instruments (in which 23.4% of innovative firms patent), computers and office machines (in which 21.7% of innovative firms patent), electrical machinery, machinery and equipment, chemicals (excluding pharmaceuticals), motor vehicles and pharmaceuticals (in which 16.5%, 15.6%, 14.8%, 14.4% and 12% of innovative firms patent, respectively)[86].

vi. **Firms rely on a combination of different factors to protect innovations.** The PINTEC 2003, shows that the use of each appropriability mechanism is cor-

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[84] As shown in Table 4.A.3, product innovating firms make a more extensive use of all kinds of appropriability mechanisms with respect to process innovating firms. For example, 18.9% of product innovating firms rely on trade secret, while the percentage lowers to 13.7% in the case of process innovating firms.

[85] The literature has extensively stressed the sectoral component of patent propensity. See: Scherer, 1983; Mansfield, 1986; Levin *et al.* 1987, Cohen *et al.* 2000; Arundel and Kabla, 1998; among others.

[86] Arundel and Kabla (1998), for example, estimate the patent propensity of firms by industry using data from the 1993 PACE survey, which collects information regarding the European largest industrial firms. These authors find that the sectoral patent propensity varies from 15% in basic metals and steel (ISIC 27) to a high of 74% in pharmaceuticals (ISIC 2423); in addition they estimate that the patent propensity only exceeds 50% in four out of twenty manufacturing sectors, which are: machinery (52%), precision instruments (53%), chemicals (57%), and pharmaceuticals, which show 52%, 53%, 57% and 74% of patent propensity respectively. In an analysis of the German manufacturing industry Sattler (2002) finds that chemicals, engineering and basic metals sectors show higher patent propensity than other less technologically intensive sectors.

related with the use of the others (see Table 4.A.7 in Annex). Some firms tend to prefer legal mechanisms, others tend to use of a combination of strategic mechanisms that guarantee protection through the "enclosure" of the innovative step.

In Brazil, foreign firms tend to be more innovative than domestic ones and therefore use more intensely legal and strategic appropriability mechanisms (see Table 4.A.6 in Annex). While 5.6% of domestic firms use patents, this share increases to 19.7% in the case of foreign firms; 11.3% of domestic firms rely on trade secret, while 32.8% of foreign firms does, and 4.2% of domestic firms declares to use lead time advantage while 20.7% of foreign firm does. The difference is less remarkable in the case of trademarks; of Brazilian innovative firms 22% registers trademarks, in contrast with 34% of foreign firms. The heterogeneity between foreign and domestic firms in the use of appropriability mechanisms depends on the fact that foreign firms are usually more technologically advanced and embed in their routines a culture of "entrepreneurial innovation", while the majority of domestic firms lacks it. It also depends on the sectoral distribution by capital ownership: foreign firms are dominant in medium-high and high technology intensive sectors, while domestic firms prevail in traditional sectors.

4.4 THE DETERMINANTS OF PATENTING IN THE BRAZILIAN MANUFACTURING INDUSTRY

This section presents a simple model to estimate the determinants of patenting. The model also estimates the probability of using trade secret conditioned to the probability of applying for patents, following the existing literature (see, among others, Arundel, 2001; Laursen and Salter, 2005). Given the structure of the PINTEC the analysis is carried out only on innovative firms, therefore conditioning the results to this premise.

The model

A probit model is computed to identify the determinants of the probability that an innovative firm had used a patent to protect its innovative efforts during the years covered by the survey[87]. The estimation of the probability that a firm has obtained a patent follows equation (1):

[87] Probit models have been used in the literature to test the probability that a firm will patent or not its invention conditioned to a series of characteristics of the firm and its innovative strategy. For example, Cincera (2003) estimates the patent R&D relationship though a probit equation.

$PAT_i = 1$ if

$$PAT_i^* = f_i^*(\alpha_i + X_i^{FIR}\beta_i + X_i^{CAP}\delta_i + X_i^{INN}\lambda_i + X_i^{CTRL}\gamma + \varepsilon_i) > 0, \quad (1)$$

$PAT_i = 0$, otherwise

where:

PAT_i is the dependent variable; it takes the value 1 if the firm declared to have used at least one patent between 2001 and 2003 to protect the carried out product or process innovation; 0 otherwise;

f_i^* is the probit probability distribution function and X_i^{FIR}, X_i^{CAP}, X_i^{INN},and X_i^{CTRL} are vectors of independent variables affecting the probability that the innovative firms patents the innovation, and β_i, δ_i, λ_i and γ_i are the respective vectors of parameters to be estimated; ε_i indicates the standard errors.

Following the literature, the model identifies a series of independent variables affecting the probability that a firm obtains a patent, (Arundel, 2001; Cincera, 2003; Laursen and Salter, 2005; López and Orliki, 2006). The independent variables are classified into four categories: the basic characteristics of the firm, (X_i^{FIR}), the firm's capabilities for innovation (X_i^{CAP}), the firm's innovative strategy (X_i^{INN}), and a vector of control variables including export orientation and sectoral specialization (i.e. the technological intensity of the sector to which the firm belongs to), (X_i^{CTRL}). Table A.8 (in Annex) reports names and description of the independent variables included in the model.

The model includes: the natural logarithm of the number of employees assuming a positive non-linear correlation between the size of the firm and its propensity to patent. It is commonly found that larger firms are more prone to patent their innovation than small firms and this relationship tends to assume an inverted U shape, confirming the Schumpeterian hypothesis that, after a certain threshold, increases in the firm's size will not be associated with increasing innovation rates and, hence, with rising patent propensity (Scherer 1965, 1983; Cohen, 1995; Brouwer and Kleinknecht, 1999; Hall and Ziedonis, 2001; López *et al*. 2005).

Large firms often dominate the market and can face reduced incentives to innovate due to lower competitive pressure. However, large firms are usually expected to make more use of appropriability mechanisms due to their higher investments in innovation, stronger enforcement capabilities and ability to avoid infringements (Griffiths and Webster, 2002). Nevertheless, the new technological paradigms are opening new windows of opportunities for small high-tech firms. For them patents can represent valuable assets, thanks to the existence of markets for technology which allow technological specialization and division of labor, and in which they patent to signal their expertise and to establish strategic alliances with larger partners (Mazzoleni and Nelson, 1998; Arora *et al.*, 2001)[88].

The model also controls for capital ownership. Foreign firms are expected to be more likely to use patents than domestic firms, due to their superior technological capabilities and to their sectoral specialization. As Table 4.A.6 (in Annex) shows in Brazil 60% of foreign innovative firms belong to high and medium high-tech industries, while this share lowers to 27% in the case of domestic firms. López and Orliki (2006) confirm this hypothesis finding a positive relationship between foreign capital ownership and patent propensity. The model also includes a control variable to specify if the firm belongs to a group or if it is an independent enterprise. The literature suggests that the firms that belong to a group are often more inclined to patent because they might be involved in more sophisticated R&D activities, or because they might use patents as mechanisms to signal their ownership of the innovation and to facilitate innovation circulation through technology licensing within the group. The literature also highlights that the propensity to patent is linked to the innovative capabilities of the firms. Capabilities can be internal to the firm, such as personnel dedicated to R&D, or external, as information or know how acquired through licensing.

Patent propensity is shaped by the innovative strategy of firms. Usually the literature focuses on the effect of R&D intensity or the R&D expenditures as determinants of patenting, introducing time lagged models to take into account the lag between the innovative effort and the expected patentable outcome (Scherer 1965, 1983; Duguet and Kabla 1998; Cincera, 2003; Laursen and Salter, 2005). This chapter uses evidence only from one innovation survey; therefore, it is more appropriate to include a variable measuring the continuity of the R&D efforts of the firm, instead of the traditional variables of R&D intensity. The fact that a firm carries out R&D activity on a continuous basis should increase the probability that that firms obtains a patent, since this should signal that the firm is actively pursuing innovation. At the same time, the literature tends to assume that the R&D intensity should be positively correlated to patents since higher R&D intensity could be associated with an increasing pool of patentable innovation (Arundel, 2001). Firms which declare to invest in R&D on a continuous basis should face higher probabilities of developing a patentable innovation, than firms which do not carry out any R&D, or that only carry out it sporadically. Patents are seen as potential outcome of the strategic decision to invest in R&D.

Firms do not innovate in isolation, and the cooperative strategy of firms might affect their patenting propensity though various channels. The relationship between cooperative R&D agreements and patent propensity is controversial. Some sustain that openness is positively correlated with patenting; others affirm that it

[88] See Cimoli and Primi (2008) for a taxonomy of markets for knowledge and their implications for developing economies. This issue is discussed further in Chapter 5 of this dissertation.

could be associated with the use of other forms of protecting innovation (Trajtenberg *et al*. 1997). Brouwer and Kleinknecht (1999) show that innovation-oriented collaborations seem to increase firms' propensity to patent. The fact that a firm has been engaged in an R&D project with an external partner might increase the probability of obtaining a patent, both because R&D partnerships could entail complex searching efforts which are more likely to be patentable, and because firms engaged in cooperative agreements might value the use of patents as mechanisms for establishing clear rights between the inventor and the agent that will use and implement the innovation. Patent propensity also varies according to the type of innovation. Product-innovating firms have higher patent propensity than process-innovating firms (Levin *et al*. 1987; Choen *et al*. 2000; Lopez and Orliki, 2006).

The model includes two control variables for testing the effect of sectoral specialization and exports on patenting. Patent propensity is skewed towards given industries, especially pharmaceutical and electronics (Scherer 1965; Mansfield, 1986, Levin *et al*., 1987; Choen *et al*. 2000; Sattler, 2002). An indicator of technological intensity is introduced as an independent variable to control for the sectoral specialization. The indicator ranks industries taking values from 1 to 4, according to the technological intensity, starting from low, to high (see table A.1 in Annex for details). Sectors have been grouped according to the technological intensity of the related activities following the OECD classification that differentiates sectors by the level of incorporated R&D. Export-oriented firms tend to patent more than the firms specialised in the domestic market because they often carry out more radical innovations due to their exposure to competition and imitation. Arundel and Kabla (1998) show that increasing exposure to competition positively affects the propensity to patent.

Beyond estimating the probability that an innovative firm obtains a patent conditioned to the independent variables shown in Table 4.A.8 (in Annex), the model also estimates the factors that affect the probability that an innovative firm uses trade secret to secure innovation rents[89]. In Brazil, innovative firms rely more on trade secrets than on patents, as firms in frontier countries. In Brazil, 14.3% of innovative firms use trade secrets to protect innovation, while only 7.6% use patents[90]. However, the two strategies are not mutually exclusive. As Table 4.A.7 (in Annex) shows correlations confirm the evidence founded for advanced economies.

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[89] The model then estimates the probability that a firm uses trade secret, following the specification of equation (1), but using as the dependent variable TRS^*_i, which indicates the probability that a firm had used trade secret to protect its innovation.

90 Trademarks are the most used appropriability mechanisms in Brazil, given that 23.7% of firms declare to use trademarks to protect their innovations, but even though this aspect is relevant for the kind of innovation activities carried out by firms in Brazil, and even though it would deserve higher attention by the literature, it is, anyway, less related with R&D efforts and with diffusion and access to knowledge, which are two crucial issues at stake in the discussion of patent regimes and policies in developing economies; a debate to which this paper intends to contribute.

The differences in the use of appropriability mechanisms derive from the variety of innovation culture in different firms and sectors.

Most of the questions of the PINTEC are addressed only to innovative firms; therefore, the analysis of the determinants of patenting might suffer of a sample selection bias. As a preliminary step, a Heckman probit model is run in order to test for eventual sample selection bias. The results of the probit model on the probability to patent with a selection equation on the probability to be innovative are presented in table 4.A.9 (in Annex). Results suggest that we cannot reject the hypothesis of unbiased estimates (i.e. the hypothesis of independence between the probability to innovate and the one of patenting). Estimates are not affected by sample selection. Table 4.A.10 (in Annex) reports the results of the Heckman probit model in the case of the probability of using trade secrets too, with a selection equation on the probability to innovate. As in the case of patenting, results suggest that we cannot reject the hypothesis of independence between the two equations, leading to assume that estimates are not biased[91]. Then a bivariate probit on the probability of using simultaneously patents and trade secrets is computed.

The results

Table 4.1 presents the bivariate probit estimations and the marginal effects of the probability that an innovative firm would protect innovation though patents and trade secret. Results suggest that we cannot reject the null hypothesis of zero correlation, i.e. firms tend to use patents and trade secrets as complementary, rather than alternative strategies.

The results shown in Table 4.1 indicate that one cannot reject the hypotheses that:

i. The probability to patent increases with firm size, and that this relationship is not linear;

ii. Foreign firms are more likely to apply for patents than domestic firms;

iii. The preference for patents depends on the innovative strategy of the firm. In particular, continuous efforts in R&D matters for patenting and firms engaged in cooperative R&D agreements are more likely to obtain patents, than firms operating in isolation.

iv. The preference for patents is higher in the case of product innovating firms and it is positively affected by the degree of novelty of the innovation; i.e. the firms

[91] Results for the selection equation (Tables 4.A.9 and 4.A.10) show that firm size, foreign ownership of capital, sectoral technological specialization and the fact that the firm belongs to a group appear all significant factors in explaining the probability that a firm is innovative.

introducing a product new for the global market are more likely to patent than less radically innovative firms.

v. The importance of patents varies across sectors. Firms in more technologically intensive sectors often show a higher patent propensity.

vi. Exposure to competition and export-orientation are often correlated with higher patent propensities.

These findings are in line with the results of the existing studies on advanced economies. The major difference is that in Brazil skilled human resources for R&D and openness to acquire knowledge through licenses do not have significant impact on the probability to patent. The lack of significance of the variable measuring the intensity of human resources for R&D with respect to total personnel is open to different interpretations. The results can be affected by the proxy used to measure innovation skills; in this case we have used the share of PhD and Master employees dedicated to R&D over total employment. This indicator might underestimate the quantity of human resources dedicated to R&D because in some sectors people carrying out the R&D that could lead to patentable products and processes might be technicians trained through working practice and not by formal PhD and master programmes. However, it might also indicate that R&D personnel is more involved in activities which will lead to development incremental innovations which are not patentable.

The lack of significance of the variable measuring the absorptive capacity of know-how and technology from outside the firm might indicate that markets for technologies are not so diffused in Brazil and that firms recur to external know-how as a substitute for internal development. Firms licensing by other firms might use the externally acquired knowledge for improvements or innovations with a lower degree of novelty that do not match the standards for inventive steps required for patentability.

In the case of the probability to protect innovation though trade secret the estimates suggest that we cannot reject the hypotheses that:

i. Foreign firms are more likely to use trade secrets than domestic firms, and the estimate of the coefficient is higher than in the case of the probability to patent.

ii. Firms' capabilities for innovation are significant in explaining the probability to rely on trade secret. The share of skilled human resources dedicated to R&D on total employment and the use of licensing and technology transfer positively affect the probability of using trade secret.

iii. Continuous efforts in R&D matters for trade secret, even though the coefficient is lower than the estimate obtained for the probability to patent. Firms engaged in R&D cooperation are more likely to use trade secret than non cooperative firms; and cooperation seems to affect more the probability of using trade secret than the one of using patents.

iv. Product innovating firms are more likely to rely on trade secrets than process innovating firms. And the more radical the innovation, the higher the probability to use trade secret (even though the degree of novelty of the product innovation seems to affect more the probability to patent than the one of using trade secret[92].

v. Sectoral specialization and export orientation matter for the probability to rely on trade secret.

The third column of table 1 shows the marginal effects after the bivariate probit estimations, of the simultaneous decision of applying for patents and for relying on trade secret. Estimates suggest that we cannot reject the hypotheses that:

i. The probability of using the two appropriability mechanisms rises non linearly with firm size.

ii. Foreign firms are more likely to rely both on patents and trade secret than domestic firms.

iii. Belonging to a group affects the appropriability strategy of firms.

iv. Firms with more skilled human resources are more likely to rely both on patenting and trade secret.

v. Investing continuously in R&D and being engaged in cooperative agreements positively affect the probability of obtaining patents and using trade secret.

vi. Product innovating firms are more likely to use both patents and trade secrets, and the degree of novelty of the product innovation positively affects the appropriability strategy.

vii. Sectoral specialization and export orientation matter for the probability to rely both on patenting and on trade secret.

Estimates of the marginal effects suggest that the two factors which have the stronger influence on the probability of jointly relying on patents and trade secrets are the degree of novelty of the product innovation and the fact that the firms carries out R&D on a continuous basis. When innovation is not just the result of a series of random events, but it is the outcome of an intended strategy, which often involves partnerships, sustained R&D investments and openness to absorb resources and knowledge outside the firm (including human resources and know how embedded in organizations and routines, the probability of using patents and trade secret to protect innovations is higher. In other words, firms with a "innovation culture" will tend to put in place an appropriability strategy using a combination of different mechanisms to protect innovations.

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[92] This can be explained by the legal requirements for patenting.

Table 4.1 Bivariate probit estimations and marginal effects
(Probability to use patents and trade secret)

		PATENTING	TRADE SECRET	Marginal effects (dx/dy)
Characteristics of the firm	Ln_size	0.089 ***	0.023	0.002 ***
		(0.029)	(0.023)	(0.001)
	For_Own	0.185 **	0.312 ***	0.008 ***
		(0.080)	(0.068)	(0.003)
	Group	0.128	0.112	0.004 *
		(0.082)	(0.069)	(0.002)
Capabilities for innovation	Skilled_HR	0.032	0.499 *	0.001 *
		(0.028)	(0.029)	(0.001)
	Know_tran	0.069	0.140 **	0.003
		(0.080)	(0.066)	(0.002)
Innovative strategy	R&D	0.515 ***	0.311 ***	0.016 ***
		(0.075)	(0.064)	(0.003)
	Coop	0.186 *	0.598 ***	0.013 ***
		(0.086)	(0.075)	(0.003)
	In_prod	0.373 ***	0.324 ***	0.009 ***
		(0.087)	(0.061)	(0.002)
	Prod_GMKT	0.925 ***	0.677 ***	0.069 ***
		(0.180)	(0.174)	(0.025)
Control variables	Sec_Tec_Int	0.224 ***	0.065 **	0.004 ***
		(0.032)	(0.026)	(0.001)
	Expo	0.270 ***	0.212 ***	0.007 ***
		(0.082)	(0.063)	(0.002)
	Constant	-3.222 ***	-2.006 ***	
		(0.181)	(0.124)	

N. of obs.	4476
Log likelihood = -2432.2687	
Wald chi2(22) = 919.55, Prob > chi2 = 0.000	
Athrho	0.217
	(0.046) ***
Rho	0.214
	(0.044)
Wald test of (rho = 0): chi2(1) = 22.1590. Prob > chi2 = 0.000	
Marginal effects after probit (predict) y = 0.008	

CONCLUSIONS

Brazil is playing in a different league in terms of technological and industrial capacities with respect to other Latin American countries. However, Brazilian manufacturing firms, on average, do not innovate as much, and in general, their innovations are more incremental than break through. As a consequence, it is not surprising that the national innovation survey shows that firms make a scant use of appropriability mechanisms. However, beyond the reduced use in comparison with frontier economies, the determinants of the use of appropriability mechanisms in Brazil are similar to the ones found in the studies based on innovation surveys of more advanced countries.

In Brazil, as it happens in more advanced economies, patents are not the preferred mechanism to protect innovations. The PINTEC 2003 shows that: i) There is a strong sectoral effect in the choice of the appropriability strategy. Firms belonging to high tech and medium-high tech sectors tend to show higher propensities both in patenting and in the use of trade secret; ii) larger firms are more likely to apply for patents than small ones, although this relationship is not linear; in fact some highly specialized SMEs could benefit from patenting by technology licensing and participating into the markets for technology; iii) the probability to patent is higher in the case of product innovations and it is positively affected by the degree of novelty of the innovation; firms that introduce a product which is new for the global market are more likely to patent than less radically innovative firms; iv) firms tend to adopt multiple mechanisms to protect innovations, and patents are complementary and not substitutes for trade secret; v) in contrast with the trend in more advanced economies, in Brazil foreign firms make more use of the different appropriability mechanisms than the domestic firms.

Data from the Brazilian national innovation survey contributes to show that the intellectual property system impacts in a different way different kinds of firms. Firms in high tech sectors tend to rely more on patent, than firms operating in other sectors. The patent gap between advanced and emerging economies might be due not to the prevailing legal system or to a lack of incentives for innovation, but to the type of technological specialization pattern. The reduced share of firms introducing break through innovations, also contributes to explain the scant propensity to patent at the aggregate level. Also, in countries where the majority of firms are SMEs concentrated in low or medium low technology sectors, a pro-patent policy for SMEs could result into an "empty policy", if not matched with a clear innovation strategy tailored to promote innovation in domestic firms. In practice, a pro-patent policy might benefit in the first place large foreign firms specialized in patent-intensive sectors, if it is not nested into a broader upgrading strategy and matched by a policy to strengthen the technological and production capacities of domestic firms.

The innovation survey also confirms that the use of appropriability mechanisms is related to the innovative strategy of the firm. Continuous efforts in R&D

and the engagement in cooperative R&D projects matters for patenting. When innovation is the result of an indented process the firm has a tendency to be aware of the appropriability problem and hence uses, according to its technological and firm-based capabilities, a combination of appropriability mechanisms that best suit it.

Governments could design better policies by assuming upfront the differentiate impact of policy choices on the different types of firms. Innovation surveys can be a powerful tool for improving policy making. Institutions (firms, statistical offices and researchers) learn how to make surveys, how to process the data, and how to analyze the results. For example, the Brazilian innovation survey could be improved by including a question on the number of patents (in force, applied and obtained), and by asking, as in the CIS surveys, to rank the different appropriability mechanisms according to their effectiveness in protecting the innovation. In addition, a question targeted to innovative firms that have not patented their innovation on the reasons why they did not applied for patents, could help in better understanding the interplay between innovation and appropriability strategies, and it could therefore be of use for policy formulation.

Innovation surveys can help to reveal firms' differentiated preferences and behavioral patterns, thus helping to fine-tune policies. A challenge for policy makers is to capture the heterogeneity in behaviors and in reactions to incentives and legal frameworks. Innovation surveys need to be used carefully as tools for evidence based policy making; it is important to think about the models and the assumptions used for processing and analyzing information. It is also relevant to complement their results with case studies.

Brazil is not yet a global leader in innovation; but things could change quickly, especially in our changing global economic environment, and innovation and patent policies need to evolve to accompany (and to promote) the ongoing country's transformation. This requires a better understanding of innovation dynamics within the country, more investment in improving innovation metrics and effective mechanisms to transfer analyses' results into policy formulation. Brazil has sound, well recognized institutions in this field, IPEA (Institute for Applied Economic Research), the more recent CGEE (Centre for Management of Strategic Studies, affiliated to the Ministry of Science, Technology and Innovation), these are institutional basis to build upon to advance in improving evidence in order to improve policy.

ANNEX- 4.1. EVIDENCE FROM THE BRAZILIAN INNOVATION SURVEY, PINTEC 2003.

Table A.4.1 The PINTEC 2003: Distribution of the sample and of innovative firms by industry

NACE	Industry	Sampled firms		Innovative firms	
		N	Share (%)	N	Share (%)
High tech inudustries		604	5.8	368	60.9
353	Aereospace	51	0.5	17	33.3
24.5	Pharmaceutical products	165	1.6	99	60.0
30	Computers and office machines	72	0.7	46	63.9
32	Telecomunication equipments	163	1.6	112	68.7
33	Percision instruments	153	1.5	94	61.4
Medium-high tech industries		1924	18.5	1049	54.5
31	Electrical machinery	299	2.9	170	56.9
29	Machinery and equipment	753	7.3	410	54.4
34	Motor vehicles	337	3.2	180	53.4
uding 24.5)	Chemiclas (exc. Pharma)	480	4.6	264	55.0
51 and 353)	Transport equipment	55	0.5	25	45.5
Medium low-tech industries		2457	23.7	942	38.3
351	Ship-building	26	0.3	11	42.3
25-26	Plastic and non-metallic minerals	1288	12.4	459	35.6
23	Oil	111	1.1	54	48.6
27-28	Basic metals and metal prodcuts	1032	9.9	418	40.5
Low-tech industries		5392	52.0	2117	39.3
15-16	Food, beverages and tobacco	1530	14.7	675	44.1
17-18	Textiles	1438	13.9	516	35.9
19	Leather	580	5.6	202	34.8
20	Wood	493	4.8	171	34.7
21-22	Pulp, paper and printing	653	6.3	258	39.5
36-37	Other	698	6.7	295	42.3
		10377	100	4476	43.1

Note: the classification of sectors according to their technological intensity follows the OECD classification (OECD, 2005). For a discussion and a comparison regarding different taxonomies of industry according to the technological intensity of manufacturing production see ECLAC (2007), and Chapter 4 of this dissertation.
Source: own elaboration on the basis of the PINTEC, 2003

Table A.4.2 Innovative firms using each appropriability mechanism, by firm size (%)

Employees	N	Patents	Utility models	Industrial desings	Trade marks	Copyright	Compexity in desing	Trade secret	Lead time advantage	Other
10-49	1406	3.1	4.6	3.4	21.6	1.1	1.4	8.5	1.3	2.0
50-99	755	3.2	5.0	4.5	12.8	0.8	1.6	9.4	1.6	2.8
100-249	851	5.6	5.5	7.4	18.4	1.1	1.6	10.0	2.1	4.2
250-499	506	8.7	9.5	13.2	20.6	1.8	3.4	13.2	5.1	4.9
> 500	958	4.0	2.9	4.0	8.9	1.2	1.7	6.6	4.8	1.3
Total	4476	7.6	7.4	8.7	23.7	2.1	3.1	14.3	6.5	3.7

Table 4.A.3 Innovative firms using each appropriability mechanism by kind of innovation (%)

	N	Patents	Utility models	Industrial desings	Trade marks	Copyright	Compexity in desing	Trade secret	Lead time advantage	Other
Product innovation	2816	10.7	10.6	12.1	31.2	2.8	4.3	18.9	9.4	4.7
Process innovation	3628	6.9	6.7	8.5	23.1	1.8	3.2	13.7	6.7	3.6
Product and process innovation	1968	10.9	10.7	13.2	33.4	2.7	5.0	19.9	11.2	4.8

Table A.4.4 Use of appropriability mechanisms by intensity of product and process innovation (% of innovative firms)

Product innovation	N	Patents	Utility models	Industrial desings	Trade marks	Copyright	Compexity in desing	Trade secret	Lead time advantage	Other
New for the firm	1246	4.3	7.5	9.5	27.0	1.4	1.7	10.4	2.2	3.0
New for the domestic market	389	27.2	15.2	18.8	43.2	7.2	9.8	37.0	27.0	9.3
New for the international market	64	54.7	34.4	35.9	64.1	17.2	20.3	60.9	46.9	9.4
Process innovation										
New for the firm	1340	4.8	5.2	7.5	22.1	1.4	2.7	11.1	4.0	2.7
New for the domestic market	237	27.0	16.9	21.1	49.8	8.4	12.7	43.9	29.5	10.5
New for the international market	33	54.5	45.5	30.3	48.5	12.1	18.2	57.6	42.4	12.1

Table A.4.5 Use of appropriability mechanisms by industry

NACE		Patents	Utility models	Industrial desings	Trade marks	Copyright	Compexity in desing	Trade secret	Lead time advantage	Other
15-16	Food, beverages and tobacco	2.8	1.9	6.5	30.4	0.4	1.8	14.4	3.4	3.7
17-18	Textiles	1.2	0.6	2.5	20.3	0.2	0.8	6.0	3.5	2.3
19	Leather	2.0	5.0	8.9	21.3	0.5	2.0	9.4	3.5	1.5
20	Wood	1.2	2.3	3.5	8.2	0.0	0.6	8.2	2.3	2.3
21-22	Pulp, paper and printing	5.8	7.4	5.8	19.0	5.4	2.3	8.9	4.7	2.7
23	Oil	3.7	1.9	3.7	24.1	3.7	0.0	11.1	0.0	0.0
24 (excluding 24.5)	Chemiclas (exc. Pharma)	14.8	8.0	7.2	36.0	3.0	2.7	25.8	11.7	4.5
24.5	Pharmaceutical products	12.1	8.1	6.1	46.5	6.1	0.0	19.2	11.1	7.1
25-26	Plastic and non-metallic minerals	8.3	7.8	9.2	16.1	1.3	3.9	13.1	7.0	3.3
27-28	Basic metals and metal prodcuts	6.7	7.7	8.4	15.6	1.2	2.6	13.6	6.2	3.3
29	Machinery and equipment	15.6	18.0	16.3	25.4	2.4	6.1	17.3	8.3	6.3
30	Computers and office machines	21.7	17.4	15.2	41.3	8.7	15.2	41.3	17.4	2.2
31	Electrical machinery	16.5	16.5	9.4	29.4	5.9	4.7	20.6	12.4	4.7
32	Telecommunication equipments	8.0	8.9	9.8	26.8	3.6	4.5	19.6	9.8	4.5
33	Precision instruents	23.4	18.1	19.1	36.2	7.4	3.2	22.3	9.6	7.4
34	Motor vehicles	14.4	12.8	15.0	23.3	3.9	9.4	26.1	13.9	4.4
35 (excluding 351 and 353)	Transport equipment	4.0	4.0	12.0	32.0	8.0	4.0	12.0	8.0	8.0
353	Aereospace	0	0	5.9	17.6	0.0	5.9	17.6	11.8	0.0
351	Ship-building	0.0	0.0	0.0	9.1	0.0	0.0	0.0	9.1	0.0
36-37	Other	4.4	7.1	13.6	20.0	0.7	2.7	8.1	4.1	3.7
	Total manufacuring (%)	7.6	7.4	8.7	23.7	2.1	3.1	14.3	6.5	3.7

Table A.4.6 Use of appropriability mechanisms by sectoral technological intensity and ownership of capital (% of innovative firms)

	Domestic	Foreign	Patents		Utility models		Industrial desings		Trade marks		Copyright		Compexity in desing		Trade secret		Lead time advantage		Other	
	N		D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F
Low-tech	1984	133	2.3	10.5	3.1	6.8	5.8	15.0	21.2	41.4	0.7	6.0	1.3	7.5	8.5	29.3	2.6	18.8	2.7	6.8
Medium-low-tech	829	113	5.8	17.7	7.1	8.8	7.0	18.6	15.2	23.9	1.2	2.7	2.4	8.0	11.3	25.7	4.9	15.9	2.8	5.3
Medium-high-tech	763	286	11.1	25.5	13.4	15.7	11.8	14.7	26.2	34.6	2.1	7.3	3.0	12.2	15.6	36.7	6.0	23.4	5.1	5.9
High-tech	282	86	13.5	17.4	13.1	7.0	11.3	12.8	36.5	33.7	4.6	9.3	3.5	7.0	19.1	34.9	8.2	20.9	6.4	2.3
Total	3858	618	5.6	19.7	6.7	11.3	7.7	15.2	22.0	34.0	1.3	6.5	2.0	9.7	11.3	32.8	4.2	20.7	3.4	5.5

Table A.4.7 Correlation (Pearson) of different appropriability mechanisms for all innovative manufacturing firms (N of observations 4476)

	Patents (P)	Utility Models (UM)	Industrial Desings (ID)	Trade Marks (TM)	Copy Rights (CR)	Complex. in Desing (CD)	Trade Secret (TS)	Lead Time Advantages (LTA)	Other (O)
P	1								
UM	0.4023	1							
ID	0.3015	0.4118	1						
TM	0.2129	0.1977	0.2176	1					
CR	0.191	0.1825	0.173	0.2946	1				
CD	0.1789	0.133	0.2199	0.1562	0.2019	1			
TS	0.2314	0.1567	0.2023	0.2597	0.1974	0.3004	1		
LTA	0.2346	0.1489	0.1735	0.2024	0.1477	0.2529	0.4099	1	
O	0.082	0.213	0.0311	0.0402	0.0379	0.0399	0.0511	0.0826	1

Table A.4.8 Independent variables used in the study, description

	Variable name	Definition
Characteristics of the firm	Ln Size	Ln of the number of employees
	Foreign Ownership (For_Own)	1 if the firm is controlled by foreign or mixed capital, 0 if the firm is purely national
	Group	1 if the firm belongs to a group, 0 if the firm is independent
Capabilities for innovation	Skilled-Human Resources (Skilled_HR)	Share of phd and master employees over total employment dedicated to R&D activities. The n. of people dedicated to R&D includes all employees dedicated exclusively plus those with partial dedication counting them has part-time
	Knowledge -Transfer (Know_tran)	1 if the firm declared to have spent a positive amount of money between 2001 and 2003 in agreements of technology transfer, licensing fess for patents, trademarks, acquisition of know how, software and other kinds of knowledge acquired from external sources for developing innovations, 0 otherwise
Innovative strategy	R&D_Continuous (R&D)	1 if the firms declares to carry out continuous R&D, 0 if the firm carries out R&D in a discontinuous way of if it does not carry out any R&D activity
	Cooperative agreements (Coop)	1 if the firm declared to have been involved in cooperative agreements with other organizations in order to carry out innovative activities, 0 otherwise).
	Product innovation (In-prod)	1 if the firm introduced a product innovation, 0 otherwise
	Degree of novelty of product innovation (Prod_GMKT)	1 if the firm introduced a product new for the international market, 0 otherwise
Control variables	Sectoral technological intensity (Sec_Tech_Int)	an indicator ranging from 1 to 4 according to the technological intensity of the sector of reference. For the indistry classification according to technological intensity see Table 1 in the annex
	Exporting firm (Expo)	1 if the firm exports, 0 otherwise

Table A.4.9 Probit model with sample selection (probability of patenting)

		PATENTING	Selection equation INNOVATIVE
Characteristics of the firm	Ln_size	0.139 ***	0.214 ***
		(0.038)	(0.010)
	For_Own	0.224 ***	0.245 ***
		(0.079)	(0.489)
	Group	0.152 *	0.115 **
		(0.078)	(0.045)
Capabilities for innovation	Skilled_HR	0.026	
		(0.027)	
	Know_tran	0.067	
		(0.075)	
Innovative strategy	R&D	0.477 ***	
		(0.086)	
	Coop	0.157 **	
		(0.082)	
	In_prod	0.352 ***	
		(0.087)	
	Prod_GMKT	0.867 ***	
		(0.183)	
Control variables	Sec_Tec_Int	0.249 ***	0.159 ***
		(0.031)	(0.014)
	Expo	0.254 ***	
		(0.083)	
	Constant	-3.770 ***	-1.444 ***
		(0.266)	(0.053)
N. of obs.	10377		
Censored obs.	5901		
Uncensored obs.	4476		
Log likelihood = -7567.194			
Wald chi2(11) = 569.24, Prob > chi2 = 0.000			
Athrho	0.555		
	(0.542)		
Rho	0.504		
	(0.404)		
LR test of indep. Eqns. (rho = 0): chi2(1) = 0.91. Prob > chi2 = 0.3407			

Table A.4.10 Probit model with sample selection (Probability of using trade secret)

		TRADE SECRET		Selection equation INNOVATIVE	
Characteristics of the firm	Ln_size	0.087	**	0.214	***
		(0.039)		(0.010)	
	For_Own	0.354	***	0.242	***
		(0.066)		(0.489)	
	Group	0.136	**	0.117	**
		(0.066)		(0.045)	
Capabilities for innovation	Skilled_HR	0.044	*		
		(0.023)			
	Know_tran	0.124	*		
		(0.064)			
Innovative strategy	R&D	0.282	***		
		(0.067)			
	Coop	0.546	**		
		(0.091)			
	In_prod	0.294	***		
		(0.065)			
	Prod_GMKT	0.618	***		
		(0.173)			
Control variables	Sec_Tec_Int	0.108	***	0.159	***
		(0.031)		(0.014)	
	Expo	0.195	***		
		(0.063)			
	Constant	-2.714	***	-1.444	***
		(0.294)		(0.053)	
N. of obs.	10377				
Censored obs.	5901				
Uncensored obs.	4476				
Log likelihood = -8181.783					
Wald chi2(11) = 773.11, Prob > chi2 = 0.000					
Athrho	0.651				
	(0.543)				
Rho	0.572				
	(0.365)				
LR test of indep. Eqns. (rho = 0): chi2(1) = 1.17. Prob > chi2 = 0.279					

CHAPTER 5

CHANGES IN INTELLECTUAL PROPERTY REGIMES AND THE "NEW" MARKETS FOR KNOWLEDGE*

This chapter discusses the changes in intellectual property management of the last two decades, within the US and at the international level. These changes, matched with rising globalization and the diffusion of information technologies, have contributed to create new "derivative" markets for knowledge, where patents have been transformed into new sources of rents, beyond the value of the patented technology. After the initial enthusiasm about the potential of these new "markets for ideas", some constituencies, including large companies that had been praising the benefits of the markets for knowledge, have started to raise concerns about the potential adverse impact of too patent-intensive marketplaces. Now, while in advanced economies the debate on intellectual property is evolving fast, with new voices asking for preserving spaces to access and share knowledge to promote innovation, the discussion in developing countries tends to be linked to more conventional positions. This chapter presents legal and empirical evidence in support of the argument that developing countries need to shift up a gear in understanding the evolution of global knowledge governance. The Latin American innovation agenda needs to include pragmatic approaches to address the issue of intellectual property and knowledge access and take original, proactive stances that reflect its varied development priorities, of today and of the future.

* This chapter draws and updates Cimoli and Primi (2007, 2008) and Cimoli *et al.* (2009a).

INTRODUCTION

Since the mid of the 1990s, intellectual property has been an issue of growing relevance in innovation policies in Latin America. However, the debate has often been focused on "extreme" positions, like "intellectual property" is "good" or "bad" for innovation in developing countries. A closer look at innovation theory (as presented in Chapter 3 of this dissertation) and more evidence on innovation and appropriability strategies of firms in the countries of the region (as the case of Brazil presented in Chapter 5) can help to shift towards more "reality-based" and pragmatic approaches to intellectual property management.

Latin American countries are designing and implementing innovation policies in a global landscape that is changing rapidly and where the issues that concern knowledge generation, appropriation and diffusion are of rising importance. For these reasons in defining the aspects of innovation policies that refer to intellectual property management it is important to monitor and understand the global trends.

Since the 1980s intellectual property regimes have changed deeply. The United States have witnessed a rising pro-patent attitude in the national patent office and an expansion of patent subject matter in its courts. At the international level, the adoption of TRIPS (Trade Related Aspects of Intellectual Property Rights) agreement in 1994 has set the US standards as minimum protection requirements for all WTO countries. These changes went hand in hand with the development of new technological paradigms, including ICT and biotechnology, in which the boundaries between science and business are blurring and in which innovations are more and more of incremental nature, therefore requiring extensive access to existing knowledge.

Stronger and globally homogenous IP regimes, coupled with the emergence of new technological paradigms engendered an explosion in patent applications and grants. Firms have started to increase the number of patents applied for. However, it is well known that patents are nor the unique or the preferred appropriability mechanism of innovative firms. What can explain the exponential patent boom of the late 1990s and the 2000s? (Levin *et al.* 1987; Choen *et al.* 2000; see also Chapter 4 of this dissertation).

The reshaping of global IP regime has favored the creation of new markets for knowledge where patents have become assets *per se,* beyond the value that could be generated by their industrial application. As in financial markets, the new patent regime has fostered the creation of "derivative" markets for knowledge. Patent holders can make profits by speculating on the future potential value of patents, by asserting or trading patents for defensive purposes without need to "use" the patented technology. In this context, the patent system seems to have departed from its original function of creating artificial monopolistic positions in exchange of information disclosure. Patents have been converted into mechanisms for rent generation. This is particularly dangerous because beyond being source of additional extra-rent, these patents still perform as "exclusive" rights in "real markets" and temporarily limit the use of patented technologies, thus rising barriers to access knowledge in the "real economy". In certain cases, the opportunities of making profits by patent trading or by bashing competitors through legal suits can even contribute to divert resources from R&D.

As knowledge and innovation become increasingly relevant to sustain growth and achieve development, the rules that shape the incentives to invest in creating and diffusing innovations become paramount. Developing economies need to be aware of the emerging global trends to be able to take proactive stances that reflect their, current and future, development priorities.

The first section of this chapter sketches out some stylized facts on patenting trends, specialization patterns and global markets for knowledge. It then analyzes the evolution of intellectual property regimes from the 1980s onward. The third section presents an interpretation of the contemporary markets for idea, highlighting the conditions that have led to the emergence of "derivative" markets for knowledge, where patents' holders can extract rents beyond the exploitation of the patented technologies. It concludes by calling for a new knowledge governance agenda to foster knowledge creation and diffusion taking into account the variety of interests and the asymmetries in capabilities that characterize the contemporary global open economies and developing countries in particular.

5.1 GLOBAL ASYMMETRIES IN TECHNOLOGICAL CAPABILITIES AND PATENTING

This section sketches out some stylized facts on innovation and patenting. It focuses on: i) recent trends in patenting, the persistency in the dominance of early innovators (like the US) and the rise of new actors (notably, the South East Asian economies); ii) the correlation between specialization patterns and patenting, and its evolution over time (i.e. as countries specialize in more knowledge intensive sectors, they increase their patent propensity); iii) the specialization in international trade in intangibles.

Patenting trends, incumbents and new entries in the "knowledge club"

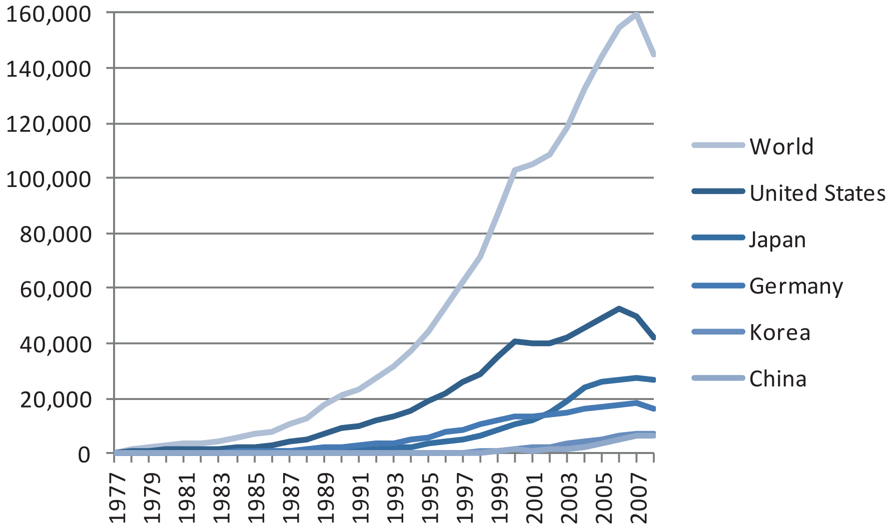
Patenting has intensified over the last decades, especially since the mid 1990s. At the beginning of the 1980s the number of world patent applications filed under the PCT (Patent Cooperation Treaty) was less than 3 000, in 2007 it was almost 160 000[93] (Figure 5.1). Patent offices have also started to grant more patents. The activ-

[93] In the case of triadic patent families, patent applications grew from 22879 to 52864 from 1985 to 2005, showing a cumulative increase of 230% in twenty years (OCED Patent Database). Several studies

ity has intensified in many national patent offices, but the most important ones still are the US, the European and the Japanese one[94]. Among them, the USPTO (United States Patent and Trade Mark Office) registers the most intensive patent activity. The office has granted, on average, 60 000 patents per year between 1980 and 1982, and 160 000 between 2007 and 2009 -this is three times the number of patents granted by the EPO (European Patent Office) in the same period[95] (Figure A.5.1)

Figure 5.1 Number of patent applications filed under the Patent Cooperation Treaty, 1977-2008

World total and top 5 countries



Note: patents are attributed to countries by priority year, on the basis of fractional counts, and as per inventor's address.
Source: Author's elaboration on the basis of OECD Patent Database.

The global increase in patenting has been characterized by three main features:

i. Patenting is a "concentrated" game. Top 5 countries own almost 90% of total patent grants in 2009 as they did in the 1960s (Table 5.1).

analyze this increase in patenting (Kortum and Lerner, 1999; Hall, 2004; Guellec, Martínez and Sheehan, 2004).

[94] Analyzing patenting activity in a national patent office for international comparisons presents the disadvantage of the "home bias", i.e. the fact that national residents have a higher propensity to patent in their national patent office, rather than foreigners. However, while it is important to have this caveat in mind, patenting activity at the USPTO and at the EPO are relatively good proxies for cross-countries comparisons of technological efforts.

[95] The EPO granted on average 3 000 patents per year between 1980 and 1982, and 55 000 between 2007 and 2009.

ii. The role of early incumbents persists. The US is still the top patenting country in the world. Germany, the UK and France, which were, respectively the top 1, 2 and 4 foreign economies for patent granted by the UPSTO in the 1960s, are still major players in the 2000s, but their shares have declined sensitively (the UK has also lost ground in terms of absolute number of granted patents, not only in the share). Japan is the foreign country that patents the most in the United States; it accounts for 45% of total patents granted to foreign economies by the USPTO (in the 60s it ranked 3rd accounting for 12%). (See also Table A.5.2, in Annex).

iii. New actors are emerging as top patent holders[96]. A major change has been the rise of the Asian economies. While up to the 1980s, Japan, Germany, UK and France were the top foreign economies for patent granted by the USPTO, from the 1990s onwards, Taiwan and the Republic of South Korea replaced the European economies in the top 5 world patenting countries (Table 5.1)[97]. China is also emerging as an innovator. In 2007 it ranked 8th as top foreign economy for patents granted by the USPTO, accounting for 1.8% of total patents granted to foreigners (its share in the 1960s was 0.05, Table 5.A.1, in Annex). The rise of Asian economies in patenting follows the structural changes experimented by these economies, which radically transformed their production structure by increasing the share of technology intensive sectors in their manufacturing industries and by catching up in productivity. Since the mid of the 2000s, foreign companies own the majority of patents granted by the USPTO (their share rose from 17% in 1965-67 to 46.45% of total granted patents in 2007-09. In parallel, the share owned by US corporations declined from 57% to 43% (Figure 5.2).

Table 5.1 Share of USPTO patent grants by country of origin, top 5 countries, 1965-2009

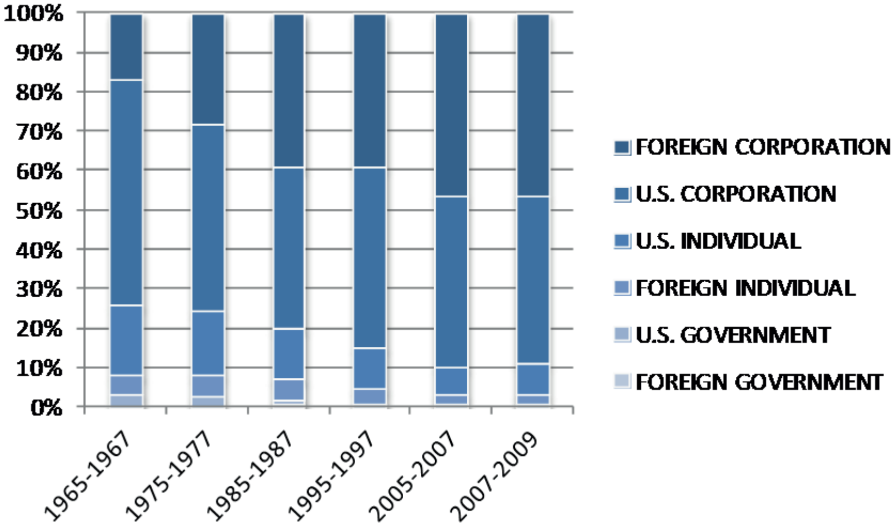
	1965-1967	1975-1977	1985-1987	1995-1997	2005-2007	2007-2009
Cumulative share of TOP 5 countries	**86.18**	**88.98**	**88.84**	**86.68**	**88.09**	**88.15**
Share of US	75.30	63.11	52.25	54.88	49.96	49.72
Cumulative share of TOP 4 foreing	16.57 (Germany, UK, Japan, France)	25.87 (Japan, Germany, UK, France)	36.59 (Japan, Germany, UK, France)	31.8 (Japan, Germany, France, UK)	38.13 (Japan, Taiwan, South Korea, Germany)	38.43 (Japan, Taiwan, South Korea, Germany)

[96] The share of USPTO patents granted to residents decreased from 75.30% in 1965-67 to less than 50% in 2007-2009, while the share of top 4 foreign patenting economies rose from 16.57% to almost 40%.

[97] China and the Republic of South Korea are today among the top 5 countries for patent applications, accounting for slightly more than 4% of total world PCT applications, while in the early 80s their patenting activity was almost inexistent.

Note: Shares are computed over cumulative number of patent grants for each indicated period. Data refer to utility patents granted as distributed by year of patent application.
Source: Author's calculations on the basis of USPTO patent database.

Figure 5.2 USPTO patent grants by category of ownership, 1965-2009



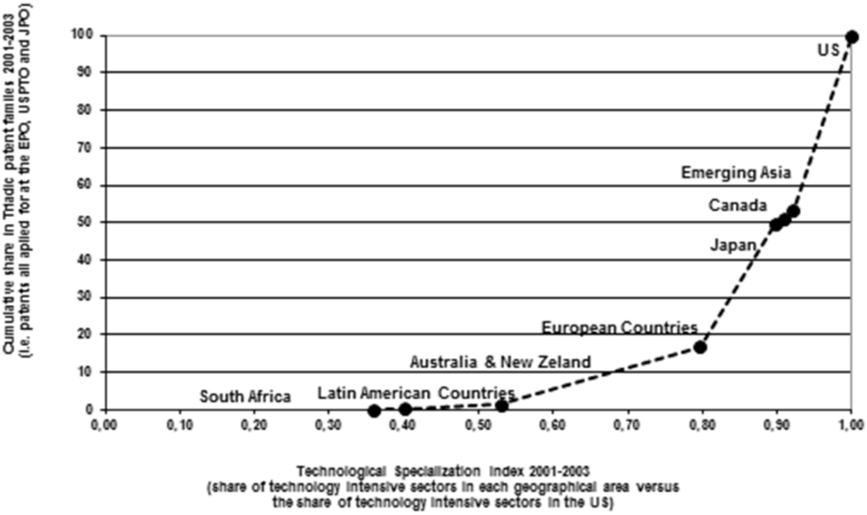
Note: Shares are computed over cumulative number of patent grants for each indicated period. Data refer to utility patents granted as distributed by year of patent application.
Source: author's elaboration on the basis of USPTO Database.

Technological specialization, R&D and patenting

Asymmetries in patenting between countries derive from the differences in production specialization and innovation models. Advanced economies are more specialized in knowledge and technology intensive activities, while developing economies tend to operate at lower levels of production. Advanced countries also invest more in R&D and human capital, than developing economies. In addition, the innovation efforts in developing countries tend to be adaptive in nature, and rarely encompass break-through inventions, thus rarely leading to patents (Aboites and Cimoli, 2002; Cimoli, 2005).

However, the geography of production and innovation is changing. Emerging economies are increasingly entering into new sectors and are learning to innovate. The catching up of the Republic of South Korea, as well as the recent transformation of China, are showing that rising patenting comes as a consequence of structural transformation towards more value-added activities and knowledge intensive sectors and increased investments in innovation. The economies that are more specialized in technology intensive sectors are also those accounting for the higher shares in world patenting, while most developing countries in which the technology intensive sectors account for less than 30% of total manufacturing value added, also have residual shares in global patenting (Figure 5.3). Emerging Asian countries, including India, the Republic of South Korea, Taiwan and Singapore have achieved a structural transformation of their economies by entering into new, technology intensive sectors. The share of these sectors in their domestic manufacturing vale added is today close to the United States. However, they are not yet major players in global patenting; they are in their "learning phase".

Figure 5.3 The global knowledge curve: production structure and patenting behavior



Note: Emerging Asia includes India, The Republic of South Korea and Singapore. Latin American countries include Argentina, Brazil, Chile and Mexico. European countries include: Finland, France, Ireland, Israel, Norway, Sweden and the UK The specialization index for group of countries is calculated as the simple average of the index value for each member country. These countries account for more than 95% of global manufacturing activity. Countries are ranked on the horizontal axis according to the relative intensity of technological specialization with respect to the technological frontier (a value 1 means that the country has the same technological specialization as the technological frontier). The vertical axis displays the accumulated share in total patent applications.
Source: Cimoli and Primi (2007) and Cimoli *et al.* (2009a), on the basis of OECD Patent Database, ECLAC-Padi and OECD-Stan Databases.

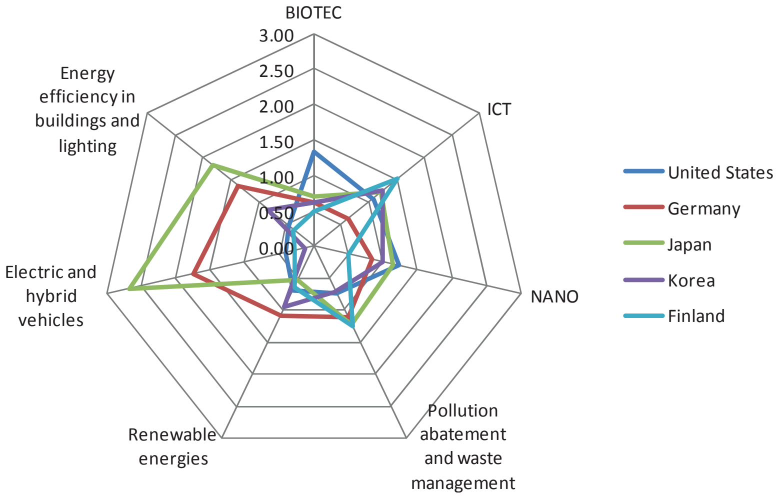
Patenting is related to technological specialization, but also to innovation efforts, and especially to investments in R&D. Even though the correlation between R&D investment and patenting does not imply causality, it is evident that to achieve an increase in patenting, developing countries need to shift towards a more R&D-intensive model. All developing countries invest less than 1% of their GDP in R&D, and the majority of them even less than 0.5% (advanced countries devote higher resources to R&D, from the 2% of GDP in France to the 4% of Sweden (Figure A.5.2). Advanced and developing economies also differ in terms of sectoral specialization of patenting. The United States leads in the patenting in emerging technological fields including, biotechnology, ICT, nanotechnology, and in environmental related technologies with the exception of electric and hybrid cars and energy efficiency in buildings and lighting, where the leaders are the Japanese. China has recently increased its patenting activity, and now qualifies among the world top 10 patenting countries in ICT and most environmental related technologies[98].

Specialization in patenting in given technologies results from the production structure, but also from the different strategies that countries follow to accumulate knowledge. Comparing the specialization profile of advanced countries with the one of emerging economies, reveals that the latter are relatively more specialized in new fields, including the green technologies (Figure 5.4 and 5.5)[99]. Among the emerging economies, India has the more balanced profile. Brazil and South Africa are relatively specialized in green technologies, especially renewable energies and pollution abatement, while China is relatively specialized in ICT and renewable energies. Some advanced countries show a balanced specialization profile, like the United States. Others, including Finland, Germany and Japan exhibit strongly specialized profiles (Germany and Japan in environmental related technologies and Finland in ICT and environmental protection, for example).

[98] Figures A.5.4 to A.5.9 in Annex show the world top 10 patenting countries in selected emerging technological fields.

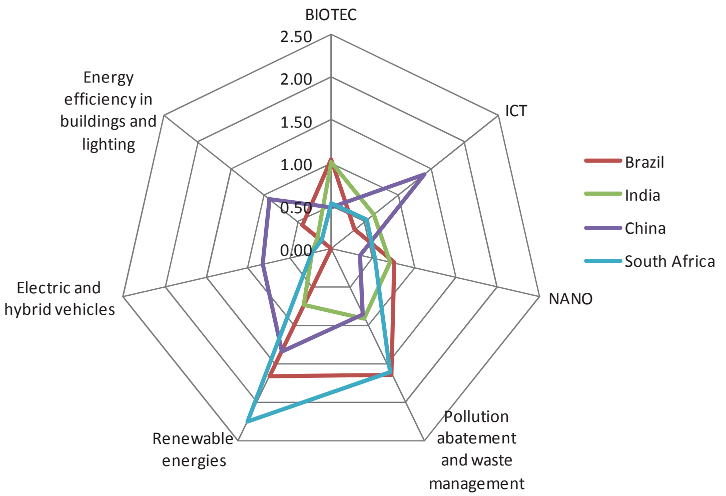
[99] When looking at specialization indexes for emerging economies it is important to take into account that their patenting activity in absolute numbers is rather low. Nevertheless, the specialization index remains a good proxy to compare the variety in sectoral orientation of countries.

Figure 5.4 Technological specialization index: USA, Germany, Japan, the Republic of South Korea and Finland, 2005-2007



Note: the Technological Specialization Index is a measure of relative specialization in technological fields with respect to total country's participation to total patenting. The indicator is the ration between the shares of patenting in technology sector j of country i of total patenting of sector j on total patenting of country i on total world patenting.
Source: Author's calculations on the basis of the OECD Patent data base.

Figure 5.5 Technological specialization index: Brazil, India, China and South Africa, 2005-2007



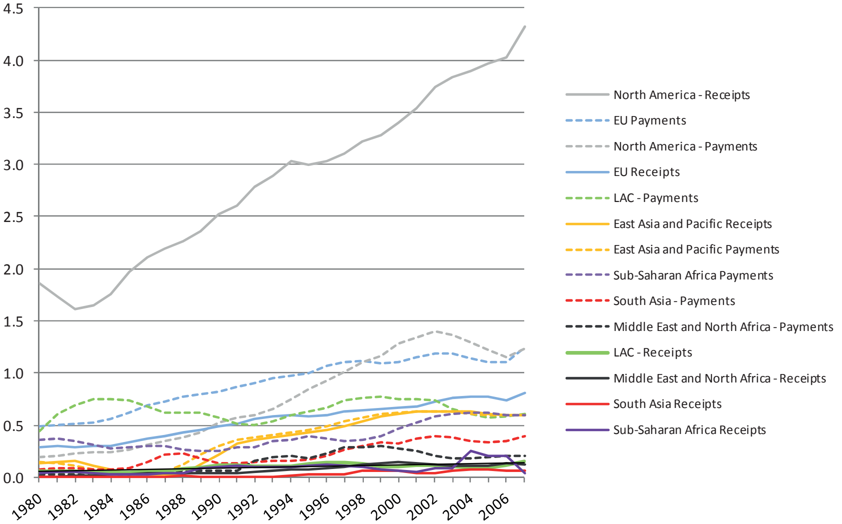
Note: the Technological Specialization Index is a measure of relative specialization in technological fields with respect to total country's participation to total patenting. The indicator is the ration between the shares of patenting in technology sector j of country i of total patenting of sector j on total patenting of country i on total world patenting.
Source: Author's calculations based on OECD Patent data base.

Global markets for intangibles: who sells and who buys?

Since the 1980s, in addition to the rise in patent applications and grants, international trade in intangibles has also increased. International licensing is, in fact, on the rise, also due to fact that firms increasingly carry out innovations combining in-house efforts and strategic alliances that involve licensing and cross-licensing to implement technologies developed elsewhere[100]. North America is the only region where receipts for intangibles relative to exports grew more than payments to access intangibles relative to imports. In all the other regions, the rise in the market for intangibles meant meanly an increase in payments for royalty and license fees (Figure 5.6).

Figure 5.6 Rising global trade in intangibles, 1980-2009

Share of payments (and receipts) over total imports (and exports), three year moving average



Note: National accounts compute country payments and receipts between residents and non-residents for royalty and license fees for the authorized use of intangible, non-produced, non-financial assets and proprietary rights (such as patents, copyrights, trademarks, industrial processes, and franchises) and for the use, through licensing agreements, of produced originals of prototypes (such as films and manuscripts).
Source: Author's calculations based on World Bank Indicators database.

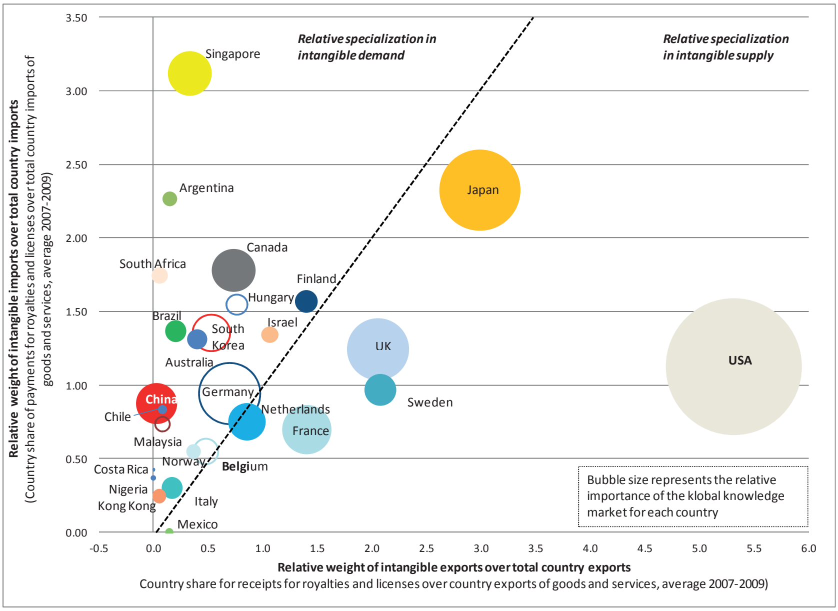
Even though new players have entered in the global market for intangibles, its global supply is still extremely concentrated. Top 10 countries account for 90% of

[100] See Athreye and Cantwell (2005); Grindley and Teece (1997); Rivette and Kline (2000); Arora *et al.*, (2001); Hall and Ziedonis (2001); Arora and Merges (2004); OECD (2005), and The Economist (2005).

world intangible exports[101]. The concentration in global knowledge supply has started to decline due to the increased globalization and technological catching up in emerging economies. The share of the US in global intangible supply has declined from 80% in the 1970s to less than 50% in 2009. A growing number of emerging economies are now main importers of intangibles, as it is the case of China and Singapore (Table A.5.2, in Annex). Countries differ in their participation to the global market for intangibles and for their specialization in knowledge demand or supply (Figure 5.7 and 5.A.10, in Annex). Most countries are specialized in knowledge demand, while the US, Japan, UK, Sweden and France are specialized in global knowledge supply. Germany, the Netherlands and Belgium show a more balanced pattern between knowledge demand and supply. The role of countries in the global market for intangibles depends on their development stage and on their development strategy. Catching up countries often need to learn and implement technologies that have been developed elsewhere; therefore they specialize in "buying" intangibles.

[101] Japan, Germany, UK, France, the Netherlands, Sweden, Canada, the Republic of South Korea and Belgium are top knowledge suppliers after the US. The fact that this ranking is not identical to the ranking of top 10 patenting country can be explained because royalty and license fees and payments refer not only to patents but also to transactions regarding copyrighted material and trademarks. But it can be also the result of different commercialization strategies of intellectual property; in fact not all patent holders license their patents.

Figure 5.7 Global market for intangibles, 2007-09



Note: The figure depicts the global market for knowledge according to the relative specialization in knowledge supply (horizontal axis) and in knowledge demand (vertical axis) weighted by the relevance of transactions in intangibles over total international trade. National accounts compute country payments and receipts between residents and non-residents for royalty and license fees for the authorized use of intangible, non-produced, non-financial assets and proprietary rights (such as patents, copyrights, trademarks, industrial processes, and franchises) and for the use, through licensing agreements, of produced originals of prototypes (such as films and manuscripts).
Source: Author's calculations based on World Bank Indicators database.

5.2 MAJOR CHANGES IN IP REGIMES[102]

The global increase in patent activity has been the result of deep changes in intellectual property laws and regimes. This section illustrates the main changes that have occurred in the last decades focusing on two major issues: i) the changes in the US that have fostered a more pro-patent attitude and ii) the introduction of intellectual property provisions in trade agreements that have established homogeneous minimum standards of protection internationally and higher protection requirements through bilateral trade and investment agreements.

[102] This draws and updates Cimoli *et al.* (2009a).

Expanding patentability in the United States

Since the 1980s the US administration has introduced relevant changes in IP management, deliberately targeted to intensify patent protection through different channels, including extension of patentable subject matter, increase in protection time-length and ease in conditions to allow patenting by universities and research laboratories[103].

The extension of patentable subject matter

According to the US law: "Whoever invents or discovers any new and useful process, machine, manufacture or composition of matter, or any new and useful improvement thereof, may obtain a patent" [104]. But patentability was strictly limited by industrial utility and applicability. The US jurisprudential tradition considered, for example, living entities, laws of nature, and hence mathematical formulas, not patentable (Gottschalk v. Benson, 1972). However, from the 1980s the United States have witnessed an extension of the patentable subject matter due to some Supreme Court rulings (Hunt, 2001). In 1981 the *Diamond v. Diehr* Supreme Court decision paved the way for the patentability of computer software and business methods by asserting that "a claim drawn to subject matter otherwise statutory does not become non-statutory simply because it uses a mathematical formula, computer program or digital computer". The relaxation of patentability criteria allowed US firms to use patents to protect physical inventions as well as more abstract ones, including computer programs or business models and methods[105].

The institution in 1982 of the Court of Appeals for the Federal Circuit (CAFC) has also contributed to extend the patentable subject matter through rulings that reversed the previous doctrine. The 1998 *State Street Bank and Trust v. Signature Financial Group* decision, allowed the patentability of business methods when the claimed invention satisfies the requirements of novelty, utility, and non-obviousness, and contributed to loosen up the utility requirement. This decision reversed the prevailing doctrine and established that it was possible to patent algorithms as long as they were applied in "a useful way", i.e. as long as they contributed to produce "a useful, concrete and tangible result". In addition, this decision established that registrants seeking patent protection for business methods or algorithms were not required to disclose their computing methods[106]. The possibility to patent mathematical formulas and algorithms has contributed to create what Shapiro has called a "patent thicket". This phenomenon has potential negative effects on future rates of innovations in the context of incremental innovations, as in

[103] There is a conspicuous body of literature analyzing the changes in IP laws and court rulings, and the boom in patenting activity, see Kortum and Lerner, 1999; Hunt, 2001; Gallini, 2002, among others.

[104] US Code, title 35, part II, chapter 10, paragraph 101

[105] The Amazon's "one click" patent granted in 1999 by the USPTO is a clear example in this sense.

[106] On software patentability see, among others, Liotard (2002) and the survey of Besen and Raskind (1991).

the software industry, where each new application can often be built upon a series of hundreds of patented algorithms (Shapiro, 2001).

The extension of the patentable subject matter has also involved living entities. The 1980 *Diamond v. Chakrabarty* Supreme Court decision stated that "a live, human made micro-organism is patentable subject matter" [107]. The 1995 *re Brana* ruling established the "presumption of utility" and it, therefore, recognized the validity of patent claims on potential discoveries. In the US system "utility" is an essential criterion for patentability. It refers to the industrial and commercial improvements enabled by the invention. Relaxing the meaning of "utility" transforms non-patentable subject matters into patentable ones. For example, partial sequences of ESTs were classified as "useful" and therefore patentable despite their value as research tools[108] disavowing a previous Supreme Court ruling that warned against inhibiting future research by restricting access to knowledge[109].

In a context in which innovation is increasingly cumulative in nature, the progressive enclosure of technical knowledge, which is at the basis for progress in science and innovation, may induce a sort of 'lock-out' of potential innovators that are not yet in a dominant position, or, on the contrary, may give excessive bargaining power in legal disputes to small, technology-intensive firms with no physical processing or distribution capacity.

The Bayh–Dole act

In 1980, the US Congress has adopted the Bayh–Dole Act which regulates the patenting of inventions resulting from federally funded R&D programmes[110]. This act has established the right for institutions receiving public funding (including universities and public research laboratories) to patent their discoveries and to license the patents as exclusive rights to private firms, and/or to engage in "joint ventures" with private firms under the conditionality that they are mostly manufactured in the US. The section 204 of the Act establishes that the right to patent and sell discoveries as exclusive licenses does not apply "unless . . . any product embodying the subject invention or product through the use of the subject invention will be manufactured substantially in the United States" [111]. The section 204 strategically reserves the exclusive license of the outcomes of inventions made with federal assis-

[107] In Europe, in spite of the 1998 UE Directive, this process of extension of the new right regarding living entities met serious opposition

[108] See Orsi (2002).

[109] This is despite the fact that the Supreme Court had specifically warned that "*a patent is not a hunting license*" in its Brenner vs. Manson ruling. (c.f., on this point, see Orsi, 2002).

[110] The Bayh-Dole act is embedded in title 35, chapter 18, of the US Code under the label of "patent rights in inventions made with federal assistance".

[111] A dispensation is given in case "*unsuccessful efforts have been made to grant licenses to potential licensees that would be substantially likely to manufacture in the USA, or where under the circumstances domestic manufacture is not commercially feasible*" (section 204 of the Bayh-Dole Act).

tance to the domestic industry. In addition, this "preference" can be granted since the exploration phase, creating an early barrier to entry to foreign competitors[112].

The literature has extensively analyzed the impact of the Bahy-Dole Act on the rate and direction of innovation. Some scholars have stressed the fact that its adoption represents a threat to the "open science" principle[113]; granting exclusive licenses on research findings obtained by universities and public laboratories can allow protecting basic research results which should constitute a publicly knowledge base (Dasgupta and David, 1994; Orsi, 2002). The Bayh-Dole act has also modified the rationale for patenting. The justification of the inventor's reward fades since the invention is made with federal financial assistance; inventors have already received an *a priori* reward (Mazzoleni and Nelson, 1998).

What if IP protection has gone too far?

Since the last decade concerns about the potential negative effects of the management of IP system on the US innovation performance have started to emerge. More and more constituencies are raising concerns that excessive patenting might discourage future innovations due to rising costs of access to knowledge or for fear of being sued for patent infringement. Business analysts, lawyers and economists have started to criticize the US system for granting patents too easily and for being too intensive in litigations.

The scientific side has called to preserve the "scientific commons" and the "open science" principle (Nelson 2003). IP management could be acting as a barrier for generation of knew knowledge, especially when court rulings limit traditional functions and exceptions of the US patent system. The *Madey vs Duke University* ruling has restricted the interpretation of "experimental use" exception. The Federal Circuit decision has considered a research university liable for patent infringement for carrying out basic research by using a patented device. This ruling has reversed the previous doctrine that allowed universities to borrow patented technologies for basic research purposes with no commercial aim. Many are asking to restore the broader interpretation of the "experimental use" exception not to block basic research (Wolf, 2009).

Several companies have started to complain about the costs of an excessive patent-intense environment. Large companies, for example, are increasingly threatened by the behavior of non practicing patent holders (patent-trolls). These firms hold portfolios of patents and suite for patent infringement companies that are exploiting these patents. Patent-trolls, which have proliferated also thanks to

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[112] In other words, intellectual property is deliberately used an industrial policy tool. For a book that argues in favor of such strategic industrial policy use, see the collection of articles published by L. Tyson (1996).

[113] See Mowery at al. 2004; Mazzoleni and Nelson, 2002; Mowery et al., 1999; Dasgupta and David, 1994 for interesting analyses regarding the effects of the introduction of the Bayh-Dole Act in the US IP regime.

the pro-patent aptitude of the US system and from the absence of regulation in the markets for technologies, have contributed to raise litigation settlement costs in the US. Business methods and genetic engineering are research fields of growing importance in the US, and are sectors in which national research centers and enterprises have a considerable relative advantage. IP has been used as an industrial policy tool to preserve the comparative advantages in these technological trajectories. However, the reconfiguration of the global geography of growth and innovation and the consequent rise of new hotspots as major patent holders are contributing to generate an incipient fear in the US of the possibility of future technological dependence.

The Federal Trade Commission (2003) and the National Research Council (2004) have raised criticisms regarding ongoing patent management practices and have suggested to apply in a more restrictive way the "non-obviousness" standard in granting patents, implementing more cost-effective and rapid processes to review "bad quality" patents and revisiting the presumption of validity of issued patents. The Federal Trade Commission has recommended specific measures to raise patent quality, including a simplification of procedures to declare patents invalid by asserting that the "preponderance" criteria of evidence of invalidity should suffice instead of the "clear and convincing" criteria applied nowadays. It has also suggested the introduction of simplified procedures to challenge the validity of patents by allowing avoiding incurring in the full federal court challenge process. The National Research Council (2004) has shown that the costs of patent acquisitions and litigations have increased. The Council, already in 2004, has called for re-creating the conditions for the patent system to perform its function of knowledge dissemination, and it has called for a re-establishment of the open science principle to support basic scientific research in the US.

However, despite the debate on the need to reform the patent system, there is no consensus on "what to do" and "how to do it". Many are still calling for strengthening intellectual property protection, arguing that better procedures to avoid excessive litigation costs and to overcome the back-log are needed. Researchers, and some firms, are concerned by the proliferation of patenting and its effect on the innovation capacity in the long run. Some large firms have started to be concerned by the possibility for small firms to increment their bargaining power by owning up and downstream patents. Entrepreneurs are also scared about infringement and law suits in a context in which innovations rely every time more on pre-existing knowledge.

Recently, the Supreme Court has reversed the previous rulings requiring the application of more restrictive criteria for patentability and for judging patent trolls and by rejecting a patent on business methods. In 2008, the US Court of Appeals for the Federal Circuit has rejected a patent on the hedging method (which would have allowed users to make fixed energy payments even if usage and energy prices vary) because it did not involve a machine and it did not result in a transformation of a material substance (*Bilski and Warsaw* case). The Supreme Court has supported the decision to refuse the patent, but has criticized the requirement of the "machine or transformation test". The Supreme Court has stated that the "machine-or-transformation test" is not the sole test for patent eligibility, therefore it lets uncertainty regarding how and which business methods can be patented or not.

In March 2011, after 6 years of negotiations the US administration has approved the Patent Reform Act. This is the major amendment to the US patent law since its origins. The reform allows the patent office to manage examiners' recruitment practices to address the backlog challenges and requires a shift to the "first-to-file" system, which is the common approach in most patent offices in the world. Up to know in the United States the rule was "first-to-invent". The "first-to-invent" approach responded to the willingness of protecting individual inventors and small companies which might not have the administrative and financial capacities to deal with patent filing process in due time. Those advocating for a reform sustained that the system created uncertainty to patent holders by allowing inventors to claim for patent validity after the patent was obtained. The "first-to-file" rule is well acclaimed by large corporations. Those that are critical about the reform raise the concern that this will increase the incentive to file applications even in the presence of not fully accomplished technological innovations. The patent debate in the US is far from being settled. To advance a border range of stakeholders needs to be involved in the debate to make the system work for innovation, and not to perform as a mere (and powerful) rent management tool in the hands of few corporations in some industrial sectors.

Intellectual property in an increasing globalized world: TRIPS and TRIPS++

In parallel with the changes within the US system, several changes have occurred at the international level. The most notable has been the inclusion of intellectual property provisions in international trade agreements. In 1994 the adoption of the TRIPS agreement has set minimum homogeneous standards of protection for WTO member countries, allowing some flexibility for reasons of national interest and development stage of countries. After 1994, the US engaged in several bilateral trade and investment agreements that have included TRIPS ++ (plus and extra) provisions raising the standards that had been agreed at the multilateral level.

Countries had agreed to set international standards on intellectual property protection since the late 17th century. The first steps being the adoption of the 1883 Paris Convention on industrial property and the 1886 Berne Convention on original forms of expression, including artistic and literary works[114]. These agreements

[114] Those two conventions were followed by the 1891 Madrid agreement on industrial trademarks and the 1925 The Hague agreement on industrial design, and other similar international agreements. In 1893 the Office for the Protection of Intellectual Property (BIRPI) was created; it was an antecedent of the World Intellectual Property Office, established in 1967, under whose administration today are various international treaties for the protection of intellectual property.

were signed at a time when international trade was growing, making modern economies more interdependent. They responded to the pressures of intellectual property holders to extend their higher standards of protection in their new trade partners that had less strict regimes. Patent and copyright holders used intellectual property to preserve their dominant positions in certain industrial fields. The rationale behind the homogenization of intellectual property protection in our contemporary global economies follows the same logic. The US economy has identified in knowledge one of its key assets to maintain global leadership. In a context of growing globalization, new forms of production unbundling, and rising power of emerging markets, the concerns about trade balance and production structure specialization, and interests of certain industrial lobbies increased calling for stronger protection of intellectual property.

TRIPS: setting homogeneous minimum standards and flexibilities

The adoption of the TRIPS agreement in 1994 has established homogeneous minimum standards of protection for WTO member countries, introducing two basic principles of international trade in intellectual property management: i) the "national treatment" and ii) the "most favored nation" treatment (TRIPS, articles 3 and 4). Each WTO member is required to treat nationals of other member states at least "as well as" its nationals, and to treat all other member states on an equivalent basis. By doing so the agreement has introduced the protection of intangibles the basic principles of international free trade in goods and services. The assumption was that by setting equal standards for intellectual property protection, trade, international technology transfer and FDI would have increased benefiting both advanced and developing economies. The TRIPS agreement has been strongly criticized for its "one-size-fits-all" approach[115]. However, as stated in Cimoli *et al.* (2009a) the agreement includes some flexibilities such as i) transitional periods; ii) flexibilities and iii) exceptions to the rights conferred (Table 5.2). However, most of these exceptions are not legally binding, or require implementation capacities that it is difficoult to find in most developing countries. In particular:

i. **Special and Differential Treatment provisions** (SDT) **confer specific rights to developing and least developed countries** (LDC). However, SDT do not eliminate the "one-size-fits-all" nature of the agreement. SDT grant a time lag to implement the standards established by the TRIPS, but do not confer the right to implement a regime in accordance with the stage of development of the country. They recognize the right to benefit from transitional periods in implementation (transitional periods, art. 65 and 66). The provisions related to technical and financial cooperation and technology transfer offer some opportunities, but they are not legally binding. Their effectiveness is therefore low.

[115] See Aboites and Cimoli, 2002; IPRC (2002), Drahos, 2002. For an analysis of TRIPS and development see UNCTAD-ICTSD 2005.

Article 31 establishes the conditions under which governments of WTO member states are allowed to issue a compulsory license. A government may authorize a party other than the patent holder of an invention to use it, even without the consent of the patent holder, when that party has unsuccessfully tried to obtain such a license on "reasonable commercial terms within a reasonable period of time". The restrictive *a priori* effort requirement does not apply in the cases of national emergencies, extreme urgency, and public non-commercial use. In addition, if a compulsory license is granted to remedy an anticompetitive practice, the prerequisites established by the art. 31 do not need to be met. If the country does not have the manufacturing and technological capabilities, the Doha declaration, and its 2003 implementation, enables importing from countries that have manufacturing capabilities. However, the term "reasonable" is open to different interpretations increasing the difficulties for making use of this exception. Issuing a compulsory license is also difficult due to lack of domestic industrial capabilities and know-how to carry out reverse engineering in most developing countries. In fact, until 2005 no developing country had recurred to this practice.

Using this flexibility requires legal and negotiation capabilities. Canada and Rwanda have exploited this space for Triavir, an HIV drug. Thailand and Brazil have also issued compulsory licenses to produce drugs for the treatment of HIV. In 2007, Brazil has issued a compulsory license to produce a generic version of a patented anti-retroviral drug of a multinational pharmaceutical company, in compliance with the WTO rules that allow countries to issue compulsory licenses for "national emergency and public interest". Brazil issued a decree declaring that the country would purchase from an India-based manufacturing company a generic version of the patented drug if the multinational company did not offer to sell the drug at a lower price. The negotiations with the company did not arrive to an agreement and Brazil issued the compulsory licensing. Brazil has an extensive anti-HIV health care program managed under the public health system, and estimates suggest that the maneuver would have saved to the country around 240 million $US by 2012 when the patent on the licensed drug would have expired. Reactions to this action have been strong. MNCs argued against this practice and raised concerns about seeing their property exploited with no compensation. The use of compulsory licensing is not frequent, and it is always controversial, especially because it exposes countries to potential retaliation in other international trade spheres.

ii. **The TRIPS agreement allows for parallel imports**. Parallel imports refer to the different exhaustion regimes of patent protection (national, regional, or international) for products purchased in one market and subsequently sold in a second market without the authorization of the patent holder. Prior to the expiration of a patent countries can take advantage of products manufactured under license in other countries, or for other markets, profiting from international price differentials. Developing countries make little use of this mechanism, in part due to the lack of technical personnel and institutional apparatus needed to implement it. In addition, this policy space is at risk as banning parallel imports is often a prerequisite for bilateral trade investments and trade agreements with the US.

The Article 30 of the TRIPS establishes the "exceptions to rights conferred". WTO member countries "may provide limited exceptions to the exclusive rights conferred by a patent, provided that such exceptions do not unreasonably conflict with a normal exploitation of the patent and do not unreasonably prejudice the legitimate interests of the patent owner, taking account the legitimate interests of third parties". In the "cautious" language of TRIPS this means recognizing the right to provide limited exceptions to the rights conferred by a patent, including the Bolar exception, also known as "early working". This exception allows producers to import, manufacture, and carry out experiments on patented products before the patent expires. For example, in the pharmaceutical sector, the Bolar exception allows firms to carry out experimental R&D to produce generic products without violating the patent. Certain thresholds of technological and production capacities, as well as public and private incentives to engage in such research efforts are needed engage in the use of this flexibility and often most developing countries lack both.

Table 5.2 Policy spaces in TRIPS: SDT, Flexibilities and self-determination provisions: taxonomy of TRIPS'(effective) policy spaces

Provision	Article of reference	(Effective) Policy Spaces
Special and Differential Treatment (SDT)		
Transitional Periods	TRIPS, art. 65, par. 2-5 Developing countries are entitle to delay for a given further period the date of application of (given) provisions of the agreement TRIPS, art. 66.1 Least Developing countries (LDCs) are entitled to delay for a period of 10 years the application of TRIPS provisions, other than Articles 3, 4 and 5. Upon motivated request by a LDC the Council for TRIPS may accord extensions of this period	The Doha Declaration on TRIPS Agreement and Public Health extended the window for LDC's even beyond what the original TRIPS article provided.
Technical and Financial Cooperation	TRIPS, art. 67 On request and on mutually agreed terms and conditions developed countries shall provide technical and financial cooperation to developing and LD countries	Non legally binding provision
Technology Transfer	TRIPS, art. 66.2 Developed countries should provide incentives to enterprises and institutions in their territory to promote and encourage technology transfer to LDCs Doha Declaration, art.7 It reaffirms the commitment of developed countries to provide incentives to promote and encourage technology transfer	Non legally binding provision

Provision	Article of reference	(Effective) Policy Spaces
Special and Differential Treatment (SDT)		
Flexibilities		
Compulsory Licensing	TRIPS, art. 31 Governments are allowed to authorize a party other than the holder of a patent on an invention to use that invention without the consent of the patent holder, on the condition that efforts have been made to obtain the authorization from the right holder on reasonable commercial terms within a reasonable period of time. In case of national emergency, other circumstances of extreme urgency and public non-commercial use the requirement of prior efforts does not apply.	Only countries with a certain production and technological capacity may make use of this provision. Actually, if the country is credible (in terms of industrial capacities, market structure and public policy) this instrument can be used as a negotiation threat. Strong political will and commitment is necessary. TRIPS does not stipulate the grounds upon which a compulsory license should be granted. Thus member countries can make provisions for CL on any ground. TRIPS only mandates certain procedural pre-requisites such as voluntary negotiation prior to the grant of a license etc. In the case of national emergencies, these pre-requisites need not be complied with. Also, if the CL is being granted to remedy an anticompetitive practice, then these pre-requisites need not be complied with. If the country in question does not have the necessary manufacturing and technological capacities the Doha declaration and its 2003 implementation provide for a CL that would enable export from countries that have such manufacturing capabilities.
Exhaustion (national, regional and international exhaustion) (Parallel Imports)	TRIPS, art .6 For the purposes of dispute settlement under this Agreement, subject to the provisions of art.3 and 4, nothing in this Agreement shall be used to address the issue of the exhaustion of IPRs. This article addresses the exhaustion of IPRs that is crucial in international trade because it addresses the point at which the IPR ceases. This provision implicitly addresses the issue of parallel imports (i.e. products placed on the market in one country and subsequently imported into a second country without the permission of the owner of the intellectual property right in the second country)	The only obligations under the TRIPS Agreement that can be used by one country to challenge another country's position on parallel imports are those relating to national treatment (Article 3) and most-favored-nation treatment (Article 4). The exhaustion regime of IPRs depends on national laws.
Exceptions to rights conferred Bolar Exception	TRIPS, Art.30 Members may provide limited exceptions to exclusive rights conferred by a patent, provided that such exceptions do not unreasonably conflict with a normal exploitation of the patent and do not unreasonably prejudice the legitimate interests of the patent owner, taking account of the legitimate interests of third parties. The Bolar exception was first introduced in the US Drug Price Competition and Patent Term Restoration Act in 1984 following the court ruling Roche vs Bolar Pharmaceuticals. The US law enables testing to establish bio-equivalency of generic drugs before patent, expiration. This mechanisms allows generic producers to place their products on the market when the original patent expires	National law can introduce exceptions according to art. 30. According to a WTO dispute settlement in April 2000 Canadian law conforms to TRIPS in allowing manufacturers to exploit this exception. (WTO case "Canada: Patent Protection for Pharmaceutical Products"). This exception has been explicitly adopted by Canada, Australia, Israel, Argentina and Thailand. In the EU it has been used in case by case to solve disputes. In the Canadian case, the WTO upheld the "Bolar" provision but struck down the "stockpiling" provision, stating that this contravened Article 30

Source: Cimoli *et al.* (2009a).

Towards a TRIPS++ world

In the decade of 2000s the United States have started to engage in several bilateral trade and investment negotiations with developing countries[116]. For intellectual property management this has meant an increase in the minimum standards of protection imposed by the TRIPS agreement (the so called TRIPS ++ extra and plus provisions) and the restriction of most of its flexibilities[117], (Fink and Reichenmiller, 2005). Bilateral free trade agreements (FTAs) with the US extend the patent term beyond the 20 years established by TRIPS by introducing extensions for delays caused by the regulatory approval and patent granting processes. In the case of pharmaceuticals, these could extend patent protection beyond the 20-year term, due to the length in the process of approval for a new drug[118]. In other cases, these treaties relax the novelty requirement allowing patenting for new uses of existing products. FTAs also restrict the conditions for parallel imports (Maskus and Chen, 2002) and reduce the opportunities for compulsory licensing, by for example including the requirement to obtain the consent of the patent holder to market a generic drug before patent expiration and by adding the requirement of data test exclusivity.

The bilateral trade and investment agreements (BITs) have established protection in “intangibles” and knowledge in exchange of free trade in tangible goods and services. Developing countries get privileged market access for their products (especially agricultural and textiles, or natural resources) in exchange of stronger intellectual property protection in their domestic economy. In the current landscape, where technology and innovation are the major sources of growth, allowing market access for traditional products in exchange of higher protection of intellectual property looks like a way to “kick out the ladder” for catching up. Also, most developing countries have similar export profiles, therefore the advantages of a privilege market access to the US will tend to decrease as more developing countries engage in the same bilateral negotiations. TRIPS + and ++ provisions raise concerns on their impact on development because they represent a barrier for the creation of domestic industrial and technological capabilities and because they directly affect

[116] The countries with which the US has active bilateral agreements are: Australia, Bahrain, Chile, Israel, Jordan, Morocco, Peru, Oman, and Singapore. Active multi-lateral trade agreements are the North American Free-Trade Agreement and the Central America-Dominican Republic Free Trade Agreement (CAFTA-DR) which covers Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and the Dominican Republic. Pending agreements are the one with the Republic of Korea (KORUS-FTA), Colombia and Panama; the three include strengthening of IP protection as items. In the Middle East and Asia, the United States has used an increasing number of trade and investment framework agreement (TIFA) negotiations to enhance intellectual property protection and enforcement.

[117] Fink and Reichenmiller (2005) provide a clear and extensive revision of IPRs provisions included in US FTAs.

[118] Some FTAs extend also the term for copyright protection up to 70 years after the death of the author, in contrast with the 50 years term of the TRIPS agreement.

welfare issues, including health, as many of the restrictions apply to the pharmaceutical industry and the production of generics.

5.3 AN INTERPRETATION OF CONTEMPORARY MARKETS FOR KNOWLEDGE: FROM TECHNOLOGY TRANSFER TO "DERIVATIVE" MARKETS?

The changes in global intellectual property management and the pro-patent aptitude of court rulings in the US have contributed to modify the functioning of the markets for technologies. Patents have started to be used not only as temporary monopolistic rights in exchange of information disclosure, but as strategic assets to maintain dominant positions. New rents have started to be generated beyond patent licensing. These changes in the functioning of traditional markets for technology have been amplified by the concurrence of two factors, as noted in Cimoli and Primi (2007 and 2008):

i. The emergence of new technological paradigms has caused a redefinition of what is innovation, how it is generated and through which channels it can be diffused and appropriated. In information technologies, but also in biotechnology and nanotechnology innovation is increasingly incremental and cumulative, intensive in interrelations and more linked to science. Replicabilty, usability and copying of innovations have been re-defined, and uncertainty about future outcomes is even higher than in the past.

ii. Globalization and the new forms of organization of production. The new global economic landscape is characterized by growing interdependency of nations and territories. Innovation is increasingly carried out through networks; this has contributed to the inclusion of intellectual property provisions in mergers and acquisitions (M&A) agreements as well as in legal dispute settlement agreements.

The changes in intellectual property regimes, coupled with globalization and the rise of new technological paradigms have contributed to convert patents into strategic assets whose relevance is increasingly disentangled from the value and industrial applicability of the patented technology. The fact that firms can build large patent portfolios also contributes to incentives patenting. The traditional markets for technologies (i.e. mechanisms for fostering technology transfer) only capture a fraction of the "use" of patents. Countries (and firms) face new markets for knowledge, which include markets for science and "derivative" markets, where the value of patents is disentangled from the patented technology (Table 5.3).

Table 5.3 A taxonomy of markets for knowledge: from technology markets to "derivative" markets

MARKETS FOR KNOWLEDGE			
	Markets for Technologies	**Markets for Science**	**Derivative Markets for S&T**
The rationale of the market	Division of labour in knowledge and technology generation and application.	Increasing "demand" for science due to new technological paradigms and changes in regulatory framework.	Increasing cumulativeness and uncertainty in the nature of technological change (new tech. paradigms) and re-shaping of IP systems which incentives the use of patents as strategic assets for making profits.
Prevailing patenting behavior	Patent to protect, commercialize and diffuse	Patent to protect, commercialize and diffuse	Strategic, defensive, blocking and sleeping patenting. Patent trading and assertion in litigations.
	The value of patents is related to the subjacent technology (present or future incorporation in production)	The value of patents is related to the subjacent technology (relevance for further research or present or future incorporation in production)	Patents acquire a value "per-se", independently from that of the subjacent technology. The value of patents is, to a major extent, a function of expectations regarding future non-deterministically foreseeable technological scenarios. - Patents enter into the asset portfolio of organizations as signal of (technological) reputation.
	Technology transfer through licensing.	Technology transfer through licensing	Patent trading and patent assertion.
Barriers to entry	Technological and production capacities	Scientific capabilities	Size of incumbents, risk-propensity, enforcement capacities

Source: Draws on and updates Cimoli and Primi (2007; 2008).

Traditional technology markets: theory and practice[119]

The traditional definition of markets for technologies derives from the assumption of the efficiency in the division of labor in knowledge and technology production. When the right to produce some artifact, or the knowledge and the know-how required to produce it, are separated from real production, two markets arise: the market for tangibles and the market for the technologies necessary to produce them. In these markets firms can specialize in providing technologies and in using these technologies to produce and sell artifacts to consumers (Eaton and Kortum, 1996; Arora, Fosfuri and Gambardella, 2001). Patents are mechanisms that allow the division of labor between technology providers and users, thus fostering economic efficiency.

The main function of the markets for technology is to favor the diffusion and the transferability of innovation through licensing. Firms carry out R&D on the basis of a body of pre-existing and available knowledge. They patent their inventions, and then incorporate the technology in their production and/or they license the know-how to other firms. The value of patents derives from its use in produc-

[119] This section drawns on Cimoli and Primi (2007; 2008).

tion and it is strictly related to the value of the patented technology. These markets can involve unilateral transactions: a firm/university licensing a technology to a licensee, or multilateral transactions when two or more entities subscribe a cross-licensing agreement. The governance of these markets might be flat when the parties interact directly (flat does not mean that the contracting parties have the same negotiating power, but that parties voluntarily decide to enter into the transaction), mediated when a technological broker is involved, and hierarchical when the law requires to a party to enter into the market and license out the technology (as in the case of compulsory licensing, for example).

Markets for technology are supposed to be efficiency enhancing because they foster knowledge circulation[120]; however, they do not always smoothly function, and firms willing to license their technologies experience difficulties in commercializing them (Bidault and Fischer, 1994; Geroski, 1995, Lichtenthaler, 2005). Gambadrella *et al*. (2007) explore the PatVal-EU data set[121] and show that often firms are willing to license a patent, but they are not able to do it[122]. The costs of identifying potential partners and of screening them and the difficulty in contract management reduce the propensity to license (Arora *et al*. 2001, Gambardella, *et al*. 2007). Reputation also affects the capacity to license patents[123]. Lichtenthaler and Ernst (2007) show that for medium and large firms, a good reputation as knowledge providers increases the capacity to license. Standardization of information on licensing contracts and procedures might favor the support of licensing of currently non licensed patents.

In addition, the propensity to license is affected sector[124] and by firm size[125]. For example, Cohen and Klepper (1996) estimate that only 1 out of 31 high-tech industries tend to rank licensing as a relevant option in their company strategy. Larger firms are less likely to license than small firms (Arora and Fosfuri 2003; Gambadrella *et al*., 2007), and they are more likely to license non-core technologies (Rivette and Kline 2000). Larger firms tend to exploit knowledge advantages through vertical integration and extensive commercialization capacities, while smaller firms, usually high-tech based, prefer to specialize in knowledge supply[126].

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[120] See Shephard, 1987; Rockett, 1990; Gallini, 1984; Arora, Fosfuri and Gambardella, 2001; Gans and Sterm, 2003.

[121] The PatVal-EU data set is based on a survey of the inventors of 9017 European patents granted at the European Patent Office (EPO) between 1993 and 1998.

[122] Gambardella *et al.* (2007) run a probit model on the probability to license a patent and then an heckman selection on the probability to license a patent giving the fact that the applicant is willing to license: 11% of patents were licensed, but there were 7% of patents which the owner was willing to license but did not.

[123] See Podolny and Stuart, 1995 and Stuart, 1998.

[124] See Grindley and Teece 1997; Teece 1998; Rivette and Kline 2000; Kline 2003.

[125] See Gambardella, Giuri and Luzzi (2007).

[126] According to Arora and Fosfuri (2003) smaller firms prefer to operate as knowledge suppliers when the expected revenues from licensing (revenue effect) are higher than the expected reduction of rents caused by the increased competition generated by the licensee in the market (rent dissipation effect).

The new market for science: (is it really the "best" approach?)

Publicly funded research was supposed to increment the pool of available knowledge for future research and for industrial production (Dasgupta and David, 1994; Mowery *et al*. 2004). The rising relevance of science for business coupled with the changes in intellectual property management have favored a proprietary science model in contrast with the open-science approach[127]. Rising barriers to access basic knowledge might increase the cost for innovation and reduce potential innovation flows, instead of favoring them. The market for science could be operating as "anterior" market to the traditional technology markets, rising barriers to access knowledge before having discovered something with industrial applicability. However, the evidence on post Bahy-Dole patenting behavior shows that US universities had a long tradition of patenting and licensing through Technology Transfer Offices (TTO) before the introduction of the Act in 1980 (Mowery and Sampat, 2001a,b). These authors explore the role of the Research Corporation, a nonprofit organization created in the 1920s to foster the development of a culture of intellectual property. The Corporation acted as a bridge organization to favor knowledge sharing among different TTOs to spread good practices and improve performance.

In the case of scientific research a "community" type of structure could be superior to a market based organization. Communities are preferable when the value of the generated knowledge increases with diffusion, to allow subsequent improvements and adaptations. Knowledge communities allow free knowledge sharing and/or collective generation (joint production) of new knowledge.

The essence of knowledge communities is that "a body of original material is made publicly available for others to use, under certain conditions" (Lerner and Tirole, 2004). The newly generated knowledge might be used for commercial or non-commercial purposes. Knowledge communities are open networks. However, effective openness is conditioned to the mastering of knowledge and capabilities that is at the basis for any type of fruitful interaction among the members of the community. The governance of knowledge communities is flat and conditioned to peer-review mechanisms. In certain cases, science is increasingly shifting towards a proprietary regime, also due to the blurring boundaries between science and business, but certain industries, such as software, are turning towards more open innovation models and "community" type of organization of innovation to increase their capacity to generate and apply new knowledge.

[127] See Adelman (1987); Rosenberg (1982); Merges (1992); Dasgupta and David (1994); Callon (1994); Mazzoleni and Nelson (1998); Mowery *et al*. (1999); Jaffe (2000); Cohen and Lemely (2001); Hunt (2001); Hall and Ziedonis (2001); Gallini (2002); Graham and Mowery (2003); Hall (2003); Bessen and Hunt (2004).

Can we talk about "derivative" markets for knowledge?[128]

The changes in the patent regimes, the growing unbundling of production and the diffusion of new technological paradigms have contributed to create new markets for knowledge. Patents have become assets in firms' portfolio and rents can be extracted from them without any linkage with technology licensing and industrial application of the patented technology[129]. In the 1990s, a new business model emerged. Some firms started to specialize in trading and asserting patents against firms that were using those patents in their research and production processes. These new markets differ from traditional technology markets because firms are incentivized to patent even though there is no intention to licenses the technology or to apply the patented innovation in production. In these new markets firms can make (extra) profits by trading intellectual property assets or by suing operating firms for infringement, without being concerned by the effective use of the patented technology in production. The value of patents is disentangled from the value of the patented technology and is related to its potential (future) value. These new markets for knowledge are similar to derivative financial markets. Patent holders, which are not necessarily operating firms, gain rents by trading or asserting patents. As in derivative financial markets, the value of the transaction is disentangled from the value of the share in the primary market; the value is linked to market's expectations.

In these markets patents "monetize". Patents become liquid assets contributing to increase patent propensity but also raising the numbers and costs of litigations. The emergence of derivative markets for knowledge influences firms' patenting strategies and fosters the emergence of new business models. The existence of derivative markets for knowledge induces speculative behavior. The possibility of setting up patent pools increases the incentives to patent by allowing firms to gain profits in the markets for patents without being involved in "material" production. In addition, operating firms are also incentivized to build growing patent portfolios to counterclaim eventual infringement allegations from other firms. The decision to patent goes beyond the expectation of incorporating the patented invention into (direct or indirect) production. Firms patent to create barriers to competitors, and to create the possibility to participate in oligopoly rents that will be generated in the future by potential additional discoveries or incremental innovations based on their patents (Levin *et al.* 1987; Cohen *et al.* 2000). Firms also patent to strengthen their position in potential legal infringement allegations, and to signal their reputation.

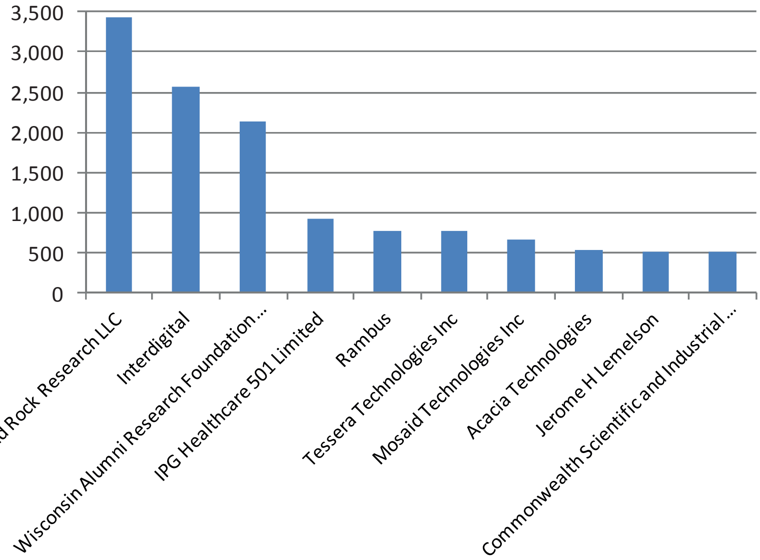
As stated in Cimoli and Primi (2007; 2008), in the derivative markets the choice of patenting can be assimilated to the decision to buy a lottery ticket. Even though the probability of winning is extremely low the winning prize (or the value assigned

[128] This section drawns on Cimoli and Primi (2007; 2008) and on Cimoli *et al.* (2009a).
[129] See Cimoli and Primi, 2008; Cimoli *et al.* (2009a); Monk (2009); FTC (2011).

by each individual to the eventual win) is high enough to encourage patenting (Lamely and Shapiro, 2005). The difference with traditional lotteries is that in derivative markets the uncertainty concerns not only the possibility to win, but also the amount of the prize itself.

The existence of these derivative markets is also sustained by the rise of a new business model, dominated by Non Practicing Entities (NPE, or patent trolls). These trade and assert patents against patent holders. One of the leading companies in this field is Intellectual Ventures, which holds the largest world patent portfolio. Estimates indicate that Intellectual Ventures holds between 10 000 and 15 000 patents. The firm was created in 2000 by a former Microsoft technology officer. In few years it has become a leading actor in the knowledge market. It has an evolving business models which has added the trading and asserting actions, also in-house R&D and patenting of in-house discoveries. The company acquires and creates intellectual property and then monetizes it by non-exclusive license agreements and by asserting patents against entities using these patents in production. The NPE is a growing phenomenon that includes a variety of firms (Figure 5.8). The Round Rock Research LLC, for example, is a technology research company specialized in patent licensing; it operates in several technology fields, including semiconductors and display technologies. Acacia Technologies offers services to individual inventors and small firms; it allows turning patents into revenues by carrying out laws suits for patent infringements.

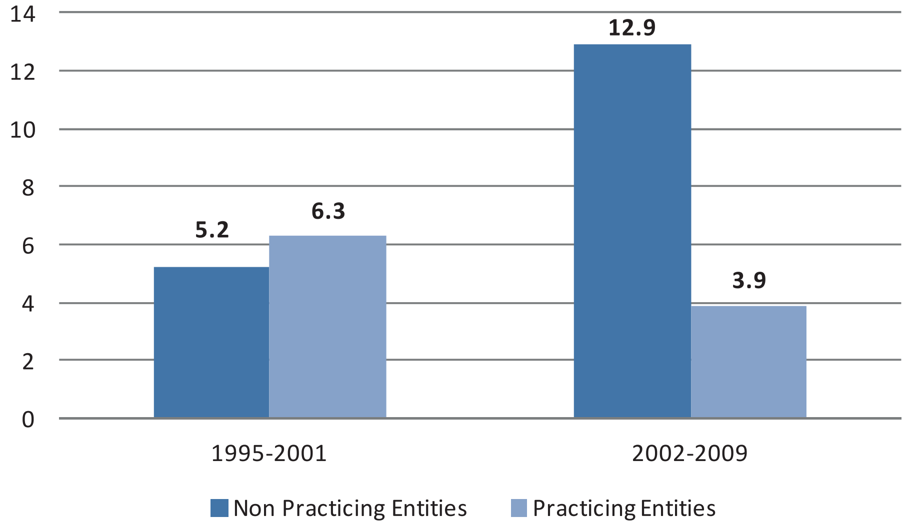
Figure 5.8 Top 10 NPE by number of patent holdings, 2011



Source: Author's calculations based on Patent Freedom as of April 2011.

Analyzing the functioning of the derivative market for knowledge is not easy, because most legal settlements include confidentiality on compensations and royalty payment agreements. Some organizations, especially the new generation of technological brokers, are monitoring the behavior of NPE to inform patent holders on how to defend from them. For example, Patent Freedom monitors and diffuses information about NPE. As of January 2011, it has identified 380 different NPE. These entities have been involved in litigations with more than 5 000 operating companies in over 4 000 legal actions. The number of companies involved in litigations with NPE has increased from 500 in 2000 to more than 2 600 in 2010. Average damages compensations have also increased, and NPE are getting the highest compensations (12.9 US million against 3.9 of practicing entities; see figure 5.9).

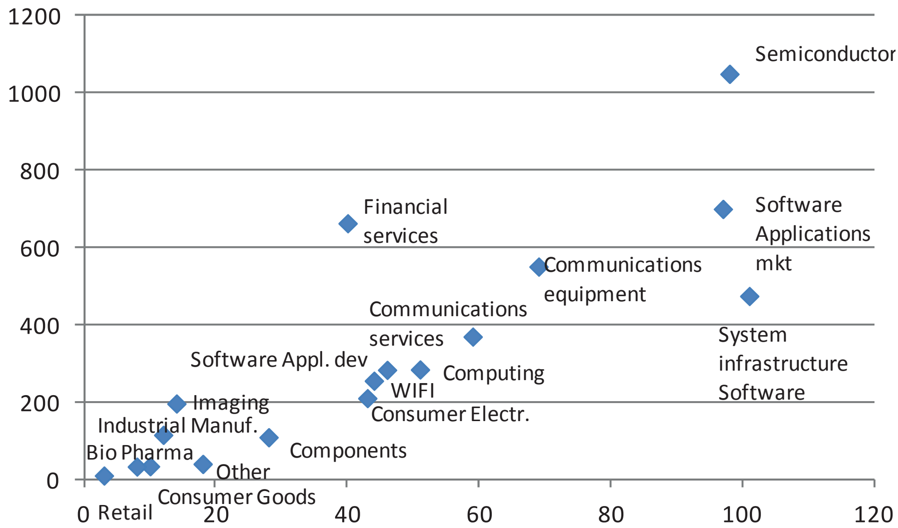
Figure 5.9 Median damages awarded by type of entity, 1995-2009



Source: Price Water House (2010).

The existence of these "derivative" markets for knowledge is related to the information and communication technologies. Patent Freedom categorizes patents and litigations according to sectoral business. Figure 5.10 shows the number of NPE asserting patents for several product categories (on the horizontal axis) and the number of litigations (on the vertical axis). Semiconductors is the sector with the highest number of litigations and of NPE asserting patents against operating firms; manufacturing and bio-pharma are the activities in which there is a relatively lower number of NPE and of total litigations.

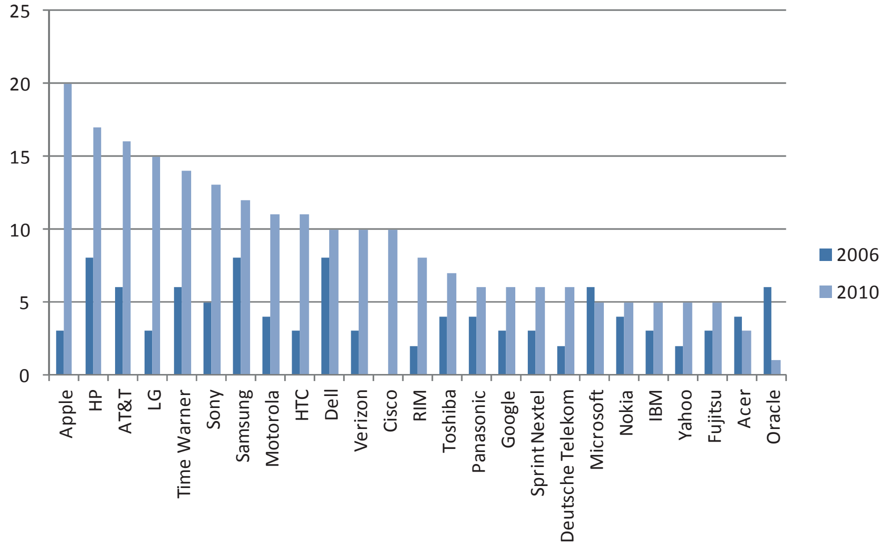
Figure 5.10 Technological preferences of NPE allegations, 2011



Source: Author's calculations based on PatentFreedom database, as of April 2011.

The business model is continuously evolving. In March 2010, the Round Rock Research LLC sold for US$ 38.5 million a "Covenant not to sue" in an Ocean Tomo Auction. "Covenant not to sue" agreements allow the "buyer" to freely operate in the technology domain of the patent holder due to an agreement in which the patent holder agrees not to litigate his patents against the party signing the agreement. The "Covenant Not to Sue" performs like an insurance contract for the buyer. It limits the risks of entering into long and costly litigations patent by patent. For the patent holder the agreement allows negotiating a larger part of its patent portfolio and increases the capacity to monetize it. The number and cost of litigations rose exponentially, especially for large firms have to face the costly and complex legal infringement processes by the NPE. In 2010, Apple, HP and AT&T were the top three firms for lawsuits from NPE (Figure 5.11).

Figure 5.11 Ranking of operating companies by number of law suits by NPE, 2006-2010



Source: Author's calculations based on PatentFreedom database, as of April 2011.

As discussed in Cimoli and Primi (2007; 2008), a market is defined liquid when its assets can easily circulate. The derivative market for knowledge is liquid because patents are easily tradable without requiring firms to have the necessary technological and production capacities to translate the invention into practice. Patents have lost the "weight and the density" of the technological component and they can circulate without having to be necessarily applied into any final artifact. In the derivative markets firms patent not only to protect innovations; they patent to signal their reputation or to protect from legal suits. Derivative markets for knowledge incentive speculative behavior. Barriers to entry in the derivative market are associated to the companies' risk propensity and to their legal enforcement capacities. Litigation and enforcement costs might be prohibitive resulting in very concentrated markets, dominated by few actors –mainly large firms, MNCs and knowledge brokers (Wang, 2010).

In derivative markets the patent system deviates from its original function of favoring knowledge appropriability and disclosure. These new markets create rent opportunities out of temporary monopolies which, in theory, were allowed in exchange of knowledge diffusion. Derivative markets for knowledge require appropriate regulation, as derivative financial markets do. Derivative markets in practice incentivize patenting, not innovation, or technological diffusion.

CONCLUSIONS

Intellectual property management is an issue of growing importance for developing countries. In Latin America, diverse issues are at stake for different countries, but a common concern is how the sets of incentives (and obligations) deriving from current intellectual property regimes influence (favour or jeopardize) the processes of learning, technology generation and diffusion and the entry in new sectors and activities by incumbents and by potential new comers. Historical and empirical evidence shows that:

i. Countries are heterogeneous in their technological and industrial capabilities. Moreover, developing countries have high within-country heterogeneity; islands of technological excellence co-exist with low value added activities. Therefore, the intellectual property system influences in a different way the different constituencies within the country. While some segments of the scientific and the business sectors would benefit from similar standards and policies of advanced countries, the rest of the economy would require adapted mechanisms to allow learning and access to knowledge.

ii. Intellectual property is a concentrated phenomenon: few actors lead the scene as knowledge providers, while a rising number of agents enter the game as "knowledge demander".

iii. Technological leadership of countries (and firms) is sticky. Dominant countries tend to maintain their position over rather long periods of time. But technological leadership is not granted. History has shown that it is possible to observe the rise new technological powers. Finland and the Republic of South Korea have managed to impose as global knowledge players over few decades by means of effective policies supporting domestic scientific and production capacities and learning. The rise of India in the generic pharmaceutical industry is also a notable case.

The changes in intellectual property regimes, the new technological paradigms and rising international dimension of knowledge flows have contributed to increase the number of patents applied for. Fears about the adverse impact of the excessive patent-intense systems grew not only in the scientific community, but also in certain spheres of the business sector that are increasingly worried about the rising litigation costs of the patent system. "From the point of view of developing countries, it is clear that "getting the IPRs right" is far for being the solution. Asymmetries in technological capacities (between firms and countries) are likely to persist over rather long periods of time, beyond the legal mechanisms defying the appropriability and transferability conditions of technologies" (Cimoli and Primi, 2007). Countries that are successful in managing intellectual property often have a clear vision of their industrial development and are able to implement intellectual property policy that take into account the needs of the different segments of their production and scientific structures.

Even though in certain cases, intellectual property can be more a barrier than a gateway for technological learning, it is also true that patents are not the only, nor the major obstacle for technological and scientific catching up in developing countries. “Public support to research and development, the recognition of the profession of researchers, capacity building in science and entrepreneurship, investment in top quality infrastructure for research, as well as industrial policies to support structural change, are more binding factors than patent protection to support industrial development” (Cimoli and Primi, 2007, pg. 13).

The lack of strategic visions and short-term pressures for easy profits jeopardize learning processes. Scientific and technological capabilities are localized and are built in a continuous process of trial, error and feedback. Countries need to recognize the industrial policy component of IP management and fine-tune the system according to the national industrial development strategy.

Searching for more balanced and tailored intellectual property systems in necessary; markets for knowledge could be functioning today far below their optimal way. New approaches are required to restore global public interest at the center of the international management of intellectual property. Taking into account the past experience and the recent trends in the markets for knowledge it is possible to identify three major areas where new solutions are needed.

First, the “North-South” polarization of the development agenda has failed to capture the complexity of the variety of interests at stake in the international knowledge game, especially among, and within, developing countries[130]. The variety of interests and capabilities within and between developing countries is high and it is important to define mechanisms to take it into account in order to propose effective reforms in global IP systems. The call for the restoration of the principle of “knowledge community” for scientific production can cluster constituencies from advanced, emerging and developing economies. The defense of the policy spaces set by the TRIPS agreement and the strategic use of intellectual property in line with national industrial development priorities might require new alliances between emerging and developing economies. Discussing the regulation of derivative markets for knowledge should be in the interest of all countries. In the derivative markets for knowledge the patent system does not perform its original function of fostering knowledge diffusion; these markets are creating new rent opportunities and new business models, but are at the same time increasing the costs of the management of the intellectual property system, though more and expensive law suits and by creating disincentives to invest in innovation by fears of entering into a legal battle with patent owners. Advanced economies should advocate for a regulation of the derivative markets for knowledge to prevent the patent system from being a

[130] See Basheer and Primi (2009).

speculative rent seeking game which hampers aggregate innovation potential. Emerging and developing economies should pursue a new regulation of these markets because they contribute to create a patent-dense environment that has raises barriers to the entry new comers in certain technological fields.

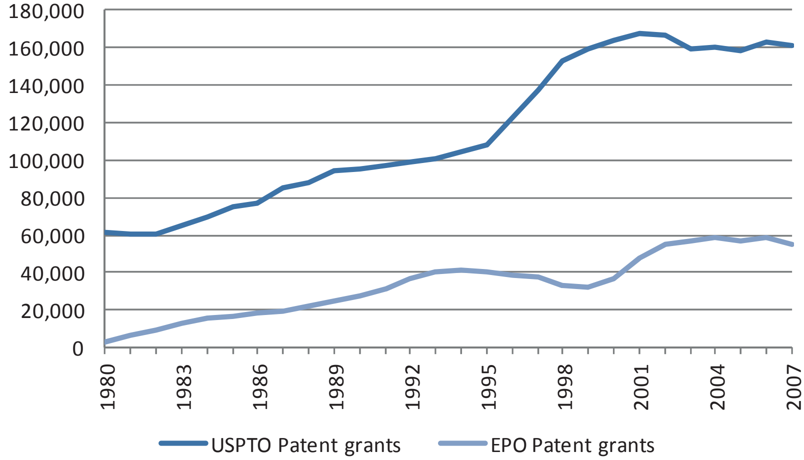
Second, the management of intellectual property policy has suffered from excessive “isolation”. Reforms of intellectual property policy are more effective when they are articulated with industrial, technological and scientific policies. Countries need to nest the intellectual property debate within the overall discussion on knowledge creation, diffusion, access and appropriation. The core of the debate should be the definition of the incentives and regulations that can help favoring knowledge generation and diffusion; these include direct incentives to research, corporate strategies, peer-review and open access, and legal mechanism to protect intellectual property, including codified documents conferring temporary monopolistic rights (such as patents).

Third, patent policy needs to be defined taking into account a wide set of stakeholders, in addition to the intellectual property community. The innovation challenge cannot be addressed only though patents, and patent policy needs also to be part of a broader scientific and industrial development strategy. No flexibility will be used simply because it is legally feasible. For example, the use of TRIPS flexibilities is subject to decisions that go beyond the pure intellectual property domain and it includes, among others, trade, industrial, competition and technology policy issues. In fact, scientific and production capabilities as well as industrial strategies concur to transform legal feasibility into action. Frontier countries have been using, and use, intellectual property as a *de facto* industrial policy to sustain the competitiveness of industries and to protect dynamic advantages in certain technological trajectories. Developing countries should learn from them and strategically fine-tune their intellectual property regimes to their industrial development needs, of today and of tomorrow. In the case of Latin America this issue is particularly relevant due to the return of innovation and industrial policies on the development agendas in the countries of the region. Missing out the intellectual property debate could be a costly mistake that could hamper future development opportunities in the region.

ANNEX 5.1. ADDITIONAL EVIDENCE ON PATENT TRENDS

Figure A.5.1 USPTO and EPO patent grants, 1980-2009

Number of granted patents, three-year moving average



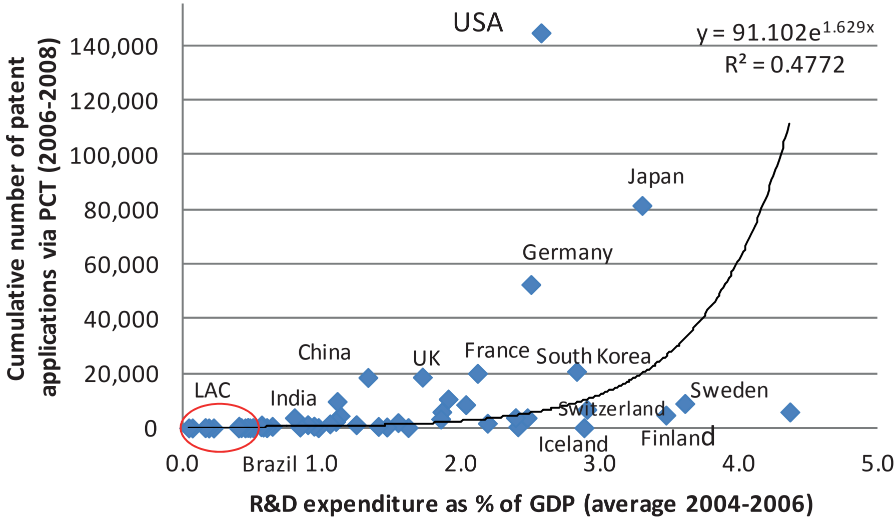
Note: Patents are counted by year of grant.
Source: Author's calculations based on OECD patent database.

Table A.5.1 Who's patenting in the US? Shares of top countries on total USPTO patent grants to foreigners, 2005-07 and 1965-67.

	Share on total USPTO patent grants to foreigners		Variation (2005-2007 1965-1967). Absolute Number
	1965-1967	2005-2007	
1 Japan	12.38	45.22	55,162
2 Taiwan	0.00	11.22	15,016
3 South Korea	0.01	10.21	13,660
4 Germany	25.88	9.53	1,587
5 Canada	6.30	4.06	2,717
6 France	10.60	2.86	-751
7 UK	18.20	2.53	-4,467
8 China	0.05	1.84	2,447
9 Italy	3.36	1.43	469
10 Israel	0.31	1.27	1,570
11 Australia	0.94	1.27	1,296
12 Switzerland	6.37	1.16	-1,196
13 Netherlands	3.27	0.96	-119
14 Sweden	4.00	0.86	-573
15 India	0.09	0.64	810
16 Finland	0.25	0.54	621
17 Austria	1.13	0.52	211
18 Belgium	1.37	0.52	103
19 Singapore	0.01	0.51	683
20 Hong Kong, China SAR	0.05	0.43	556
21 Spain	0.35	0.32	273
22 Denmark	0.72	0.28	69
23 Malaysia	0.00	0.21	281
24 Norway	0.36	0.21	121
25 Russian Federation	0.00	0.19	251
26 Ireland	0.06	0.17	204
27 Brazil	0.09	0.09	84
28 New Zeeland	0.12	0.09	68
29 Mexico	0.31	0.08	-31
30 South Africa	0.35	0.07	-62
31 Argentina	0.10	0.04	13
32 Hungary	0.16	0.04	-13
33 Poland	0.16	0.04	-21
34 Luxmbourg	0.03	0.03	30
35 Chezch Republic	0.77	0.00	-334
37 Other Countries (142)	0.89	0.52	312

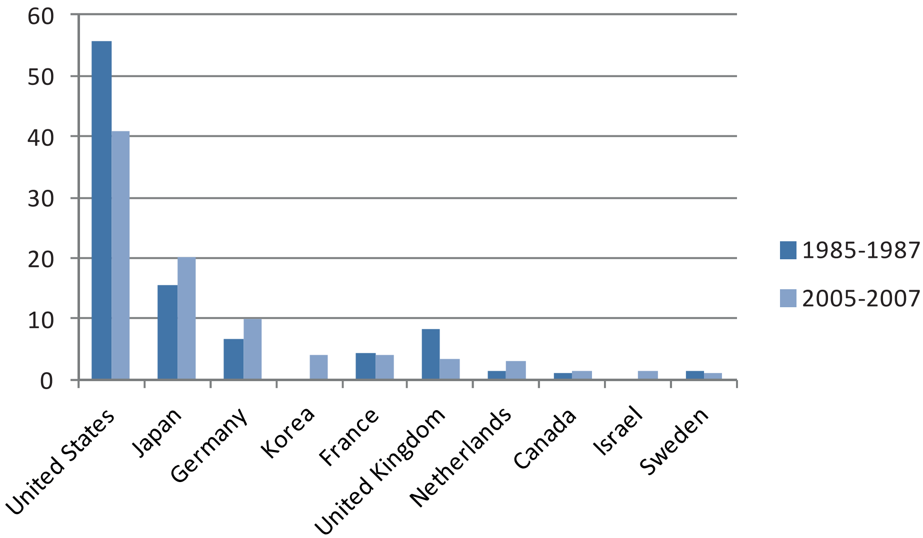
Note: Shares are computed over cumulative number of patent grants for each indicated period. Data refer to utility patents granted as distributed by year of patent application. Countries are ranked according to their positioning in 2005-2007.
Source: Author's calculations based on the USPTO Database.

Figure A.5.2 Global patenting and R&D efforts: countries in a comparative perspective, 1970-2009



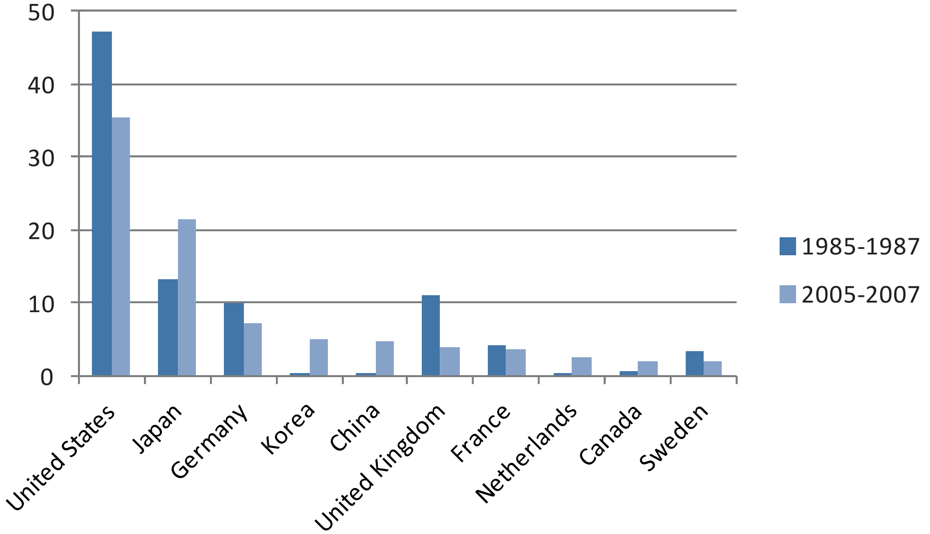
Source: Author's calculations based on OECD Patent Database (for patents); MSTI OECD, RICYT and WB database (for R&D expenditure).

Figure A.5.3 Top 10 patenting countries in biotechnology, 1985-2007



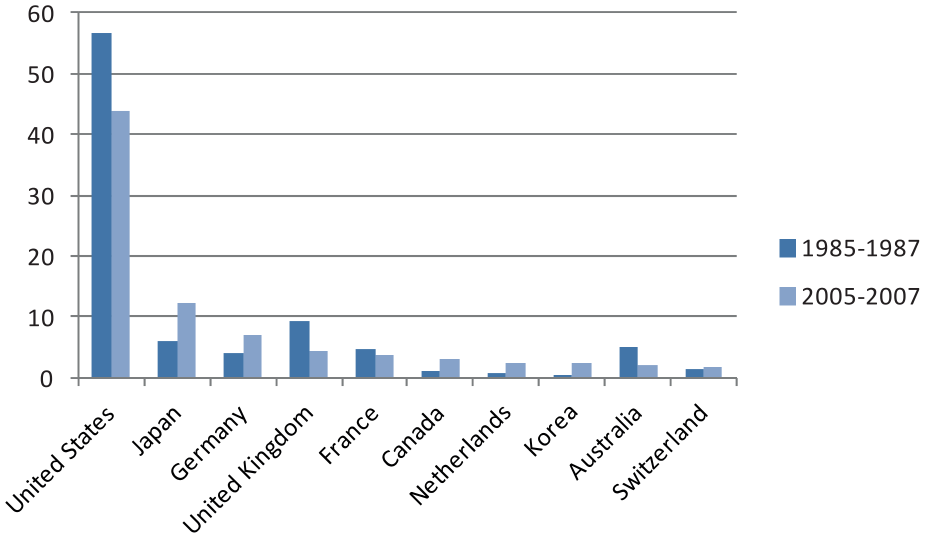
Note: data are cumulative numbers of patent applications by priority year for each period.
Source: Author's calculations based on the OECD patent database.

Figure A.5.4 Top 10 patenting countries in ICT



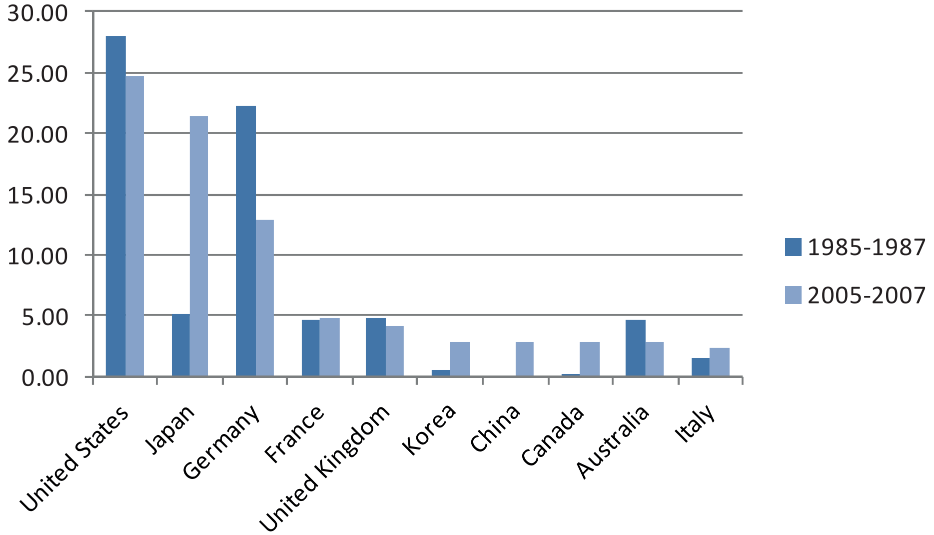
Note: data are cumulative numbers of patent applications by priority year for each period.
Source: Author's calculations based on the OECD patent database.

Figure A.5.5 Top 10 patenting countries in nanotechnology



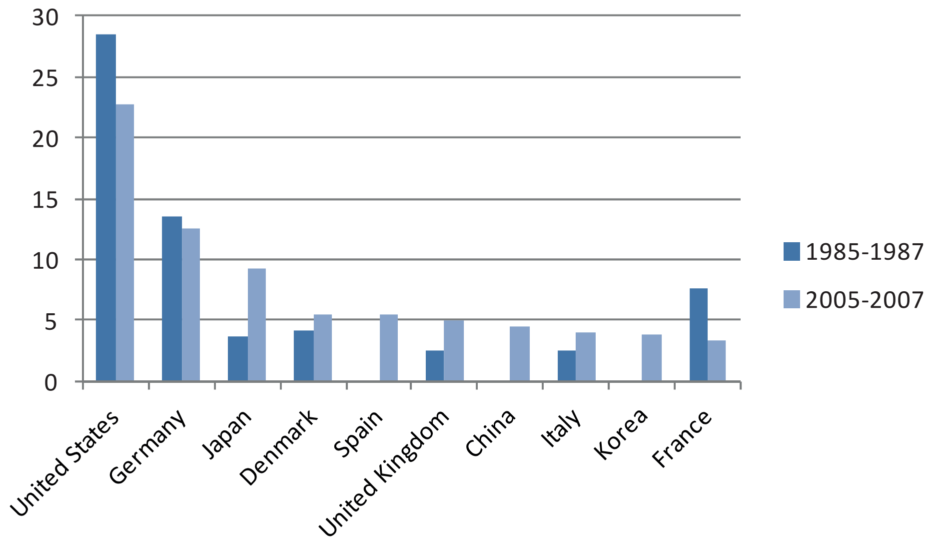
Note: data are cumulative numbers of patent applications by priority year for each period.
Source: Author's calculations based on the OECD patent database.

Figure A.5.6 Top 10 patenting countries in pollution abatement and waste management



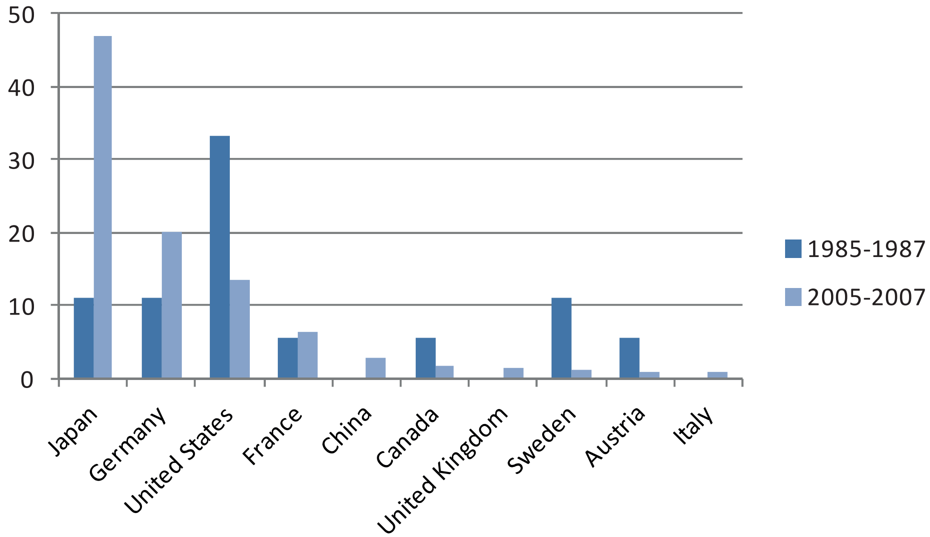
Note: data are cumulative numbers of patent applications by priority year for each period.
Source: Author's calculations based on the OECD patent database.

Figure A.5.7 Top 10 patenting countries in renewable energies



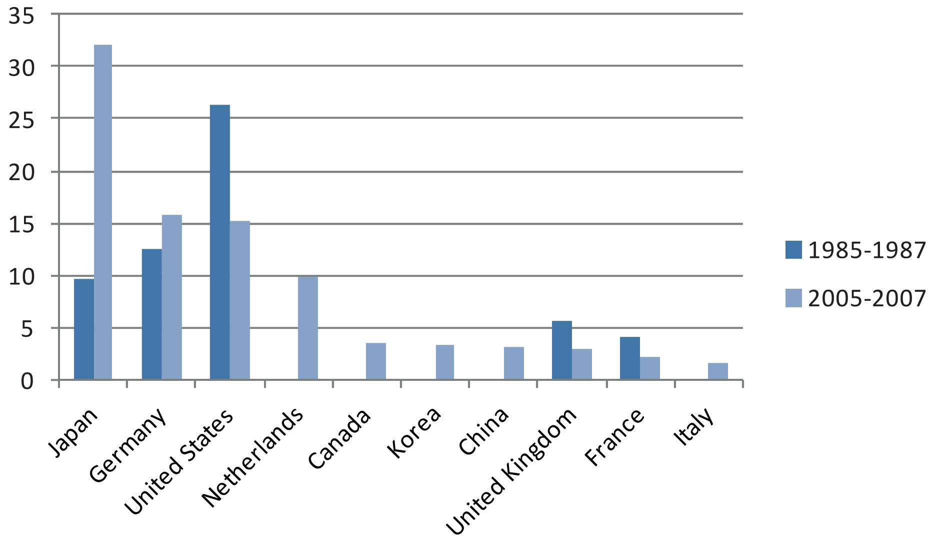
Note: data are cumulative numbers of patent applications by priority year for each period.
Source: Author's calculations based on the OECD patent database.

Figure A.5.8 Top 10 patenting countries in electric and hybrid vehicles



Note: data are cumulative numbers of patent applications by priority year for each period.
Source: Author's calculations based on the OECD patent database.

Figure A.5.9 Top 10 patenting countries in energy efficiency in buildings and lighting



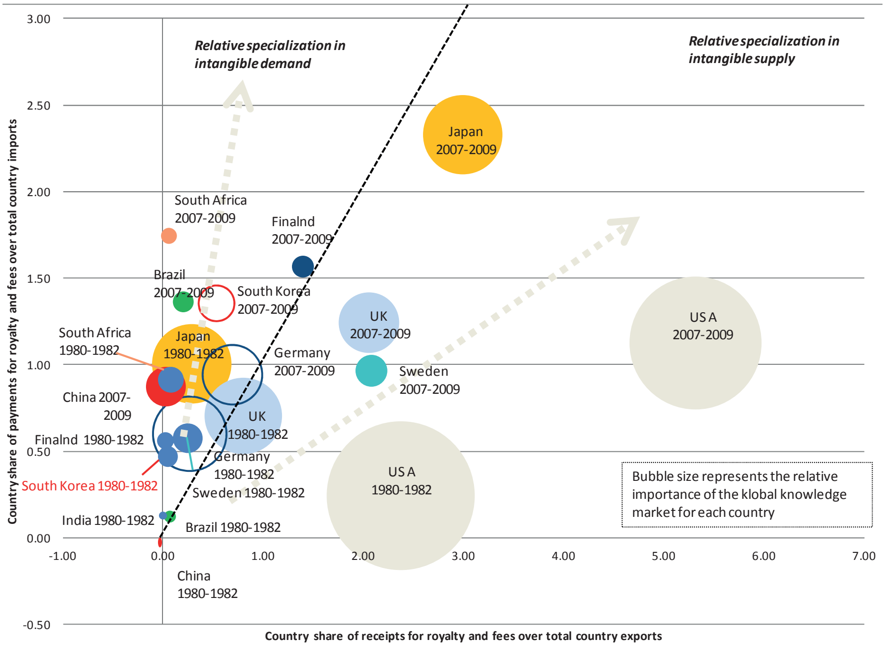
Note: Data are cumulative numbers of patent applications by priority year for each period.
Source: Author's calculations based on the OECD patent database.

Table A.5.2 International trade in intangibles: top 10 countries, 1970-2009

Major players in global knowledge supply									
Country share in world total royalty and license fees receipts									
1970-1972		1980-1982		1990-1992		2000-2002		2007-2009	
United States	80.12	United States	65.56	United States	59.75	United States	53.85	United States	49.74
United Kingdom	11.63	United Kingdom	10.85	United Kingdom	11.39	Japan	13.06	Japan	13.10
Germany	3.60	Germany	5.68	Germany	6.48	United Kingdom	10.48	Germany	5.91
Netherlands	3.25	Japan	4.67	Japan	5.99	Germany	4.23	United Kingdom	7.95
Sweden	0.54	France	4.48	France	4.61	France	3.45	France	5.42
		Netherlands	3.78	Netherlands	4.50	Canada	3.01	Netherlands	2.72
		Sweden	0.87	Sweden	2.06	Netherlands	2.46	Sweden	2.61
		Italy	0.78	Italy	1.80	Sweden	1.77	Canada	1.91
		Australia	0.66	Australia	0.51	Korea, Rep.	1.03	Korea, Rep.	1.35
		Norway	0.63	Norway	0.41	Finland	0.85	Belgium	0.98
CR (3)	95.36	CR (3)	82.09	CR (3)	77.62	CR (3)	77.40	CR (3)	68.75
CR (4)	98.60	CR (4)	86.76	CR (4)	83.60	CR (4)	81.63	CR (4)	76.70
			97.96	CR (10)	97.49	CR (10)	94.20	CR (10)	91.68
Major players in global knowledge demand									
Country share in world total royality and license fees payments									
1970-1972		1980-1982		1990-1992		2000-2002		2007-2009	
United Kingdom	26.09	Japan	18.46	Germany	14.48	United States	20.28	Ireland	16.90
Germany	21.29	Germany	14.47	United States	13.95	Japan	12.88	United States	13.75
United States	21.14	France	11.11	Japan	13.52	Ireland	11.14	Japan	9.37
Netherlands	10.74	United Kingdom	10.17	United Kingdom	12.32	United Kingdom	7.78	Germany	6.82
Australia	6.93	United States	8.41	Netherlands	7.24	Germany	6.42	Singapore	5.92
Sweden	4.43	Netherlands	6.98	France	6.27	Singapore	5.71	China	5.32
South Africa	4.38	Italy	4.92	Italy	5.84	Canada	4.66	United Kingdom	5.14
Austria	3.14	Australia	3.48	Korea, Rep.	5.28	Korea, Rep.	3.61	Canada	4.45
Italy	0.96	Argentina	2.76	Spain	3.63	Netherlands	2.89	Korea, Rep.	3.22
Colombia	0.56	Mexico	2.63	Australia	2.89	China	2.42	France	2.79
CR (3)	68.52	CR (3)	44.03	CR (3)	41.95	CR (3)	44.31	CR (3)	40.02
CR (4)	79.26	CR (4)	54.20	CR (4)	54.27	CR (4)	52.09	CR (4)	46.84
CR (10)	99.65	CR (10)	83.38	CR (10)	85.43	CR (10)	77.80	CR (10)	73.68

Note: Royalty and license fees are payments and receipts between residents and nonresidents for the authorized use of intangible, non-produced, nonfinancial assets and proprietary rights (such as patents, copyrights, trademarks, industrial processes, and franchises) and for the use, through licensing agreements, of produced originals of prototypes (such as films and manuscripts). Data are in current U.S. dollars.
Source: Author's calculations based on World Bank Indicators database.

Figure A.5.10 The evolution of the global market for intangibles, selected countries



Note: National accounts compute country payments and receipts between residents and non-residents for royalty and license fees for the authorized use of intangible, non-produced, non-financial assets and proprietary rights (such as patents, copyrights, trademarks, industrial processes, and franchises) and for the use, through licensing agreements, of produced originals of prototypes (such as films and manuscripts).
Source: Author's calculations based on World Bank Indicators database.

CONCLUSIONS

This dissertation has discussed the role of the State in promoting innovation in Latin America, with a special focus on the changes in the innovation policy and on intellectual property management. The experience of Latin American countries offers interesting insights to understand the relationship between technology, innovation and development and to clarify the challenges for governments in global open economies.

Most countries in Latin America are experiencing a boom in their commodity exports. This new landscape is opening new fiscal spaces, but it is also reinforcing the incentives against production diversification. To profit from the current global context and accelerating development, Latin American countries need to break some of the persistent elites' arrangements and develop new partnerships for development.

The global economic landscape is in continuous evolution and countries are under pressure to deliver better policies to improve the standards of living of their citizens. The rise of China is contributing to define a new geography of production and innovation increasing the competitive pressures in certain industries and opening new windows of opportunity in others. In parallel, the economic and financial crises of 2008 highlighted the weaknesses of the capitalist model of development in advanced countries, leading many of them to launch initiatives to support domestic manufacturing capabilities. In this new landscape, the global development debate seems to have shifted to Africa, the continent with the highest reservoir of world young and with an impressive growth performance. Latin America will receive less Official Development Assistance (ODA) and will increasingly need to rely on its own resources to foster development.

In this new landscape, a renewed attention to innovation and production development is crucial to guarantee over time inclusive and sustainable growth and better living standards in the countries of the region.

Talking about "Latin America" as a whole might seem a literary artifice. Despite the similarities, Latin American countries differ for institutional setting, natural resources endowments, and specialization patterns as well as for the configuration of its political and social elites.

This dissertation is articulated in five chapters, each following a different methodology. While this allows elaborating a comprehensive overview of innovation and intellectual property by touching on different topics and by mixing country analysis with cross-countries comparisons, this also limits the capacity to focus the analysis on a specific country, sector, technology or policy instrument. This dissertation does not include an empirical assessment of the impact of innovation policies in

Latin America countries, nor does it empirically estimate the impact of the new markets for knowledge on the region. Nonetheless, it contributes to understand the evolution of innovation policy models in the region, to assess the learning in policy making and to derive some policy implications. It opens new questions about the role of innovation in development. Exploring the differences between large and small economies in the region, as well as between the countries with models of growth based on extensive participation to global markets or on domestic demand, and the ones searching to diversify from natural resources, are relevant exercises that could bring new elements to the understanding of the evolution of policy models in Latin America and to identify future challenges for the development of the countries of the region.

What are the key findings?

Since the end of the 1990s innovation has become an issue of rising concern in Latin America; but most countries have struggled to achieve the right reforms and consensus to support innovation. The governments of the regions were debilitated by the structural reforms of the Washington Consensus. These reforms have not only weakened public institutions, but have engendered a generalized mistrust in government intervention, and especially in its capacity to shape industrial development and select technologies and business activities. The structural reforms have also interrupted learning processes in the private sector. Industrial sectors and jobs have been destroyed favouring the specialization in natural resources in South America and in *maquila* type of industries in Central America. The experience of Latin American countries shows a region in "slow motion", with interesting progresses, especially in the last decade, but with major challenges ahead.

Each chapter of this dissertation focuses on a specific issue. Some of the key findings can be summarised in the following points:

- Innovation policy is not neutral with respect to economic theory; different theoretical approaches shape policy design in different ways (Chapter 1 and 3). The dominance of the conventional approach in policy making has led to a detachment between the science and technology policy agenda and the structural transformation debate. This gap has contributed to jeopardize the effectiveness of innovation policies, because these policies work better when they aligned with production development strategies.
- Innovation theories could help in implementing better intellectual property policies (Chapter 3). The literature has showed that the transferability of knowledge, technology and learning is limited due to their intrinsic characteristics (e.g. tacit, complex, and embedded) and to the imperfections of the patent system itself (e.g. patent quality). It has also shown that the appropriability of innovation goes beyond the legal rights conferred to the innovators, and that it depends on the capacities to enforce the rights conferred. The clarification of the properties of knowledge, technology and learning contributes to redefine

the rationale for patent protection (rent management *versus* incentive). In practice, the capacities of the patent system to perform the appropriability and disclosure function are limited by the tacit nature of knowledge and by the relevance of learning by doing processes in applying new technologies.

- Innovation policies in Latin America shifted from a linear-supply model in the 1950s to a linear-demand oriented approach in the 1990s (Chapter 2). In the 1950s and 1960s innovation was assumed to ensue linearly from scientific discoveries to industrial application, then with the structural reforms of the 1990s the role of the state in support of innovation has been minimized to regulatory reforms and framework conditions. As a consequence of the structural reforms, the state efforts started in the 1950s and 1960s to create domestic scientific, technological and production capabilities have been rationalized. During these years a gap between innovation theory and the policy practice started to emerge. Innovation theory advanced in understanding the complexity of the mechanisms through which knowledge and technology are created and diffused in socio-economic systems. The theory had highlighted the importance of market and non-market incentives for innovation and the systemic nature of innovation, while, in practice the policies have followed a more linear logic. A preference for horizontal policies prevailed deriving from the lack of an explicit linkage between the industrialization and the innovation agendas. The Washington Consensus showed its fallacies and new political leaderships have started to emerge in some countries in the region, the policy model has evolved towards a more complex scheme matching supply and demand-oriented incentives. However, a generalized distrust in government capacity to select sectors and technological avenues persists, limiting the capacity to design and implement effective innovation policies.
- A major drawback of innovation policies in the post-Washington Consensus phase has been the lack of synchronization with the policies to promote production development and structural transformation. Innovation was assumed to be neutral, and could be therefore promoted without re-opening the debate on the role of the state in promoting industrial development. The structural reforms of the 1990s have helped to attain macroeconomic stability and stabilize inflation, but on the real economy side they have interrupted the processes of industrialization, learning and accumulation of production and institutional capabilities reinforcing the specialization of the countries of the region in primary commodities or in low stages of international production networks. The structural reforms have contributed to generate a paradigm shift in the prevailing economic development model. They have induced a generalized distrust in the capacity of the State to shape in efficient and effective ways the development trajectories of firms and countries. The package of the structural reforms rested on conventional theories that assumed that global and free markets would have exposed Latin American countries to competition, promoting modernization and technological development in the region. In practice, global free markets

have favoured consumption of imported goods and services, at the costs of slowing down, or interrupting, industrialization processes in knowledge and technology intensive fields where foreign firms had already accumulated substantial comparative advantages.

- Since the end of the 1990s four different innovation policy models have emerged in the countries of the region: competitiveness-based (e.g. Colombia), cluster-based (e.g. Chile), science-based (e.g. Argentina) and production development strategy (e.g. Brazil). These approaches have in common the recognition that innovation is shaped by the quality and density of the interactions in the national innovation system. Most countries have started to design sector specific instruments based on public-private partnerships and have opened new spaces for policy coordination. At the same time, many countries have started to define new intellectual property policies, due to the rising relevance of intangibles for innovation and to the inclusion of intellectual property provision in trade and investment agreements.
  In Brazil, the introduction of sectoral technology funds in 1999 and the explicit return of industrial policy on the government's agenda since 2003 have contributed to give a new impetus to the innovation policy. Brazil has started to invest more in innovation, also thanks to the introduction of innovation as one of the priorities of the National Development Bank (BNDES). The BNDES has started to reform its existing instruments and procedures for credit allocation to channel financing to innovation. The effectiveness of the Brazilian sectoral technology funds, based on a sophisticated mechanism of coordination between the private and the public sectors, has inspired the design of sectoral funds in other countries of the region, including Argentina and Mexico. In parallel, the rise in the revenues from natural resources, sustained by the growing demand from China, has allowed some countries to channel more resources towards innovation. Chile has been the pioneer in this field with the creation of a Fund for Innovation and Competitiveness in 2005 on the basis of a complex agreement on the royalties of exploitation of the copper mines. On the basis of this experience, Colombia and Peru have started to debate to finance innovation through the rents coming from natural resources. These mechanisms require sophisticated governance arrangements capable of aligning actions of different ministries but also across levels of governments, because they need coordination between the central government and the regions hosting the natural resources.
- The appropriability strategies of innovative firms in Latin America are similar to the ones of innovative firms in more advanced countries. Few studies have analysed the determinants of patenting and more generally the appropriability strategies of firms in the countries of the region. This is partly due to the low number of firms declaring to have applied for patent protection and to the type of questions related with appropriability strategies. Brazil is the only country in Latin America that includes in its innovation survey a question regarding the appropriability strategy. Innovative firms are asked to declare if they have used

one or more mechanism to protect their product or process innovations, differentiating in legal, including patents and copyrights, and strategic mechanisms, including trade secret and lead-time advantages. The econometric model presented in Chapter 4 estimates a probit model to test the probability that an innovative firm in Brazil protects its innovations through patents and it contrasts it with the use of trade secret, on the basis of the results of the national innovation survey of 2003. Following the existing literature, and having verified for the absence of sample selection bias, the model shows that patenting and trade secret are complementary rather than alternative strategies in Brazil, confirming the general evidence that innovative firms protect their innovations through a combination of mechanisms. In addition, the analysis shows that the determinants of patenting in Brazil are similar to what has been found in more advanced countries: larger firms, that carry out R&D on a continuous basis and that are specialized in more technology-intensive sectors tend to patent more than other firms. The chapter shows that innovative firms in Brazil use patent and trade secret as complementary mechanisms, patenting propensity is sector-specific and that firms tend to patent more than small firms. The difference with respect to more advanced countries is that in Brazil foreign firms are more likely to patent than domestic ones. Therefore, strengthened intellectual property protection might favour large, foreign firms, rather than domestic ones, in the absence of targeted policies for promoting production development and innovation in domestic firms. Brazil, similarly to the other Latin American countries, suffers of structural heterogeneity. Few, innovative firms co-exist with production units that operate at much lower levels of technology and productivity.

- The inclusion of intellectual property provisions in trade agreements has marked a major shift in intellectual property management (Chapter 5). The adoption of the TRIPS agreement in 1994 has applied the WTO free trade principles to the protection of intellectual property, favouring knowledge "owners" with respect to knowledge "demanders". The agreement also includes some flexibilities and exceptions including early-working rights before patent expiration for non-commercial purposes, compulsory licensing and parallel imports; however, the use of these flexibilities often requires political and legal capabilities that most developing countries lack. In addition, many countries in Latin America have engaged in bilateral trade and investment negotiations with the US which include more stringent intellectual property provisions than what had been agreed at the multilateral level.
- The reforms of intellectual property regimes at the international level matched with the rise of a more pro-patent attitude in the US and the diffusion of information and communication technologies have contributed to reshape the traditional markets for technology. New "derivative" markets for knowledge have been created where patents have become liquid assets whose value is increasingly disentangled from the value derived from the industrial application of the

patented technology (Chapter 5). Patents have started to become liquid assets. Their value is increasingly linked to expectations rather than actual industrial application. Patent owners have started to use patents for defensive purposes and to protect research advantages and to increase their reputation. New actors emerged as non-practicing entities that own large patent portfolios and sue companies for inappropriate use.

The rise of these new markets is reshaping the incentives to patent, it is opening new ways of generating rents through patents and, in certain cases, it is raising barriers for innovation, both for incumbents and for newcomers. In these new markets patents can be assimilated to liquid assets that can be used to extract rents beyond technology licensing. Recently, the development of these "derivative" markets for knowledge is raising concerns in advanced economies on the potential adverse impacts of patent thickets on the generation and diffusion of innovation, as well as on rising legal costs. Identifying the new trends in the markets for knowledge, including the existence the "derivative" markets for knowledge matters for developing countries because these markets can have an impact on the innovative strategies of their companies and universities. Latin American countries should recognize these global trends and define their position on the basis of their national interest. Developing countries lack today the capabilities to gain rents from these markets, but can be negatively affected due to the rise in barriers to access existing knowledge, as well as by the development of barrier to access in given technological fields.

In advanced countries several voices have started to demand a reform in the patent system to bring it back to its function of granting temporary and exclusive protection in exchange of information disclosure. What will be the position of Latin American countries? Will they define a patent policy in line with their development strategy balancing the interest of top innovation players with the need to knowledge access of the majority of the agents of its innovation system? The recognition of global trends and more and better analyses of domestic innovation trends are steps that could help to advance in this direction.

What are some of the policy implications of the findings?

Policy recommendations are context and time-specific. A high dose of pragmatism is required in policy design and implementation. The analyses presented in this dissertation contribute to show that innovation polices should be part of broader development strategies. In particular, it is possible to single out some policy implications in the following areas:

- Designing and implementing innovation policies in global open economies entails a high degree of complexity, especially for developing economies like Latin American ones which suffer of high structural heterogeneity. Diagnostics and foresight capacities are needed, as well as sophisticated policy mix.

- The innovation agenda of the 21st century cannot be carried out in "isolation". Science, technology and innovation have an overarching impact on development, quality of life and quality of services that can be delivered to citizens. Different communities should be involved in defining the innovation agenda, including the civil society and the different business communities. A major challenge is how to convey the views from the incumbents and the visions of the new players that the policies would like to support, but who are still not present at the moment of the definition of the strategy.
- Identifying the factors that are at the origin of failures in policy design and implementation is paramount to target reforms to the real causes of the failures and not to the consequences. Policies evolve, in fact, through trial and error. Building scientific, technological and innovation capabilities is costly, time-consuming and intense in institutional learning and experimentation. While it is normal to progress through trial and error, it is also important to recognize that errors are not always easily reversible and that it is important to introduce reforms taking into account the systemic dimension of policies. Policy outcomes often depend on complex interactions of different incentives, and costly reforms in one area without a general look to the overall system might not conduce to the expected results.
- Latin American countries need to bridge innovation policies with strategies for production development. Innovation policies without active industrial policies cannot be effective. In some cases they can even be counterproductive because they tend to privilege existing incumbents, rather than fostering the creation of new actors and of a dynamic innovation system.
- Advancing in the innovation agenda in Latin America means creating a consensus for a change in social and economic power equilibriums. The challenge for Latin American countries is not only to improve the design of policy instruments, but also to create a real consensus for innovation and to get the commitment of the private sector to invest in it. In addition, for most Latin American countries, innovation policies need to develop a capacity to deal with the territory in a more balanced way in order to mobilize untapped development opportunities.
- Patent policy should be an explicit component of innovation policy, and it should be defined taking into account the priorities of the production development and innovation strategy. The patent system contributes to define the conditions for knowledge generation and exploitation and therefore the position on intellectual property management should be defined on the basis of the national interest. Frontier countries have been using, and use, intellectual property as a *de facto* industrial policy tool to sustain the competitiveness of industries and to protect dynamic advantages in certain technological trajectories. Developing countries should learn from the experience of more advanced countries and strategically fine-tune their intellectual property regimes to their industrial development and innovation needs. Countries in Latin America should

better exploit the flexibilities of the TRIPS agreement to support their industrial development and innovation strategies.

- More evidence about innovative and appropriability strategies of firms in Latin America is needed to design more effective policies that take into account the way in which firms generate and diffuse innovations. Evidence suggests that innovative firms in Brazil and in Latin America in general, tend to behave similarly than innovative firms in more advanced countries, but that the critical mass of innovative firms in the countries of the region is much smaller than in frontier countries. The challenge for Latin America is therefore to put in place the incentives to create more innovative firms and to increase the propensity to innovate of existing firms.

  Innovation and patent policies need to be designed taking into account that islands of technological excellence co-exist with production systems that operate at much lower level of technology and productivity. These different realities require different incentives. Top performing firms will benefit from intellectual property protection in line with global standards, but for the majority of firms intellectual property regimes in line with global standards might be irrelevant because the probability that these firms will carry out patentable innovations is low, or might be counter-productive because they might raise the barriers for the entry into given innovation fields. Patent policy needs to be defined taking into account the time dimension. Firms and countries change their attitude towards patent protection as they move along the learning curve. When most firms in the country generate substantial innovation flows, they will demand better and higher patent protection. The experience of more advanced countries shows that patent policies are better defined when they are nested into broader industrial development strategies and when they take into account not only the need for appropriability, but also the need for knowledge circulation.

Some ideas for future research

The analyses presented in this dissertation open several research questions, especially in the light of the changes that are occurring in the global economic landscape and the repositioning of powers and equilibria at the global level. In particular, I would like to mention five issues:

i. How to design innovation policies in the changing global economies? The open economies context implies increasing globalization and interdependence between countries and a reconfiguration of global industrial powers. The literature has already started in the late 1990s to define the impact of globalisation on innovation policies, however, today the scale and deepness of globalization have increased and changed in nature. Latin American countries need to design innovation policies taking into account an increasingly complex global economic landscape, with high mobility of capital, labour and talents. New forms of business organizations as well as new patterns in the mobility of capital and labour are redefining the competitiveness space. The innovation policy mix should take into account these changes to improve its effectiveness. An improved understanding the international externalities of innovation policies is needed in the new global context, as well as a definition of new priorities in international cooperation. Up to now the US and Europe have been the major points of reference for global innovation, but it is likely that the world will see the emergence of multiple innovation hotspots around the globe, especially in Asia. How these trends will impact innovation policies and *vice versa* are topics that deserve more research.

ii. Global economies are experiencing a shift in prevailing economic models. We could hope that we are facing a turning point in modern capitalism. Confronted with the limits of its own expansion, capitalism is now requiring new directions and new regulatory mechanisms for guaranteeing job-creating and sustainable growth. Social and environmental sustainability are today economic concerns, which if not addressed will reduce growth potential in the future. For example, up to now it has been possible to grow almost in the condition of an open frontier for energy generation. Now the frontier is approaching at a rising peace. New sources of growth and new forms of energies for sustaining production and consumption are required. Innovation will be increasingly important to address these challenges. However, innovating in the future will not only mean to increase the "rate" of technological change; it will increasingly require acting on the "direction of technological change". Countries are facing the challenge to identify globally shared values to orient future technological change and innovation. To what extent production and innovation policies in Latin America are forward looking? What could be some of the potential areas in which Latin American countries could leap-frog frontier countries? Territorial management and organization of cities, for example, are areas of rising concern for Latin American countries, how this could impact and be influenced by the generation of domestic innovative capabilities?

iii. How to finance structural transformation and innovation? In certain cases development banks could play a determinant role; but what are the characteristics and the management models that enable development banks to effectively support innovation today? In other countries, the rising revenues from natural resource exploitation could represent new sources of financing for innovation. However, little is known about how to do this in practice. Which institutional settings better work? How do deal with the territories hosting the natural resources? What are the institutions and the rules that would allow having financial markets that properly favour investment in innovation and production development? The linkage between the institutionality for financial markets and the requirements of an economy searching for an innovation-based model of growth is underexploited in the literature. More research in this area could help addressing a major constraint for development in Latin American countries.

iv. Better qualifying and understanding the dynamics of the "derivative" markets for knowledge could be of help to propose reforms in the knowledge governance system. The intuition of the existence of "derivative" markets for knowledge is an important step to call the attention on the fact that incentive schemes in practice tend to work in a different way than in theory. However, quantifying the derivative markets for knowledge and estimating their impact on the creation and diffusion of knowledge is an open challenge. To restore the principle of global public interest and to propose reforms in the regulations of the mechanisms that define knowledge appropriation and circulation requires a deeper understanding of the dynamics in the knowledge markets, including of the "derivative" ones.

v. Promoting innovation in Latin America is not only the task of innovation policies *strictu sensu*. It requires a change in power balance and a redefinition of political, social and business elites. To advance in the innovation agenda a multidisciplinary approach is needed to match firm level visions with more sociological analyses of developing societies. The prevailing specialization of the production structure is at the origin of the scant innovation performance of the countries of the region. But the evolution and conformation of the capitalist society in Latin America and its connection with political elites also play a determinant role. The linkage between the elite and power groups in Latin America and private sector development is an issue that would deserve deeper analyses.

A key challenge for development is to create incentives to generate social mobility, and innovation and production development policies should contribute to this, while in many cases they tend to reinforce dominant positions. Innovation (i.e. new products, new processes, new business methods, new services, and new forms of organization of production) can greatly impact not only the rate of growth, but also the "quality" of growth. Innovation related options will become strategic choices for contemporary societies. This is particularly true for developing economies that have been growing at higher rates than advanced countries in the last decades, and that have started to accumulate production and innovation capacities, as well as a variety of new aspirations and demand in their societies.

Innovation is seen as the future shaper of socio-economic well-being of our societies. Contemporary economies need to rethink current development models and identify new sources of growth. There is a need to build a new social consensus for innovation and to think about the "quantitative" dimension of growth (How to guarantee high growth in the future?), but also about the "qualitative" dimension of growth (How to guarantee inclusive and sustainable growth? How to generate well-paid and secure jobs? How to promote environment friendly growth?). Analyzing under which conditions these policies are able to contribute to the ultimate goal of achieving social and structural change is also a promising area for future work which would benefit from adopting a multidisciplinary approach.

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Annalisa Primi was born in 1977 in Rome, Italy. She obtained a degree *cum laude* in "Economics of Institutions and Financial Markets" from the Faculty of Economics of the University of Tor Vergata in Rome (Italy) in 2001 and, in 2003, a Master in Economic Development and Cooperation from the European School of Advanced Studies of the University of Pavia (Italy). From 2003 to 2009 she was Associated Expert at the Division of Production Productivity and Management of the Economic Commission for Latin America and the Caribbean (ECLAC), Santiago (Chile). Her work focused on innovation, intellectual property and industrial policies in Latin America, carrying out policy oriented research and technical assistance to the countries of the region in designing and assessing their production transformation and innovation strategies. While working at ECLAC, in 2006, she was admitted to the PhD program at UNU-MERIT, Maastricht (The Netherlands). In 2009 she joined the OECD (Organization for Economic Co-operation and Development), Paris (France), where she currently is Senior Economist at the OECD Development Centre. She is Head of the OECD Policy Dialogue Initiative on Global Value Chains, Production Transformation and Development. She has been the lead-economist of the *OECD Perspectives on Global Development 2013: Industrial policies in a Changing World.* She is author of several ECLAC and OECD publications, as well as of some academic articles on technical change and economic development, the role of the state in development processes, economic transformation strategies, industrial, innovation and intellectual property policies.

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