# THE IMPACT OF PUBLIC POLICIES FOR INNOVATION IN THE INCREASING NUMBER OF PATENTS – BRAZIL AND CHINA

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## ABSTRACT

Innovation, generation of technologies and intellectual property are increasingly recognized as important issues and marks of competitiveness of business and economic development of countries. As such, the interaction between innovation and intellectual property has been analyzed by economists from different schools of thought. The same could be addressed to the connection and impact on the technological knowledge and the level of maturity of an economic system among countries and regions. This paper analyses how the configuration, structure and degree of interconnection between innovation and intellectual property policies influence the generation of technologies and patents in two countries with emerging economies - Brazil and China, and draws some considerations about the link between innovation strategy and economic performance in both countries. Our findings suggest that a relative small set of critical points, such as greater integration between innovation and IP policies, more aggressive role of local governments and long-term policies, allowed a much stronger performance of the Chinese innovation system as compared to the Brazilian.

**Key words:** intellectual property, innovation systems, industrial and innovation policies, patents

## INTRODUCTION

The concept of National Innovation Systems has received great attention in the last few decades. As a matter of fact, this concept, which was originally introduced by Freeman in the 70s, has also been studied extensively by other authors, among which are Lundvall (1999) and Nelson (1967). This systemic approach to innovation was drawn from empirical studies conducted in the late seventies, which demonstrated the importance of both formal and informal networks of innovation, even if those were not perceived that way then (Liu at all, 2011).

According to Lundvall and Borras (2005) the concept of innovation system implies a perspective where most policy areas need to be considered in light of how these areas can contribute to the innovation process. Freeman (1987) and Lundvall (1992) propose a broader view than some authors. That perspective includes all institutions related to the development of technology and innovation, and, further, other institutions such as the financial system and public policies that affect directly or indirectly innovative capacity. It is important to note that the national innovation systems differ in terms of patterns of specialization and institutional structure and are reflections of several factors: political, economic, historical, social (Liu at all, 2011).

They also point out that structuring policies for innovation requires insights and specific inputs considering the institutional characteristics of the national innovation system, the existence of collaborative networks and the existence of sectoral policies of each country.

Chaminade and Edquist (2006) define systemic problems as systemic imperfections that can be reduced in pace or even block an interactive learning and other activities that are crucial for the parties involved in the innovation process in a given innovation system” (Woolthuis et al. , 2005. P.610). According to this systemic approach proposed by Chaminade and Edquist (2006), companies do not innovate in isolation, but rather within a system of networks where direct and indirect relations are established, formally or informally, between various institutions and organizations, such as teaching and research institutions, government and other companies, and taking into account the macroeconomic environment in which are inserted.

One key aspect of policy innovation concerns the condition to review and redesign the links and connections between the various parts of institutional agents, companies, researchers, public policy makers and managers. According to Chaminade and Edquist (2006), in a systemic approach the importance of competition is recognized, but demand close cooperation between actors, producers and users of technologies, and sometimes even competitors.

Asymmetries in the technological capacity of companies and countries usually persist for long periods of time, beyond the legal mechanisms challenging the process and conditions of ownership and transfer of technology. Also the rationale in protection derives from the need to introduce the possibility of discretionary exclusion in order to create incentives for the agents to engage in efforts that will lead to the generation of the "conceptual" and "intangible", which would otherwise be easily appropriated by its competitors as discussed by Cimoli and Primi (2007).

While patents are not the only mechanism for appropriation, this is undoubtedly the most relevant mechanism with direct impact on the degree of sector specific, and influenced by a number of structural characteristics of the companies.

Besides these factors, we consider that other variables contribute to streamline and improve the economic results of the countries, based on their systems and policies for innovation, among which we highlight:

i. System Structure of Science, Technology and Innovation - S, T & I
ii. Degree of coordination of policies (governance model, design and implementation);
iii. Existence of Long-term policies
iv. Infrastructure for innovation
v. Legal and Institutional Framework for Innovation and Intellectual Property (IP).
vi. Therefore, this study is aimed at improving our understanding on how the configuration, structure and degree of interconnection between innovation and intellectual property policies influence the generation of technologies and patents in two countries with emerging economies - Brazil and China.

This paper is structured as follows. After this introduction, we provide a description of our research methodology. Then, we assess the trajectory of the innovation systems of both Brazil and China. The final section draws some overall conclusions.

## METHODOLOGY

Since literature remains debatable on the relationship between public policies for innovation and patent filings in developing countries, we adopt a qualitative/quantitative approach based on a combination of literature review, interviews with experts and analysis of patent statistics regarding both Brazil and China.

In order to adopt a pure quantitative approach, extant literature must offer clear conventions the researcher can use, such as the widely accepted and well-known rules of algebra through which the validity of mathematical deductions is known (Lee, 1989). This is not the case of our study given the controversial evidences on our research object. A fundamental characteristic of a qualitative approach, in turn, is that researchers may have less *a priori* knowledge of what the variables of interest will be and how they will be measured (Benbasat et al, 1987).

Conversely, qualitative researchers are sometimes disposed toward causal determination of events, but more often tend to perceive events not simply and singly caused (Stake, 1988). Consequently, the combination of qualitative and quantitative approaches can be very synergistic (Eisenhardt, 1989).

## TRAJECTORY OF SYSTEMS AND INNOVATION POLICIES IN BRAZIL AND CHINA (2001- 2013)

### Brazilian Innovation System

Brazil is a federative republic composed of 26 states and a federal district where the capital Brasilia is located, with a population of 198,7 millions and a GDP US$ 2.242,9 billions (Global Innovation Index, 2014). Brazil is a low R&D performer in OECD terms. GERD/GDP has increased slowly in recent years to 1.28%. In the 80´s various programs and public policies were also directed to support applied research and technological development. However, due to economic crises like the oil crises (1973 and 1979) and a macroeconomic context of inflation and high exchange rate, there was a drastic reduction in resources offer in the last years to 1.00% in 2000. From the 1980s when it averaged 0.45% it almost doubled in the 1990s at 0.83% on average. The major sources of funding for R&D in 2000 were Federal Government (0.40% of GDP), Business (0.41%) and State Government (0.18%) reaching US$ 12.53 billion PPP (R$ 10.97 billion reais); the average annual budget Rs $ 4 billion.

During the 60s and 70s there was a strategic guidance for structuring the academic setting, which coincides with the period of the military dictatorship, the emphasis then was in the areas of engineering , human and life sciences for S , T & I.

During this period, 80-90, which the economists call the "lost decade", Brazil resorted to external sources - loans from multilateral sources with the IDB and Bird. Due to this situation a major challenge for the country was to structure a new funding model.

Until recently, research policies in Brazil were geared mainly to public research, exceptional individual researchers in universities and public research organizations. They often lacked financial resource continuity due to cyclical budgetary constraints and a generally fragmented disbursement which are product of a highly segmented policy with a multiplicity of disjointed target areas.

As far as innovation policies are concerned with the central state (federal government) and the regions (state governments) identify priorities and resources, each will contribute to that. This process happens through the implementation of programs and operational activities related to Science, Technology and Innovation (STI).

**Government Policy Making And Coordination**

Since the 80´s, the coordination of the research policy (research projects, scholarship programs, research institutions) is under the responsibility of the Ministry of Science and Technology and Innovation (MCTI), at that time only MCT (created on March 15, 1985) , at the government level.

In terms of definition and execution of the research and development budget, however, there is an involvement of other ministries: mostly the Economic and Industrial Development- MDIC, Energy, Education, Telecommunications, Planning, Trade. Research budgets (S&T) are structured on an annual basis but are part of a multi-year budgetary planning tool, the Pluri Annual Plan- PPA, designed and coordinated by the Ministry of Planning, Budget and Administration- MPOG. Budgetary sections at each ministry prepare the budget proposal to MPOG, in which they have to identify planned expenditures on S&T activities on line with the PPA objectives and guidelines for the area.

The Ministry of Science, Technology and Innovation ‑ MCTI (which carries a new name since 2012) is the central body of the Federal System of S&T and is responsible for the formulation and implementation of the Science, Technology and Innovation Plan - PNCTI (Chapter IV of Federal Constitution (1988). The MCTI mandate areas comprise: scientific and technological heritage and their development; related cooperation and exchange policy; definition of PNCTI; coordination of sector policies; and national research, development, production and application of new materials and high technology services policy.

The key research policy institution is the MCTI, with its innovation agency FINEP, its basic research arm, the National Council for Scientific and Technologic Development (CNPq) and its network of PROs. Graduate education financing policy is also set by CAPES, an agency of the Ministry of Education ‑ MEC. Finally, there is the Ministry of Development, Industry and Trade (MDIC), responsible for the leading the definition of Brazil`s industrial policy through the recently created policy organization, Brazilian Agency for Industrial Development (ABDI).

MCTI and MDIC jointly define the industrial and technological policy priorities, and, in partnership with the Ministry of Finance establish the percentage budget (mainly from the National Scientific and Technological Development Fund - FNDCT) to be directed to economic subsidies and the percentage directed exclusively to medium and small companies. The MCTI main funding agencies are FINEP for technological development and innovation and CNPq for basic research and human resources. MCTI also has two mission agencies ‑ CNEN in nuclear energy and AEB in space. Finally, it has several executive PROs under its purview set in different states of the country.

**RECENT BRAZILIAN SCIENCE, TECHNOLOGY & INNOVATION ACHIEVEMENTS (2000-2014)**

During the last decade the Brazilian government has taken over the development of Industrial Policy and thereby leveraged and gave greater visibility to innovation agenda. The government has initiated a new cycle of Industrial Policy establishment and innovation was recognized as a strategic pillar of economic development. In this context the government also created a new legal framework to give legal support to new arrangements between public and private actors and allow the creation of new financial instruments.

From 1999, a new financial framework has evolved with the establishment of extra-budgetary sector funds for research, each with a different revenue formula. Resources come from a re-direction of shares of existing and new taxes and levies on sectors` services and operations. Each can only fund research of interest to the sector and priorities are generally set by joint sector-specific public-private commissions. The creation of sector funds, in 1999, brought a new perspective of funding to the national and regional scientific and innovation systems. The first sector fund was related to Oil and Gas industry; until 2005 there were 16 sector funds structured.

Administrative costs are kept down by centralization of the funds (except for one) under the responsibility of Brazil`s Innovation Agency (FINEP), a government agency under the Ministry of Science, Technology and Innovation (MCTI). They provided a more continuous stream of financial resources into research, took research financing to new and growing level (although there are significant differences among the 14 operating funds), established new mandatory university-industry arrangements for research execution and created new joint public-private research selection procedures. Because of the creation of the sector funds the annual budget for S, T&I jumped from RS $ 1 billion to more than RS$ 4 billion.

The governance structure was reinforced by the implementation of Science & Technology Secretariats Council ‐ CONFAP with the representation of all the 27 states, created in 2006. The Council debates and defines regional and state priorities linked with the national ones, and tries to establish a budget level, or at least, identify finance sources at the public and private sectors. These efforts have generated at another level an integration of the “territorial reality” in their national scientific strategies. In practice, that implies that the regional authorities and PROs are increasingly developing innovation network activities.

Federal-state programs were promoted and developed, and state agencies were created, reinforced and expanded the scope of their research policies (e.g. IP and innovation concerns brought to the agenda). Some of the main challenges facing the research policy and innovation system include the maintenance of the actual flow of disbursements of sector fund resources, the efficacy of their commissions in terms of strategic targeting and continuity, firm stage funds distribution and transparent priority-setting criteria.

This shared implementation and the relative flexibility it allows to state partners is one of the products of the ongoing conversations between the Federal Government research and innovation policy makers with peak organizations of state ST&I secretariats (Conselho Nacional de Secretários de C&T) and research support foundations - FAPs (Conselho Nacional de Fundações de Amparo a Pesquisa). Another prominent example of this emerging research policy partnership trend between the MCTI and the states is the Regional Scientific Development Program.

A set of horizontal action programs partly funded by resources from the budget of the 13 others aims to finance strategic programs of the MCTI within the priorities set by the Industrial, Technological and Trade Policy of Brazil. One horizontal fund, financed by shares of existing taxes and levies, "Verde Amarelo Fund" is geared towards the creation of mechanisms to reinforce university-industry research relations and to extend this cooperative research process into the innovation stage. Furthermore, funding levels for traditional graduate and research scholarships were significantly increased and incorporated greater continuity due to the infusion of resources also from the sector funds.

These policy initiatives brought research policy makers and institutions closer to the market players, including capital and stock market institutions and organizations. Moreover, large business groups were attracted to venture capital. The National Program to Support Incubators and Technological Parks ‐ PNI (Programa Nacional de Apoio a Incubadoras e Parques Tecnologicos), developed by MCTI in collaboration with several partners (Ministerio do Desenvolvimento, Industria e Comercio Exterior; Banco do Nordeste, Sebrae, Senai, Instituto Euvaldo Lodi and Associação Nacional de Entidades Promotoras de Empreendimentos de Tecnologias Avançadas (Anprotec)) is aimed at capacity-building for the creation of new ventures and support to the structuring of state and regional networks of incubators.

**THE NEW LEGAL FRAMEWORK (2004- 2010)**

In December 2004, Brazil passed an Innovation Law, which allows researchers in Public Research Organizations (PROs) - and federal universities to leave their post for up to three years, maintaining pension benefits and career evolution rights, to create a technology-based start up. It also promotes the establishment of technology transfer offices (TTOs) in PROs and federal universities among other provisions, approved just in December 2005. The Innovation Law promoted the harmonization of the old legal basis on university-industry cooperation, along the lines of Bay-Dohle American Act. This law provided all the institutional apparatus for forming strategic alliances between research institutes and firms and established mechanisms for sharing infrastructure and economic benefits of the resulting innovations (Araujo, 2011).

At the end of 2006, completing a research policy shift in the division of labor towards research for the private sector, the government implemented a new research funding mechanism exclusive for enterprises. For the first time companies can receive non-reimbursable funds for RDI activities; this new financial instrument was approved in the framework of the Good Law , enacted in 2005 .

In November 2007, the Government launched the S, T &I Action Plan 2007-2010. This Plan expresses the new configuration of the National Policy of Science, Technology and Innovation, reflecting the expectation that the MCTI act in a more intense and crucial way to the economic and social development of the country. Joint initiatives will be strengthened between the MCT and other ministries, states of the federation, municipalities and the business sector, still counting with the participation of other relevant government agencies, such as the BNDES and Petrobras.

In part, the national research system has not fully kept up with the dramatic changes in the policy particularly in regard to the new required set of institutional arrangements among key players and organizations, to monitoring and evaluation needs, innovation specialized human resources and sharing of accountability.

Several measures and instruments aimed at raising the level of R&D investments have been developed and implemented over the past few years, with an emphasis in the last couple of years on those for policy areas in the agenda of the Innovation Law of December 2004 (Law 10.973). This policy innovation cycle seems to have been completed at the end of 2006 although refinements and reorientations in instruments will be needed. The near majority of the research policy instruments make use of competitive calls mechanisms.

In Brazil, there is an inefficiency of the national innovation system to translate already R&D investments into commercial applications, namely: poor collaboration between private firms and researchers at universities and quality of research institutions, lack of fiscal and financial incentives to companies to patent in the country or abroad.

**THE INNOVATION LAW - A REGULATORY FRAMEWORK APPROVED IN 10/11/2005.**

Besides creating the subsidies for innovation research presented earlier, the Innovation Law also established a series of measures to stimulate R D & I in firms and ROs, particularly federal research institutes and universities, facilitating cooperation among them. Among the main provisions are:

i. provision of direct RD&I subsidies to firms;

ii. special conditions for provision of RD&I subsidies to SMES;

iii. new regulatory framework for investment funds for technology and innovation;

iv. government R&D procurement;

v. special support to strategic innovative firm (industrial policy priorities);

vi. new venture incubation;

vii. creation of TTOs in public ROs;

viii. public researcher mobility in public ROs;

ix. economic incentives for public researchers in universities and ROs;

x. administrative flexibility for technology transfer for public ROs, allowing them to sign technology transfer agreements;

xi. support to strategic alliances between public universities/ROs and firms; and

xii. enhance flexibility for sharing public universities/ROs R&D infra-structure with firms.

The current structures of research governance structure have been developed since the creation the MCTI and have not experienced major changes. It remains a largely opaque, top-down governance structure although it increasingly incorporates new regional, sector and research organization trade association actors at lower levels of policy detail and regulatory framework definition. New types of governance partnership have been developed in recent years between the MCTI and other ministries in order to formulate, design, regulate and implement policies for strategic areas convergent with missions or activities of other ministries.

It is however at technological development and innovation governance structures that major changes have been taking place, particularly as a consequence of the establishment of the Sector Fund (SF) programs and their evolving governance structure. A major governance innovation of the SFs was the Management Committee composed of public and private experts of the sector, charged with the establishment of objectives, goals, guidelines and orientations for the fund operation. This was to focus resources solving a longstanding research policy problem of resource dispersion due to difficulties in identifying strategic areas and aggregating interests to support choices over the long term.

Brazil has a tradition in the formulation of national plans for STI since the seventies, with so-called Basic Plans for Scientific and Technological Development - PBDCTs - and then in the MCT rearing period, in the 80's (IEDI, 2011). However, even with the launch of plans and recent national policies -

S, T &I Action Plan 2007- 2010 -PACTI. The establishment of industrial and technological policies: Política Industrial, Tecnológica e de Comércio Exterior (PITCE) (2004), Política de Desenvolvimento Produtivo (PDP) (2008), Plano Brasil Maior (2011) and the consequent creation of new funding instruments, these plans do not behold, at the same level, priority sector choices, at least not in the long term, unlike the Chinese case which is based on learning and Japanese and Korean models (Erawatch, 2008-10).

The most recent program launched in 2012 - the “Inova Company Plan” that includes a family of sectorial public calls that presents two new approaches: 1- a program that includes a set of different types of financial instruments: grants, loans, venture capital and equities and 2- the definition of sectors and thematic areas is made jointly by FINEP and BNDES, with resources of the two federal agencies. The budget for the program in 04 years is US$ 16.6 billion.

**CHINESE INNOVATION SYSTEM**

China, officially the People's Republic of China (PRC), is a sovereign state located in East Asia. It is the world's most populous country, with a population of over 1.35 billion, with GDP of US$ 9.181,4 billion.

Since the introduction of economic reforms in 1978, China has become one of the world's fastest-growing major economies. As of 2013, it is the world's second-largest economy by both nominal total GDP and purchasing power parity (PPP), and is also the world's largest exporter and importer of goods. China is a recognized nuclear weapons state and has the world's largest standing army, with the second-largest defense budget. The PRC has been a United Nations member since 1971, when it replaced the ROC as a permanent member of the U.N. Security Council. China is also a member of numerous formal and informal multilateral organizations, including the WTO, APEC, BRICS, the Shanghai Cooperation Organization, the BCIM and the G-20. China is a regional power within Asia and has been characterized as a potential superpower by a number of commentators.

**HISTORY**

The Chinese innovation system started with the Soviet model in the 1950s, where the activities of science and technology innovation and the industrial activities are separated. The transfer of technologies developed in R&D institutes under this system was also controlled by different levels of governments. As a result of this system, public research institutes had no incentive to understand the needs of enterprises for technology, while state owned enterprises (SOEs) were supposed to concentrate on production activities, without improper incentive system for innovation by using technology by public research institutions (Motohashi, 2006).

In 1985, a Resolution of the Central Committee of the Communist Party of China on the structural reform of the science and technology system was enacted, serving as the cornerstone of a departure from the Soviet model of innovation system, where S&T activities at public research institutes (PRIs) and production at state-owned enterprises (SOEs) were completely separated (Xue, 1997). Several policy actions concerning innovation system reforms have been targeted at the introduction of proper incentive systems for both science and industry sectors for innovation, i.e., R&D for new product development, improvement of production processes, etc. In the science sector, PRIs and universities are given greater autonomy in selling their research outputs, while institutional funding from the government is reduced (NRCSTD, 2003). (Motohashi, 2006).

One of the major goals of recent policy initiatives in China is to solve such incentive problems in both science and industry, in order to stimulate innovations based on research outputs from science sectors.

In China's fifteenth 5-year plan, from 2001 and 2005, economic development driven by technological progress is stated as a central theme, and further stimulating innovation activities and institutional reforms to abolish the imperfections associated with socialist systems constitutes one of the major pillars for achieving sustainable and balanced growth of the Chinese economy (World Bank Institute, 2001). This plan is based on a series of innovation system reforms started in the 1980s, conducted in such a way as to be consistent with China's economic shift from a centrally planned system to a market-based economy (Motohashi, 2006).

**REFORMING THE SCIENCE SYSTEM (1985–1992)**

In March 1985, the Central Committee of the Communist Party of China (CCCPC) proposed a strategic guideline that `economic development must rely on S&T, while the development of S&T must be oriented towards serving economic development` (CCCPC, 1985). This guideline served as a roadmap for the reform of the science system. It had five main thrusts, namely to:

i. reform the funding system for S&T and manage funding;
ii. implement a technology contract system, so as to develop the market for technology and
iii. promote the commercialization of research results;
iv. introduce a market mechanism and adjust the organizational structure of S&T, in order to
v. strengthen enterprises` capacity for technology development;
vi. empower research institutes by giving them the right to self-determination and independent status;
vii. reform the system of S&T personnel management and implement a merit-based pay system.

In 1978, China initiated the first of a series of far-reaching reforms and began opening up to the outside world. The first reform as far as the science system was concerned consisted in extending the decision making power of R&D institutes and reforming the R&D funding system. This was followed by the gradual introduction of a market mechanism into the S&T system and by S&T-related legislation. The last stage has seen the establishment of a national innovation system favoring S&T-based socioeconomic development. The reform of the science system can be divided into different stages.

Between 1982 and 1990, China promulgated several laws and regulations related to IP issues that included the Trademark Law (1982), Patent Law (1984), Madrid Agreement Concerning the International Registration of Marks (1989 ); Patent Cooperation Treaty - PCT (1993) and The Agreement on Trade- Related Aspects of Intellectual Property Rights - TRIPS in 2001.

**THE SECOND WAVE "RECONSTRUCTING THE SCIENTIFIC MANAGEMENT SYSTEM" (1978–1985)**

The National Science Conference in March 1978 marked a turning point in China. The conference emphasized that `S&T is the productive force' and that `the modernization of S&T is the key of the four modernizations', the other three being industry, agriculture and defense. The conference approved the Outline of the National Science and Technology Development Plan (1978‑1985) and issued three complementary documents: Main Tasks of Scientific and Technological Research, a National Plan for Basic Science and a National Plan for Technological Sciences. Two critical measures were adopted in this period: the national examination system for higher education was restored in 1978 to develop qualified S&T personnel and the National Leading Group for Technology Contract Law (1987) and Copyright Law (1990).

It also improved the national S&T awards system by adjusting existing awards and setting up new ones, including the: National Natural Science Award, National Invention Award and National Science and Technology Progress Award. In parallel, China adopted a series of important policy measures to adapt institutions and policies to the needs of socio-economic development, including: establishing the National Natural Science Foundation of China; initiating the National High-Tech R&D Program, also known as the 863 program because it was proposed by four top Chinese scientists in March 1986; creating high-tech industrial development zones and; encouraging the development of technology-based enterprises (OCDE, 2010).

**MAKING SCIENCE & TECHNOLOGY AN INTEGRAL PART OF THE ECONOMY (1992–1998)**

In 1992, China proposed establishing a socialist market economy. In order to make S&T an integral part of the economy, the government proposed adjusting the allocation pattern for resources destined for S&T. A key policy measure was the instigation of the Combination Development Project for Industries, Universities and Research Institutes in April 1992 by the State Economic and Trade Commission, in tandem with the State Education Commission and Chinese Academy of Sciences.

The Science and Technology Progress Law, promulgated in July l993, resolved some fundamental legal issues. For instance, it defined the objective and key tasks of S&T activities and Science and Technology of the State Council was established in December 1981 to strengthen scientific management. (OCDE, 2010).

Some characteristics of the innovation systems of two countries are given below:

| | Brazil | China |
|---|---|---|
| Structure of C, T &I System | Existing institutional framework with strong appeal to the academic areas of life sciences | Institutional framework well structured and robust, integrated with an emphasis in engineering. |
| Level of governance / coordination of innovation policy | Low / under consolidation | Very high |
| Key/ Main institutional actors | MCTI, MDIC, ABDI, MEC | MOST, central government and regional governments |
| Investment in R & D - public and private | Strongly by the government | Government and Business |
| Existence of Long-term policies | Short policies of existence and medium term | Existing with a high degree of coordination |
| Degree of discontinuity of programs and actions | Very high | Very Low |
| Bottlenecks, critical factors | Innovation policy is government policy; high degree of discontinuity of actions and programs, including industrial policies; little alignment between the agendas of innovation and economic | Innovation policy is state policy; actions and long-term programs to identify priorities; strong alignment between the agendas of innovation and economic |
| Infrastructure for innovation | Existent, in consolidation | Existent, with great advances in the last decade. |
| Legal framework for innovation and IP | Existing, fragmented with little connection between innovation and IP | Existing, integrated, redesigned in China's entry into the WTO . |
| Companies ´Business Model | Mainly focused on the local market | Global |

Source: Author´s elaboration, 2014.

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Based mainly on Dahlman (2008), Pacheco (2011), some considerations about the structure and innovation policies between Brazil and China can complement and highlight the analysis of data on innovation policies and intellectual property as shown below:

i. Brazil and China have a specific Ministry (MOST in China and the MCTI in Brazil), with higher levels of coordination and a set of decentralized actors (universities, research institutes and companies). However, this formal similarity masks the fact that in China, there is a much greater degree of centralization of decisions and a stronger weight of the National

Coordination Group of S & T and Education, which are designed and followed the big plans for STI.

ii. Formulation of Chinese systematic and implementation of five-year plans gives its planning, either in general or sectorial terms, a much more effective instrument for promoting the development of new technologies. First, because of long-term planning culture is already established and is a routine for all government bodies. Second because there is continuity in the actions and the new plans give continuity to the previous ones, without the disruptions that commonly occur in Brazil. Third, because the implementation of the programs is favored by the command and control degree that the Chinese state has on many of the actors involved, which largely depends directly on the government (state-owned enterprises, federal research institutes).

By analysis of the results accomplished by China, it is possible to perceive that a major performance gap exists between the Brazilian and the Chinese innovation systems. In fact, although some Brazilian technological sectors are highly competitive, most sectors are operating still far away from the technological frontier. More salient is still that Brazilian innovation policies, which have gained importance in the last decade, are highly concentrated in the reform of the instruments, but give little importance to the strategic aspects and economic objectives arising from these actions.

On the other hand, Brazil's policies are more sources of stimulation or inducing changes in conduct of the actors than mandatory rules, as in China. Compared to the Chinese strategy, may indicate that in Brazil prevail some problematic aspects of policies, like:

i. Brazil has formulation of national plans of tradition for STI, since the seventies, with so-called Basic Plans Scientific and Technological Development - PBDCTs - and then in the MCT rearing period in the eighties. However, this tradition was only recently recovered from the creation of new instruments for the promotion and financing, and industrial and technological policies a little more active;

ii. The plans and recent national policies (PACTI, PITCE, PDP, Greater Brazil Plan) place great emphasis on innovation, but are weak in terms of strategic options. It shows an intrinsic difficulty of choosing priorities or deploy sectoral actions of great heart, which are hinged to the strategies of the private sector, perhaps with some exceptions in the oil and gas , energy and health sectors;

iii. As regards the governance structure, in Brazil, the National Council of Science and Technology is a fragile instance, more geared to house affairs and contemplating 'stakeholders' conventional S & T system to formulate long-term national strategic plans. It is remarkable that the Brazilian CCT badly available staff or resources is capable of devising and monitoring national plans of fact, while the process of preparation of the relevant plans of China count on numerous working groups and technical staff not only qualified but also numerous;

iv. Another great difference between Chinese and Brazilian strategy is the precarious relationship between Brazil's strategy in S T & I and national economic agenda. Partly this is explained by the origin of the Brazilian MCTI, created during the democratization of the country, more due to the political context than a development strategy option. The precarious articulation of MCTI with the economic agenda emphasizes its locus feature of dialogue with the scientific community, vis-a-vis their role as liaison with central government sectors, such as the Ministry of Development and the Ministry of Finance. This is not the Chinese case, much inspired by the success of the Asian strategies and 'models' of Japanese and Korean technology policies. Additionally, the higher education systems of the two countries is exactly the profile of graduates: in China, 5.0% of these graduates have gone in science and 36.1% in engineering (full training and three years) as shown in the following table. In Brazil equivalent percentages are 7.8% and 6.7%, respectively. In absolute terms the differences are striking (IEDI, 2011).

In higher education, literature specialist has called attention to a supposedly low the quality of human resources in the areas of science and technology is in China, if compared to other developed countries. Even so, to assess the growing number of Chinese universities that are positioned among the world's best in various rankings available, the effort to provide world-class universities has had positive results.

**INNOVATION POLICY AND INTELLECTUAL PROPERTY – HOW THE SETTING OF INNOVATION SYSTEMS AND IP STRATEGY AFFECTS THE RESULTS IN THE TWO COUNTRIES**

Developed country innovation systems have some pretty remarkable features for a strong state participation in the system coordination; Influence of the defense system on the agenda of Research & Development (R & D); a high degree of entrepreneurship and, above all, developed countries have the innovation agenda as a critical factor of development, also supported by a strong investment in R & D by the private sector, and a well-structured Intellectual Property system.

One of the transverse and fundamental components of innovation systems is the set of public policies and legal framework for Intellectual Property (IP). Without it, much of the R & D does not occur as expected, nor does it allow a considerable amount of knowledge to reach the market or society. The origins of Intellectual Property Rights (IPR) go back several centuries but the institution matured and took its modern configuration in the first half of the 19th century, in the sequence of the industrial revolution. Patents were envisaged as a device to provide inventors with monopoly power so that they appropriate the returns on their invention.

The use of patents statistics in innovation assessment was first proposed by Jacob Schmookler (1966). Since then, patent statistics have been widely used over the last few decades, with the number of new patents being taken as an indicator of innovation.

Marzal and Tortajada-Esparza (2007) point out to the many advantages of using patent statistics: a patent is associated with the development of a new technology; patent databases give easy access to information and enable comparison between countries; and patent analysis also allows for the understanding of knowledge flows, through citations analysis. Some studies have shown a strong relation between innovations and patenting. The European Patent Office estimated that 50 percent of innovations are patented (EPO, 1994, p. 25). Also, some empirical studies which have been carried out with both patents and actual innovations have not detected significant differences among these two output indicators (Jaffe, 1989; Acs and Audretsch, 1993; Acs et al., 2002).

However, several authors, some of them pertaining to the very community that championed the use of patent statistics, have also highlighted problems in using patents as an innovation indicator (Pavitt, 1988; Griliches, 1990; Trajtenberg, 1990; Archibugi, 1992; Smith, 2005). Since the pioneering study of Levin et al. (1987) it is well known that the intensity of patent demand varies widely across sectors. Levin et al. (1987) and Cohen et al. (2000) have further shown a strong variance in the use of patents vis-a-vis other appropriation mechanisms. It is also known that traditional SMEs display a much lower patenting propensity than larger firms (Marzal and Tortajada-Esparza, 2007). Moreover, Cohen et al. (2002) point out how patent usage depends on national laws.

Despite these criticisms, the interest on patent statistics in connection with the analysis of innovation has grown significantly as the advanced economies moved in an era of “intellectual capitalism” (Grandstrand, 1999), which arose in the sequence of the so-called “patent boom” or patent explosion (Hall, 2005).

Innovation systems in countries with developed economies like the USA, Japan and several countries in Europe saw a very strong connection between the policies and strategies focused on innovation with the theme intellectual property. However, studies that address these three variables together, especially for countries with emerging economies, are still not very common.

In this context it is important to take into account that intellectual property should not be considered only an instrument or legal mechanism of protection, but also an important component in the process of dissemination of knowledge and innovation strategy of research institutions and innovative companies, besides being a strategic component in the economic development process of countries.

Cimoli and Primi (2007) point out that the role of patents is influenced by the generation rate, adoption and innovative knowledge that is strongly related to the generation of technologies.

Patents are considered a mechanism that allows inventors temporary monopolies and thus appropriation of returns on their inventions. These monopolies, granted for specific periods of time, protect the inventor at the same time, which gives them exclusive rights to exploit new technologies. Given this function, the patent has been portrayed as an intermediate stage between invention and innovation, without which the inventors will have no incentive to bring their inventions to market.

Patent statistics can be used for comparative analysis between innovation systems of countries of different degrees of technological specialization, taken as a technological advantage as well as to evaluate the performance and progress of national innovation systems, although they are not sufficient to fully investigate the performance of the economy of the countries.

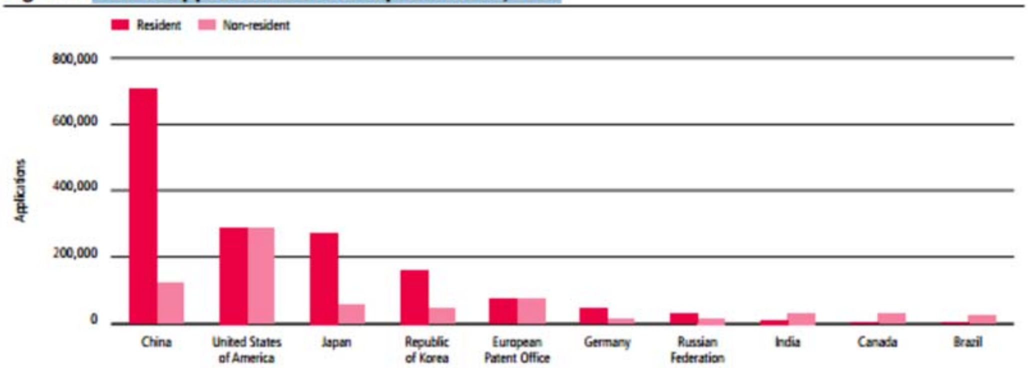
Another perspective that should be considered is that the patent and other appropriation mechanisms play different roles in different sectors - for companies in the biotechnology and pharmaceutical sectors, for example, there are highly relevant different mechanisms than the ones used by companies in the software sector or services, for example.

Recent studies published by the Organization for Economic Cooperation and Development (OECD), World Bank and World Intellectual Property Organization (WIPO) show significant results for emerging countries in innovation policy and intellectual property, especially China, as well as evaluate the main differences between economic models and innovation among other countries, including Brazil.

Data from WIPO´S Report (2013) realize that Patent filings grew by 9.2% in 2012, representing the fastest growth in the past 18 years. Of the top five IP offices -SIPO- IP Chinese office - was the only one to record double-digit growth for each of the 03 types of IP. For the first time, residents of China accounted for the largest numbers of applications filed (560,681) throughout the world. This "boom" coincides with the process of restructuring and consolidation of IP system, since 2001, when China became a member of the WTO. This trend was reinforced with the long- term policies and plans adopted from 2006 until now. The gap between SIPO and other offices has widened considerably since 2011, when SIPO became number 1 (as showed in the figure below).

One striking aspect in the recent development of China is its performance in terms of intellectual property rights (IPR). Patent and trademark applications have risen very fast in these two countries. If the focus is on the demand recorded at the national Patent and Trademark Offices (PTOs), China has risen to number one worldwide in trademarks and number three in patents, immediately after the US and Japan, while India is now, respectively, number five and number nine (Godinho, 2011).

**Figure 2. Patent applications at the top 10 offices, 2013**




Source: Standard figure A8.

Regardless of the analysis differentiating between domestic and foreign users of patents and trademarks, the evidence is that IPR take up has grown extremely fast in China and India in recent years. These trends suggest both countries might be on an economic catching up trajectory not only in terms of GDP per capita but eventually also in innovative capacities. This particular dimension of the catch up process might have important implications.

In the early 2000s, Goldman Sachs projected that in less than 30 years the combined GDP of the BRIC economies would collectively exceed that of the G6 in US dollar terms (Goldman Sachs, 2003). There are some indications that due to their size and growth dynamics, at least China and India may advance faster than the other BRIC economies (Altenburg et al., 2006). Growth rates and high savings also enable these countries to invest heavily in infrastructure and R&D, concentrate highly skilled workers in certain regions,

purchase licenses and promote mass education (Altenburg et al., 2006). Further to this endogenous effort, the codified nature of most business knowledge related to information systems, logistics, or supply chain management make its transference easier. The two countries are also benefiting from inflows of R&D, with China today being the leading recipient of outsourced R&D (UNCTAD, 2006). Moreover, Chinese and Indian researchers are increasingly linked up to transnational scientific networks (Saxenian, 2006).

In the case of China, a combination of factors has proven successful in bringing about this catching up process. China ensured its industries were oriented towards technological learning, prepared for innovation and able to become the natural partners for foreign companies, even before trade liberalization was implemented (Chandra et al., 2009). This was achieved through policies supporting investment in R&D in combination with financial subsidies to selectively nurture certain industries, especially in high-technology areas, in parallel with an export growth strategy and strongly attractive terms for foreign investment (Chandra et al., 2009). Once trade liberalization was implemented, China did not hesitate in taking advantage of competitive prices to attain additional gains in efficiency.

The boom in Indian and particularly Chinese patenting, together with very intense usage of trademarks in both countries, may signal a turning point in the development of both countries. The observed trends may represent a strong indicator of the sustainability of economic growth in China and India, enabling them eventually to effectively catch up in economic terms. As Fagerberg and Godinho (2005) noted, other successful catching up processes occurring since Britain took over economic leadership with the Industrial Revolution in the early 19th century have been marked by the newly catching up countries adopting important institutional innovations together with the absorption and diffusion of foreign technological know-how. The surge in IPR usage in both China and India may be indicative of such a type of institutional change (Godinho, 2011).

Several studies associate that patent boom that happened in the advanced economies in the 1980s with the emergence of R&D intensive sectors such as microelectronics, ICT and the biotech sector (Kim and Marschke, 2004). Growth in R&D expenditure has led to a rise in innovation which, together with managerial improvements, has resulted in a rise in patenting (Kortum and Lerner, 2003).

Some studies have been produced on the rising IPR usage in both China and India. In relation to China, and referring to a sample of medium and large-sized firms, Hu and Jefferson (2009) have shown that the increase in patenting is linked not only to rising R&D expenditure but also to foreign direct investment inflows and to a changing legal framework that favors patent owners. (Godinho, 2011).

An empirical and preliminary analysis indicates that the combination of structural issues of the IP system, coupled with the level of refinement and consolidation of the legal framework, tax and financial incentives strongly influence the actors - universities and research institutions, government, business - to do strategic use of industrial property protection, more specifically from patent protection on different levels.

Information on structural aspects of the IP system of the two countries are presented in the table below:

| | **Brazil** | **China** |
|---|---|---|
| IP Office | INPI | SIPO |
| Estimate Number of Patent Examiners in 2013 | 273 | 8000 |
| Average time of Patent Grant | 08 years, reaching 10 years | 04 years |
| Major depositants (TOP 10) | Universities and Companies<br>(* see table below) | Companies<br>(* see table below) |

Source: Author´s elaboration, 2014.

In the case of Brazil, the enactment of the Innovation Law represented an important step change in the context of policies for innovation in the country. Brazilian universities were to patent their technologies and transfer them to the companies, because of that there was a significant increase in the number of deposits made by the Brazilian research institutions. In the period 2010-2013 there was an increase of 76,3% (1078 requests in the base year 2010), showing that the protection of intellectual property has entered the agenda of ICT as an important element in the negotiation process technologies.

Furthermore, this process does not happen on the side of Brazilian companies. Brazilian Innovation Research (PINTEC) indicates that in Brazil, despite the explicit government efforts since 2003, performance in relation to innovation indicators has not changed dramatically in the last decade compared to the previous. Since the first edition of the PINTEC, covering the period 1998-2000, to its latest version 2005-2008, advances shown through innovation indicators such as R & D / total sales, innovation rates and personal R & D

were relatively modest when compared to other countries.

On the other hand, as analyzed by Cavalheiro et al. (2014) there was a significant growth of patent deposits in Brazil for oil multinationals as shown in the graphic below:

*G.M.C. Cavalheiro et al. / World Patent Information xxx (2014) 1–10*

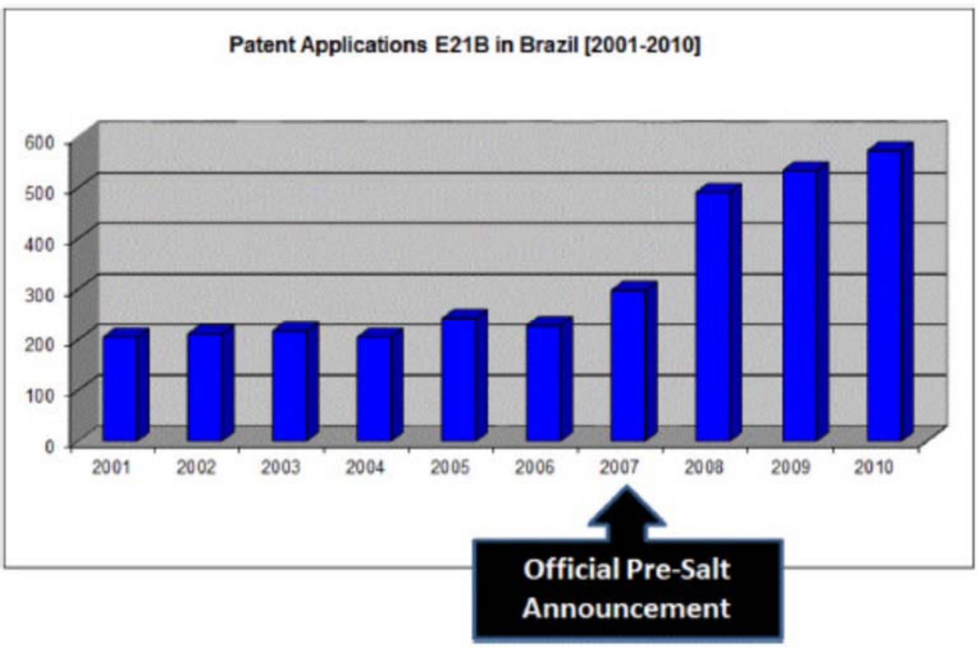



**Fig. 1.** Patent applications related to upstream oil and gas technologies in Brazil: 2001–2010.

The growth of Brazilian deposits in the United States Patents and Trademarks Office (USPTO) was 8.5 % per year between 2000 and 2009 - slightly below the annual rate of growth of total deposits of 9 % of the USPTO and 12 % of foreign deposits - reaching 497 deposits 2009. Brazil is far in China (about 4,000 deposits per year) and India (about 2,000), for example (Araujo, 2011).

According to Araujo (2011), regarding indirect incentives for innovation, Brazil and China have adopted very similar measures, and are among the most generous countries in tax incentives to innovation. Brazil is in fifth place in the ranking and China in third among countries more generous in terms of tax incentives to R & D in 2007.

In addition to the tax incentives in China, particularly in Beijing and Shanghai, there are the financial incentives to SME's. This is a recent initiative and aims "to encourage enterprises to become the major force in creating and using intellectual property" which is one of the strategic emphasis (Section 40 of the Strategy Outline of the National Intellectual Property Strategy, 2008). According to the preferential policy, any patent applicants and patentees, who are, indeed, in difficulties to pay for the patent fees, have the right to apply to the State Intellectual Property Office for reduced or postponed patent fees. The patent charge standard of SIPO can be reduced by an amount of 70%-85% depending on whether the applicant is an individual or enterprise. The SMEs who face the financial difficulties during its patent application can seek the help of such policy. Shanghai's patent fund policy adopts the method based on the actual costs on patent applications, that is, to set different percentage of subsidizing standards for three kinds of patent application: invention, utility model and design patent. Beijing's patent funds policy is based on the fixed amount for three kinds of patent applications and various categories of enterprises. In addition to the division according to three kinds of patents, different groups of applicants shall also apply for different subsidizing standards (Jin et al.2013).

**FINAL REMARKS**

According to Dahlman (2011) over most of the second half of the 20th century, the world rankings of patents and trademarks were dominated by the so-called triad (US, Japan and EU countries). Several other countries, however, seem to be catching up in patents and trademarks with the most advanced economies in recent decades. That was first the case with South Korea that has converged fast with the triadic countries beginning in the late 1970s. More recently, since the mid-1980s, China and lately India have been following an apparently similar trajectory of convergence.

Based on Godinho (2011), Dahlman (2011) with regard particularly to public policies for innovation and results in patents we should consider some issues:

i. One of the first differences noted with regard to the condition that China's innovation agenda is, in fact, a national development strategy is that innovation is part of a state policy together with the existence of a clear economic agenda and both are treated as such. In this model there are structured long-term courses of action (five-year plans), whose coordination is done by the Ministry of Science and Technology - MOST in a results-oriented manner.

ii. There is a big gap if compared to the routine path of Brazil, where innovation agenda is seen as "annexed part of an agenda of science and technology, with its traditional partners, and not as part of the stabilized economic policy agenda." Brazil has a particularly similar situation to China, as the Ministry of Science, Technology and Innovation (MCTI) is the main agent of government responsible for the preparation and implementation of innovation policy in the country. However, this formal similarity masks the fact that in China, there is a much greater degree of centralization of decisions and a stronger weight of the National Coordination Group of S & T and Education, which are designed and followed the big plans for STI (IEDI, 2011).

iii. On the one hand, in China the weight of the state sector in the economy and the degree of centralization of decisions, on the other, also notes the effectiveness of measures and large capacity making far-reaching decisions.

iv. The most important events of the new Chinese strategy came with the 11th Five Year Plan (2006-2010), when China has shifted the focus of its growth strategy, prioritizing activities oriented to technological innovation in the industry place and traditional agriculture.

v. Another striking difference is the performance of the Chinese trade balance in high tech goods. About 31% of the export basket of Chinese manufacturing is associated with this type of product, against only 11% in Brazil.

vi. One last big difference pointed between the two systems is related to the role of the private sector in each country. In China, expenses on R & D are today mainly of corporate responsibility, to the extent that it represents three-quarters of national expenditure on R & D (74%), against a percentage of private spending in Brazil of about 50%. This private spending on R & D in China is already more than ten times the equivalent in Brazil, though, as one ponders further on, One should bear in mind that state-owned enterprises have a very important role in the Chinese economy and much lower in Brazil (IEDI, 2011).

Regarding to industrial property, we highlight the following issues:

i. OECD data indicate a growth of patents in China, unprecedented in the modern economy, similar to the results achieved by the United States since the Second World War;

ii. In Brazil the situation is a little different - despite the advances and efforts of the various institutional actors - business sector, firms, government and research institutions - and the results achieved through innovation in the last decade there has been a very shy stance on investment in R & D and result in patents;

iii. One of the most relevant facts about the technological performance of the Chinese economy is the growing number of patents in international offices and also in China's patent office, SIPO State Intellectual Property Office. The number of international patents (filed or granted) by Chinese institutions and companies has grown exponentially, from 2001 to 2002. While between 1998 and 2012 China presented a number of deposit 14,159 patents in 1998, in 2012 this number increased to 561,377 patents. 08 out of 10 depositors in China are large and medium-sized businesses (Wipo, 2013).

In Brazil the situation is quite different: in 1998 the number of patents was 3,079, in 2012 the number of patents reached only 6,597. With regard to the main Brazilian depositors 04 out of 10 are research institutions and 06 are companies (WIPO, 2013). Another critical point in Brazil is the insufficient number of examiners: the INPI currently has about 280 examiners and the patent granting average time is 08 years, reaching 10 years. Even with all the commitment of leaders and researchers from the Brazilian Industrial Property Office in recent years, it is very difficult to reverse this short-term situation without resorting to urgent operational and administrative measures.

What we see in China is a built-in motion of various policies - economic, financial, human resources training - coordinated efficiently by the government, while in the case of Brazil, even considering the advances of the last decade, especially with regards to the legal framework, the innovation agenda seems to lag behind from what is formulated by the science and technology agenda (IEDI, 2011).

The goals for 2015 are quite ambitious: to increase the ability to create patents, to reach 2 million patents (invention, design and utility model) in five years, double the 2010 numbers; be between the two leading countries in terms of patents registered internally to the country; also double the number of international patents originated in China; to enhance the efficiency and quality of patent examinations, targeting an average of 22 months for examining patents and 03 months for utility model and design; enlarge the staff of SIPO examiners to 9000 - SIPO today has about 8,000 examiners, this is 50% more than today has the USPTO, US patent office.

The plan estimates are that by 2020 China will have the largest number of technology workers in the world, with 2.5% of GDP dedicated to research and development and will be the most competitive country in the world in the production, manufacturing and high-tech design, more computerized society and the largest weight in the development of knowledge. Being expected that by 2050 China will have surpassed the United States in total production of knowledge. But, in addition to planning and state control of the economy, perhaps among the greatest differences between China and Brazil, with regard to national STI policies, is the degree of importance that the Chinese State gives science issues, technology and education, understood as inseparable part of China's development strategy (IEDI, 2011).

China's experience shows that a strategic political decision and a high degree of interrelation between structural, political, operational and financial factors make more concrete and very significant results. In Brazil we point out that among the many challenges for formulators of public policies for innovation the most critical are the search for greater integration between the policies of innovation and IP; the establishment of long-term plans, the implementation of structural measures, such as strengthening the INPI, combined with an incentive policy for Brazilian companies realize the importance of protecting their products, processes and technologies in the country and abroad.

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