Science, Technology and Innovation Policies in Global Open Economies: Reflections from Latin America and the Caribbean*

AREA: 1
TYPE: Application

Políticas de ciencia, tecnología e innovación en economías abiertas globales: reflejos de América Latina en el Caribe

Políticas de ciência, tecnologia e inovação em economias abertas globais: reflexos da América Latina e das Caraíbas

AUTHORS

Mario Cimoli
ECLAC-United Nations
University of Venice.
mario.cimoli@cepal.org

João Carlos Ferraz
BNDES, Brazil.
jcferraz@bndes.gov.br

Annalisa Primi[1]
OCDE.
annalisa.primi@oecd.org

1. Corresponding Author: OECD, DSTI ; 2, rue André Pascal, 75016 Paris ; France.

This paper argues that the downturn in the global economy will negatively impact not only investment, production, and employment in Latin America, but also its accumulated stock of human capital and technological capability. The risk is that the crisis may lead to cutbacks in some of the areas that are most critical for the medium and long term viability of Latin America. After a brief historical overview of the evolution of the economic structure, and the demand for innovation, it summarizes four lessons that have been learned about technology policy in Latin America. It concludes with some reflections on the types of measures that are necessary to strengthen Latin America's future prospects.

Este artículo defiende que la recesión de la economía mundial tendrá un impacto negativo no sólo en la inversión, la producción y el empleo en América Latina, sino también en sus activos acumulados de capital humano y de capacidades tecnológicas. El riesgo de que la crisis pueda suponer recortes en algunas de las áreas más críticas de viabilidad a medio y corto plazo es real en América Latina. Tras una breve introducción histórica de la evolución del tejido económico y la necesidad de innovación, resume cuatro lecciones aprendidas sobre la política tecnológica de América Latina. Concluye con algunas reflexiones sobre los tipos de medidas que deben tomarse para reforzar las perspectivas futuras de América Latina.

Este artigo defende que a recessão na economia mundial terá um impacto negativo não só no investimento, produção e emprego na América Latina, mas também no stock de capital humano armazenado e na capacidade tecnológica desta região. O risco é de que a crise leve a cortes nalgumas das áreas mais importantes para a viabilidade da América Latina a médio e longo prazo. Após uma breve resenha histórica da evolução da estrutura económica e da procura da inovação, resume quatro lições que foram aprendidas sobre política tecnológica na América Latina. Conclui com algumas reflexões sobre os tipos de medidas necessárias para reforçar as perspectivas futuras da América Latina.

DOI
10.3232/GCG.2009.V3.N1.02

*This paper is based on and updates Cimoli, M., Ferraz, J. C. and Primi, A. (2005), Science and technology policy in open economies: the case of Latin America and the Caribbean, Serie de Desarrollo Productivo y Empresarial, ECLAC-UN, Santiago Chile. The opinions expressed in this paper are those of the author and do not necessarily reflect those of the organization

1. Introduction

The current financial crisis poses serious challenges for the design and implementation of development strategies in countries that are in the process of building technological and production capabilities. The global downturn of economic activity will negatively impact investment, production and employment also in developing and catching up economies. The impact of the crisis on firms' behavior and on the real economy is not neutral with respect to the characteristics of the microeconomic structure and its technological specialization. Accumulated human capacities, technological capabilities and the specialization of the production structure shape the response and the way out of the crisis of different economies. While a crisis has strong effects on the productive structure, it is also true that the structure defines how the economy reacts to the crisis. Business analyst argue that high tech and IT related business will suffer the most in terms of losses in their share-values. On the other hand, those firms will also be the ones that recover the fastest after the crisis shock. In other words, economies that are more specialized in high tech sectors will have higher income elasticity with respect to global growth: besides responding more dynamically to global growth in normal times, they also recover more easily in post-crisis scenarios[1].

In context of crisis firms and sectors readapt their capabilities, learning processes and production and investment strategies. The production base undergoes processes of restructuring, which may imply the destruction of certain productive, technological and human capabilities. On the other side, the overlap of the negative shock in prices and the fall of economic activity influence the strategy of the firms, which start to look for more flexibility[2]. These processes affect not only the microeconomic structure, but also the macro-performances in terms of productivity, diversification and the sources for long term growth and development.

In a crisis scenario, firms tend to close some R&D departments, producer-user interactions tend to cease, public research agencies are underfinanced, and human capital drains out the production structure. At the same time, firms might envisage the way out of technology through technological leadership, creating responses for new problems and demands that might prevail in the post-crisis scenario.

However, the potential disruptive effects of a financial crisis in human and technological capabilities are especially risky for catching up economies which have not yet reached the frontier, since the destruction in the process of accumulation of capacities would entail a higher systemic impact than in frontier economies, where the level of human and technological capital is higher, and where there will be higher resistances to downturns[3]. In addition, the crisis scenario shapes a world of fierce competition, both in terms of prices and qualities. Falling behind in terms of technological capabilities makes the process of catching-up increasingly difficult, as market shares and investment decrease.

1. See Cimoli et al. (2009) for an econometric estimation of how the industrial structure -and its sectoral composition- affects the response of countries to global financial shocks.

2. See Ferraz, Kupfer and Serrano (1999) for an analysis of micro-macro interactions in the case of Brazil.

3. The features that characterize technological learning, i.e. cumulativeness, path-dependency and complementary learning across sectors, determine the costs of the destruction of capacities.

Key words
Technology, Innovation, Adaptation, Latin America, Competitiveness

Palabras clave
Tecnología, Innovación, Adaptación, América Latina, Competitividad

Palavras-chave
Tecnologia, Inovação, Adaptação, América Latina, Competitividade

JEL Codes
N760; 0300; 0540

In the case of human capital, relocating unused skills is not an easy challenge. Human capital is produced along with investment and production in high-tech industries, and it can be "destroyed" as much as financial assets. Engineers that lose their jobs during a protracted recession would not become psychologists the following day (and even if they do so their contribution to aggregate productivity would be quite different…). Possibilities of re-conversion of technical skills is not so elastic; when higher real exchange rates, or rising prices, will make industrial production profitable again, the entrance of those engineers into production processes would not be automatic. Training will be needed, and this is costly and time consuming, and it implies, for an (uncertain) period of time less competitiveness and less industrial production. The process of change and re-adaptation of technological capabilities are characterized by rigidities and uncertainty. And, in a globalized and polarized world, industrialization and technological development need policies and institutions to strengthen it against current market incentives. And this is even truer under crisis scenarios. This poses a major challenge to the governments of the region, which should be concerned with the long run process of technological accumulation, and with the risks of its destruction, both in normal times and in times of crisis.

The current global economic downturn challenges the S&T policy formulation and implementation in the region. During the first half of the decade of 2000, Latin America experienced favourable terms of trade for its commodities and rising GDP growth rates. During these "good times", however, very little was done to upgrade technology and human capital. Policy-makers looked at selective industrial and technology policy suspiciously. Any step to promote an industry or to encourage learning had to be carefully explained and justified. Any policy "picking winners" or protecting technological capabilities has received little support. While policies for diffusion of general purpose technologies, like ICT has been promoted. In most cases, S&T policies were conceived to strengthen current exporting sectors, rather than developing new sectors in which technological learning is more intense.

A key question now is: what is going to happen with the already weak industrial and technological policies under the global financial crisis? When short-term and rescue policies prevail, the consensus for S&T policies tends to decline, if there is no agreement on the fact that technological capabilities might represent the way out of the crisis for most firms (and countries). If Latin American countries abandon their (even slight) policy efforts for S&T, the production structure that will emerge after the crisis will not be able to catch up with the new technologies and paradigms that will shape global production and trade. Instead of catching up there is a risk of augmenting the gaps with leading actors, if smart polices are not implemented. The challenge is to identify which set of policies are implementable to support the generation of capacities and the preservation of accumulated capabilities to transform the crisis into a creative destruction opportunity. In an attempt to contribute to this debate this paper presents a critical reflection about S&T policies in the region, starting with a brief overview of the industrial structure and the demand for knowledge and innovation. The second section presents a taxonomy of the evolution of policy models in the region from the import substitution era to current times, focusing on instruments and IP management. The third section presents a model which links S&T policies with industrial development, and the last section concludes framing the discussion about S&T policies in Latin America in the context of the current world financial crisis.

2. Industrial structure and technological incentives

Starting from the nineties economic liberalization and increased participation in international trade modified production incentives and specialization patterns in Latin America and the Caribbean, leading most countries to further specialize according to static comparative advantages. In the post-reform period, two different specialization patterns emerged: the one based on natural resources, basically in the Southern Cone, and the other specialized in labor-intensive activities, especially in Central America and the Caribbean. However, beyond sub-regional differences, there are commonalities among Latin American and Caribbean countries: the scant pervasiveness and diffusion of knowledge and intangibles in regional production systems and the heterogeneity determined by the co-existence of islands of technological excellence with a generalized low-tech and low-skilled jobs production apparatus. These changes favored the generation of an industrial structure that "per se" expresses a scant demand for knowledge, thus implicitly limiting the potential positive stimuli effect towards technological catch up of liberalization and increased competition. In contrast, the Asian economies like Korea and Taiwan, followed by Malaysia, Thailand and Indonesia, were successful in creating expanding capabilities in technology intensive industries and production stages, combining selective import substitution policies with aggressive, but gradual, export oriented strategies[4]. In comparative terms, in a context of global knowledge economies, in which a repositioning of key players is taking place, the countries of the region are still specialized in low technology intensive industries and production stages (ECLAC, 2004; ECLAC, 2008). The rising prices of commodities in the last years, the improvement in the terms of trade for natural resources and the consequent appreciation of regional exchange rates have reduced the incentives for production diversification in favor of technological capabilities, undermining S&T policy effectiveness and implementation. A self reinforcing process of concentration in fewer activities took place, reducing the incentives to learn and invest in other sectors (ECLAC, 2008).

2.1 Specialization patterns and technological intensity

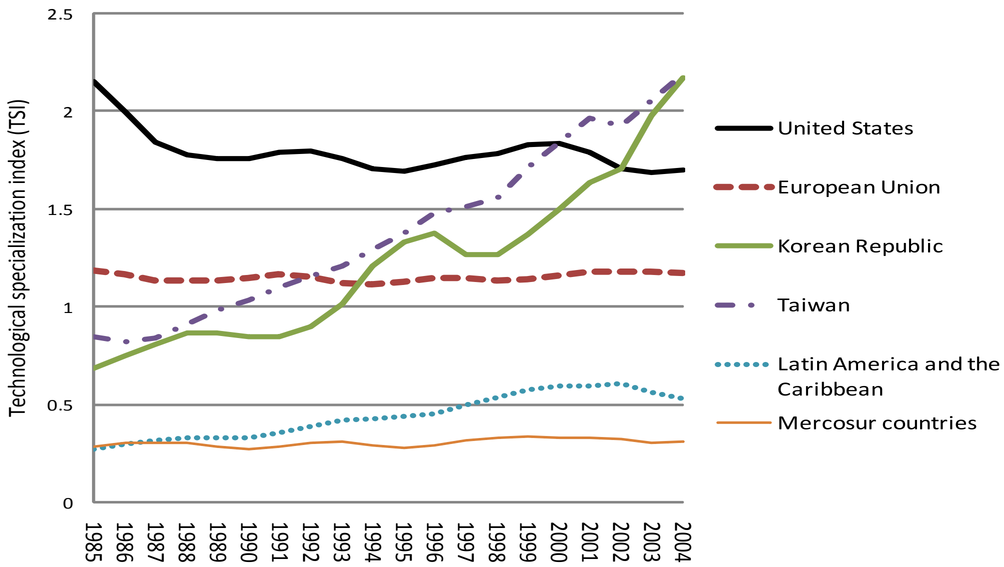
Figure 1 shows this asymmetry in terms of international technological specialization. Following Alcorta and Peres (1997), the technological specialization index (TSI) proxies the technological dynamism of different countries (and regions) with respect to world trends[5]. The Asian economies have experienced an increase in the value of the TSI since 1985. Latin America and the Caribbean (LAC), on its turn, has registered only a slight increment. Furthermore, excluding Mexico, the pattern of the TSI Latin American turns out to be almost a flat curve[6].

4. The literature on the "Asian miracle" is vast; for some analysis sustaining the role of policies see Amsden, 1989; Jomo, 1997 and Wade, 1990. For a comparative analysis of the evolution of industrial development and technological capabilities between Latin American and Asian economies see Cimoli et al (2006).

5. The TSI is obtained by dividing the market share of technology intensive exports (of a given area) by the market share of its low technology exports. Thus the index increases as an area evolves towards more technology intensive exports.

6. Actually, the difference between the TSI for LAC and the one of MERCOSUR is basically explained by Mexico. In the case of Mexico, the technological intensity of exports is higher than the regional average because they derive from maquila activities, which have been, , until recently, mostly of assembly nature and with scant local innovation and spillovers, (Capdevielle, 2004).

Figure 1. Technological Specialization Index (TSI), trend 1985-2004, various countries



Source: authors' e the basis of the TSI database, ECLAC-United Nations.

Note: following Alcorta and Peres (1997) the TSI for each country (or group of countries is estimated as follows:

$$TSI_i = \frac{MS_i^H}{MS_i^L} \qquad MS_i^H = \frac{\sum_{j \in H} X_{ij}}{\sum_{j \in H} X_j} \qquad MS_i^L = \frac{\sum_{j \in L} X_{ij}}{\sum_{j \in L} X_j}$$

Where MS stands for market share, H for high technology intensive, L for low technology intensive. and stands exports of i country in the j product group to the rest of the world, while is total export in the j products group to the rest of the world.

The TSI measures the exports' degree of technological specialization[7]. The analysis of the structural composition of manufacturing value added leads to similar conclusions. In Latin America the share of technology intensive sectors do not overcome, on average, the 30% of the total value added of domestic manufacturing industry; while in frontier and emerging economies those sectors contribute to generate more than 60% of total manufacturing value added, as it is the case of the US and South Korea, for examples[8]. Table 1 shows the evolution of the share of knowledge intensive sectors in total manufacturing value added. On average, during the eighties and the nineties, the countries of the region have experienced a process of destruction of production capacities and technological capabilities, coupled with less entrepreneurial efforts in R&D and increased imports of capital goods for moderni-

7. In the long run, it is reasonable to assume that the expertise and capacities of countries will be embodied in their exports.

8. For a comparative analysis of Latin American and Asian economies see Cimoli et al. (2006).

zation. In more recent years, approximately between 2003 and 2007, there has been a slight revival of those sectors, which started to regain weight in the regional industry. However, Latin America stays behind the technological frontier both in terms of technological specialization and productivity growth. In the US, the productivity is much higher in all sectors, and the knowledge intensive sector induces spillover effects that foster productivity growth in the whole industry. Conversely, in many Latin American countries (such as Argentina, Chile and Colombia for example), the increasing share of natural resources has not be accompanied with a process of generalized technological upgrading. Brazil and Mexico are to same extent exceptions since the industrial structure has been transformed in favor of the engineering sectors; however, this has failed to produce a significant impact on aggregate productivity[9]. The combination of a traditional macroeconomic management with a lack of real coordination in policies fostering industrial development and structural change contributes to explain the general stickiness in aggregate productivity growth in Brazil. Mexico, on its turn followed a different strategy, pushing for increasing openness coupled with policies to support the integration of the local *maquila* industry to global production networks.

Table 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. (2009), on the basis of the ECLAC-PADI database.

2.2 Globalization, capital ownership and network hierarchies

In open economies, agents face global opportunities and constraints. The decade of the nineties brought about deep reorganization in international production chains and a shift capital ownership balance in the region. By the turn of the decade, around 40% of the 500 largest Latin American corporations where foreign owned, compared to around 30% at the beginning of the nineties (ECLAC 2004).

On the one hand, the wave of international mergers and acquisitions, led foreign firms, which were already dominant in many economic sectors, especially in durable and capital goods, to expand their presence towards other economic sectors (Mendes de Paula, Ferraz and Iootty, 2002). The structural weaknesses of local economies and the competitive pressures

9. As Ferraz et al. (1999) show beyond the restyling in the prevailing features of the Brazilian manufacturing industry, where the majority of firms chose to follow efficiency and prioritized modernization increasing imports of capital goods and introducing new organizational techniques, the structural change was not "radical" as it would have been required. Attitude towards R&D investment remained generally cautious, and in general the export profile of the country remained unchanged keeping relying on basic industrial commodities.

originating from liberalization have imposed a dilemma for large size, locally-owned companies: either to expand abroad or to merge or transfer ownership to foreign companies. The privatization of services and commodities also played a major role in reshaping the patterns of capital ownership[10]. However, while foreign transnational companies dominate production networks, regional firms tend to participate in global production systems mainly performing at the lowest hierarchical levels, generally far away from control positions, and carrying out raw materials processing or basic assembling activities.

On the other hand, globalization and increased competition have favored modernization. However, those processes have been biased towards rationalization, and took the form of expansion of capital imports, outsourcing of non-core activities, adoption of new organizational techniques, like quality systems controls and just in time management, and introduction of new equipment, especially in big firms. The rationalization of regional production processes resulted in a "truncated" modernization because the leapfrog towards effective domestic technological upgrading is still to be done. Technological upgrading entails the development of endogenous capabilities through complex, dynamic and collective trial and error processes, which need to be backed up by targeted policies. In the new global knowledge economy, with increasingly powerful foreign actors and weak domestic scientific and technological infrastructure, market incentives push firms to increasingly rely on foreign sources of knowledge. At the same time, the few local results of innovation and technological upgrading tend to be transferred abroad, and not to be appropriated locally.

In fact, many Latin American and Caribbean research centers and laboratories of domestic enterprises were closed during the nineties and the first years of the following decade, due to the change in the logic of innovation investments in open economies. In effect, controlling companies, mainly located in advanced economies, benefit from comparative advantages in technology and innovation[11]. Indeed, multinational companies have tended to concentrate the bulk of research and development activities in their countries of origin or, as recent tendencies suggest, in strongly dynamic economies that have accumulated well trained human capital in scientific and engineering and which are specialized in highly technological intensive industries and that represent huge potential markets for technological produce.

Globalization, the new technological paradigms and the emergence of new economic powers, as China and India for example, is transforming current global patterns of technology generation and control. Multinationals outsourcing strategies are no longer merely based on existing comparative advantages of host countries. Alongside outsourcing of pure assembling activities, following the maquiladora pattern, multinationals are growingly expanding and internationalizing R&D activities in order to keep up with boosting demand for new technologies of emerging and dynamic future markets where there is adequate scientific and technological infrastructure, including the supply of qualified human resources. Market size and active policies play a catalytic role in inducing firms to invest in innovation centers away from home. Hence, the current global evolving scenario presents a twofold dilemma for Latin America and the Caribbean. On the one hand rising

10. National state corporations have been replaced by North American and European companies (especially Spanish ones) and by Latin American new comers, (Bonelli, 2000; Cantwell and Santangelo, 2003).

11. Maintaining the control over R&D activities has been a major concern for multinationals till recent times (Patel and Pavitt, 1991; Chesnais, 1995; Cimoli, 2000).

China has the potential to wipe out the bulk of Mexican and Central America manufacturing exporting activities, i.e. the maquila industries (as it is currently happening), and on the other hand, the increasing tendency to outsource R&D to emerging markets may generate adverse incentives to carry out S&T activities in the region, unless a serious effort of strengthening domestic research capabilities is carried out[12].

Albeit the establishment of research and development laboratories by multinational companies could be a risky business for host countries, since the link with increasing local innovation capacities is not automatic, it could offer new sources of advantages to recipient emerging economies, if strategically managed. This new trend could represent a new form of "center-periphery" relationship built up on dynamic comparative advantages. Indeed, to fully grasp the benefits of this new type of knowledge-based correlation and outsourcing of headquarters localized in advanced economies and remote research centers hosted in emerging economies, host countries need effective national innovation systems that enable recipient economy to retain potential emerging benefits, to promote high level human capital formation on a continuum basis, to strategically manage intellectual property rights systems and to master physical and cultural distances with headquarters.

Latin American integration to global trade is thus occurring on asymmetric basis. Domestic agents are marginal actors in the globalization of scientific and technological activities. The transition from global traders to global players is still a quite distant goal. If specialization in natural resources and labor intensive activities prevail, if local firms are placed in low value niches in international production chains, how to increase their "density" by extending and strengthening linkages to knowledge, services and products suppliers? If inward internationalization means a dominant role for foreign companies in economic activities for the years to come: how to induce them to localize innovation efforts in the region? If the modernization process has been strongly biased towards rationalization, how to further advance this process by turning its directions towards process, product and organizational innovations? Actually, addressing these questions is not an easy task. And the current financial crisis increases the need for thinking about implementable solutions to preserve the processes of accumulation of capacities and to sustain the creation of endogenous technological capabilities.

3. Industrial structure and technological incentives

Efforts of designing and implementing policies for scientific and technological development are not new in Latin America (table 2 shows a taxonomy of the evolution of policy models form the import substitution to current times). During the import substitution a linear supply model prevailed. The public sector played a major role in identifying priorities and in carrying

12. In recent years hundreds of multinational companies started to look at China as a location for research and development investment. Microsoft recently set up a research center in the Chinese technological district of Haidian in Beijing, where a cluster of 40 universities, 138 technological institutes and 810000 scientist and research engineers interact. Nokia outsourced to China the development and production of software codes. Starting 2005, one thousand two hundred researchers are supposed to be at work in the recently established General Motors Shanghai research center. Laboratories and research centers set up by transnational companies in China are augmenting, in number, by 200 per year.

out S&T activities. Technology policies aimed at backing up the expansion of local production capacity[13]. Public investments in S&T supported the creation of domestic capabilities and infrastructure in S&T on the basis of government priorities[14]. R&D activities were mainly carried out by big public enterprises operating in strategic sectors like telecommunications and transport and by public research institutes and universities working in the areas of agriculture, energy, mining, forestry and aeronautical, among others, thus manifestly following a selective industrial approach (ECLAC, 2004). According to governmental priorities Latin American countries, especially the larger ones, started to build up research institutes and commissions in strategic sectors[15].

Knowledge and innovation were supposed to flow from government and public institutions (supply-side) to production (demand-side). The theoretical background of these science and technology policies derived from the assumption that knowledge was a public good, i.e. non rival and non excludable in consumption. From this perspective, government and public agencies were natural knowledge providers. In other words, there was a strong belief that scientific progress would automatically turn into technological innovation.

Public funds were the major source of S&T financing; by then 80% of regional expenditure on S&T was financed by the State (ECLAC, 2002). The public sector and the scientific world shaped priority setting and resource allocation. Their influence went beyond orientating the expansion of research and development activities. The public sector logic of institutional management dominated in the administration of S&T institutions, which were run under hierarchical, non-flexible and pyramidal managing style that made difficult, if not impossible, coping with and responding to the dynamics of private sector knowledge and technological requirements. In a nutshell, the linear supply model contributed to the creation of the S&T infrastructure, at the same time, the model was weak in coordinating different sectoral agencies leading to overlapping initiatives and consequent waste of resources (Capdevielle, Casalet and Cimoli, 2000; ECLAC, 2004; Yoguel, 2003).

The structural reforms induced changes in S&T policy design and management. The room for policy interventions shrank. Following the Washington consensus approach S&T policies were marginalized, on the basis of the logic of comparative advantages. Faith in market mechanisms resulted in neutral and horizontal policies planned to minimize state interference with market behavior. The Main concerns were favoring of technology transfers, investments in quality and efficiency and the provision of technological services following a logic

13. See Capdevielle, Casalet and Cimoli, 2000; Crespi and Katz, 2000; Tigre, Cassiolato, and De Souza Szapiro, Ferraz, 2000.

14. During the import substitution period many technology agencies were instituted, like the National Council for Scientific and Technical Research (CONICET) in Argentina in 1958; the National Council for Scientific and Technical Development (CNPq) in Brazil in 1951 and the National Council for Science and Technology (CONACYT) in Mexico in 1970.

15. In Argentina the National Atomic Energy Commission (CNEA) in was set up1954, followed by the National Institute of Industrial Technology (INTI) and the National Institute of Agricultural Technology (INTA) in 1957. Both were responsible for the provision of technology services (Yoguel, 2003). Correspondingly, 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 (ECLAC, 2004; Pacheco, 2003).

of “commercialization” of knowledge and technology[16]. This stance towards public policies meant placing knowledge and innovation on an equal footing with information accessibility. Linearity in the process of knowledge generation and technology diffusion persisted[17].

The shift towards the linear demand model entailed institutional and organizational changes. Management procedures changed and new institutions were created[18]. Beyond countries' peculiarities, the reorganization of institutions generally brought about: i) increments in resources and in the relevance of those S&T agencies dedicated to capture private sector demand for technology and knowledge, ii) an incipient interest towards greater articulation and coordination between private and public sector, resulting in cross-countries augmented interest in universities-enterprises connections and, iii) changes in competencies and objectives of agencies. S&T priorities shifted from basic research to the provision and commercialization of technological services, mainly oriented to support production management and quality control. Reward systems and management styles of S&T institutions changed as well, privileging performance based models of evaluation and allocation of priorities. Innovation related institutions came to be regarded as “markets” for trading or exchanging information more than as part of an articulated and flexible system through which know-how, codified and non-codified knowledge embodied in routines, production processes or research results are transferred (Dosi, Sylos Labini and Orsenigo, 2003; Nelson, 2003). Imports of capital goods and technology licensing were seen as the basic sources of technological upgrading. Indeed modernization of industries effectively happened through these channels, even though it remained circumscribed to leading and larger firms[19] (ECLAC, 2004).

In recent years, together with the diffusion of new technolgigcal paradigms and the rising prices for natural resource based commodities, a new policy model started to emerge in line with global changes. In the last years there has been a shift in the S&T policy discourse from market incentives towards the role of networking and linkages between public and private agents, echoing the political practices of the north[20]. From the mid of the nineties the word national innovation system entered the political debate. Policies to support the creation of research consortia, science parks and public-private partnership for research have been designed, although seldom implemented, in almost all the countries of the region[21]. Although this recent shift in the policy model overcomes the drawback of linearity in policy conception, allowing for interaction and cooperation between public and private sector to be at the core of policy formulation, this new model seems to be a kind of “soft” policy approach. The linka-

16. ECLAC; 2004; Casalet, 2003; Jaramillo, 2003; Pacheco, 2003; Vargas Alfaro and Segura Bonilla, 2003; Yoguel, 2003.

17. Knowledge was supposed to follow bottom-up non-hierarchical pattern, in a setting where the key engine for innovation and knowledge generation is the autonomous initiative of the private sector (Cimoli and Primi, 2003).

18. For example, 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.

19. Colombia and Costa Rica are two additional different examples of the reduced autonomy of technology policy in the region. In these countries technology policies were basically linked to trade policies and especially to the export promoting strategy (ECLAC, 2004; Jaramillo, 2003; Vargas Alfaro and Segura Bonilla, 2003).

20. This is a common trend in the countries of the region, even though in each case the path shows different nuances and timing.

21. For a review of policy instruments to support S&T development by country for Latin America and the Caribbean see the ECLAC-GTZ database, available at www.cepal.org/iyd.

ge with sectoral differences and industrial priorities is still missing, and neutrality in selection prevails. Beyond fostering innovation through introducing public-private partnership, it is the synchronization between industrial transformation and technological capabilities that should be constantly searched for. There is a need to go beyond good intentions in policy formulation and to avoid the typical mismatch between supply and demand in public policy intervention.

Table 2. The Evolution of Technology Policy in Latin America: A Taxonomy of Policy Models

	Linear supply model	Linear demand model	Public-private partnership model
Timing	Import Substitution phase	Washington consensus era	Post Washington consensus era
Framing approach	Structuralist	Market failure	National Innovation Systems
Core-idea	Public sector as main S&T provider	Private sector as main source of technical change and innovation	Public and private sectors as co-sources of technical change and innovation
Assumed pattern of diffusion of knowledge	Top-down	Bottom-up	Bidirectional
Policy proposals	Selective and centralized supply-pushed S&T policies	Horizontal and demand oriented policies for technological development and innovation	Networking, partnership, multidisciplinary and technology transfer-oriented policies
Management criteria of S&T institutions	Predominance of academic, scientific and public sector criteria	Predominance of market and efficiency criteria	Increasing orientation towards participatory approach in institutional management

Source: Primi (2009) on the basis of Cimoli, Ferraz and Primi (2005).

Note: S&T means science and technology.

3.1. Policy instruments

The management of policies for science technology and innovation follows different institutional arrangements in the countries of the region. Argentina, Brazil, Cuba, Costa Rica and Venezuela have ministries for S&T, while in the other countries the policy responsibility is placed in National Councils which, in general, respond to the Presidency, to the Ministry of Education or to the Ministry of Economy. Beyond asymmetries in institutional infrastructure, there are considerable differences among countries in terms of origins of funds, magnitude of administered budgets, objectives and priorities. Each country establishes its own science and technology policy, which is more or less formalized and contextualized according to the institutional development, the complexity of the production apparatus and articulation of the national innovation system[22]. The sets of instruments for S&T policies are well known in the countries of the region. Usually the bottlenecks appear more at the level of implementation and management than at the level of policy design. In short three main issues might be highlighted: the instruments for supporting human capital formation and public private partnership, technology funds and the rising topic of IP management.

Human capital formation and public private partnership

An area of general consensus is the support for human capital formation for S&T. Brazil with its articulated system of grants and loans for financing university postgraduate studies forms around 7000 PhDs per year and scores the highest in domestically formed PhDs in the region (accounting for more than 70% of total Latin American PhDs according to RICYT's estimates)[23]. In recent times, another common feature of S&T policies in the countries of the region is the increasing concern in fostering interaction and coordination between the public sector (mainly universities and research laboratories) and the private sector (essentially enterprises) in research and development. Most financing mechanisms emphasize articulation and co-participation of supply and demand side in technological upgrading, establishing incentive schemes to foster cooperation between them through various channels. Private-public partnership might be a prerequisite for applying for financial support, or additional mechanisms might favour the transfer of capacities between the different agents. An example is the new Brazilian Innovation Law in which greater degree of freedom is given to university researchers for undertaking temporary research at private sector institutions. These initiatives, however, have still to gain strength and economic significance as budgets remain low and practices are still not in accordance with the behaviour of production agents. In effect, partly of the scanty results of these regional S&T supporting mechanisms, alongside reduced budgets, could be due to the asymmetry between this attention to coordination and the characteristics of regional production specialization. The Latin American and Caribbean production pattern on the one hand, induces private sector and enterprises to express a meagre demand for knowledge, and on the other hand, leads domestic agents to mostly seek outward oriented linkages, privileging foreign companies and research laboratories that already have sound reputation and worldwide recognized experience in effective and efficient S&T efforts. Thus a mismatch ensues between demand side needs and supply side offerings, hampering policies' impact.

22. In November 2007, a group of countries of the region signed a protocol agreement expressing the political support for the generation of a regional dialogue for S&T policies for increasing cooperation in S&T policy formulation and implementation in the frame of the ECLAC activities for S&T policies. The issue of regional cooperation in S&T policy represents a key element in the management of S&T policies in global knowledge economies.

23. Almost all countries have, at least at the level of policy design some measures to support human capital formation. In Argentina the 2004 Argentine National Plan for Technology and Production Innovation put in its forefront the strengthening of national scientific and technological base through supporting PhDs formation. In Chile the National Commission for Scientific and Technological Research (CONICYT) supports postgraduate training through a series of articulated pad-hoc programs oriented to assist PhDs formation within the country and through international networking. The Bolivian National Secretary for Science, Technology and Innovation, the Colombian National Program for Industrial and Technological Development 2000-2010 and the Uruguayan National Service for C&T (SENACYT) and FUNDACYT support post graduate and doctoral human capital formation through credit and grants systems. In Costa Rica support to graduate and post-graduate studies is mainly coming from private universities, while in Mexico National Council for Science and Technology (CONACYT) allocates public funds for sustaining high level human capital formation and the Public Research Centres (CPI) directly intervene in human capital formation and subsidize it through grants which are financed by specific CPI's funds. According to a selective intervention strategy, in Peru the Genome Program finance post-graduate formation in genetics, while the Paraguayan 2002 National C&T policy prioritize formation in the engineering and mining sectors, for example.

Technology funds

Resources to finance S&T activities are channelled for the most part through technology funds. At the country level, deep differences emerge in terms of beneficiaries and targets (research centres, enterprises, and special treatment given in certain cases to SMEs), source of financing, i.e. national (private or public) and international, and in terms of access mechanisms (basically supply or demand-side mechanisms or mixed). Since the structural reforms, technology funds have been fostering the promotion of consultancies and technical assistance services aiming to reinforce R&D in universities, research centres and enterprises. Two main categories of funds exist in the region: the one oriented to the demand and the other which emphasizes the coordination between demand and supply.

The demand subsidy scheme, which prevails in Argentina, Chile, Costa Rica and Mexico, channels public funds, or loans from international organizations, to S&T activities subsidizing the demand by following a horizontal logic based on the evaluation of proposals and applications directly presented by potential recipients (enterprises or research centres)[24]. This kind of system, where access to incentives for innovation depends upon a direct initiative of potential targets, may lead to increasing heterogeneity in technological behaviours because it could ingenerate adverse selection mechanisms among recipients. In the demand subsidy scheme, incentives to recur to financial assistance for innovation are biased. More pro-active agents, which perhaps have a comparative advantage in technological upgrading, and 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 participate in this scheme. A further weakness of the demand subsidy model is that a proper information dissemination policy is needed in order to allow beneficiaries to be aware of the possibility offered by the financing schemes. Most of the sub-utilization of technological funds managed under a demand-oriented mechanism is that potential beneficiaries lack information[25].

The Brazilian system of sectoral technology funds, introduced 1999, overcomes the limits of a purely demand-pull or technology-push incentive scheme. It represents a step forward in regional technology policy design on two accounts: regarding mechanisms to finance S&T and in terms of operational management. Twelve industrial technological funds are set up through 12 sectoral laws that identify the amount of the income generated in each industrial sector that has to be devoted to support S&T development in the corresponding industry. Then, these 12 industrial funds collectively contribute to sustain S&T and R&D in three priority non industry-specific areas for which three respective funds are built up (cooperation among universities, research centres and enterprises, maintenance and improvement of R&D infrastructure, and development of S&T activities in the Amazonian region). The Brazi-

24. 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, which allocate resources on the basis of a demand-pull mechanism, 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.

25. See Casalet, 2003; Jaramillo, 2003; Pacheco, 2003; Vargas Alfaro and Segura Bonilla, 2003; Yoguel, 2003.

lian sectoral technology fund scheme entails a strategic collective management approach. Representatives of academies and research centres, industrial ministries, members of the Minister for Science and Technology, the business sector and regulatory bodies constitute a mixed management committee that run each technological fund according to a coordinated and consensual strategy. This mechanism, which has the great advantage of promoting coordination and stimulating interaction between private and public sector in technological management, is hard to administer and could originate serious governance troubles which could lead to a sub-utilization of the funds.

In addition to funds there are the fiscal incentive schemes, which essentially take the form of i) tax credits and deductions for different types of R&D activities according to the categories of involved actors, ii) public development bank loans. Both mechanisms are marginal in terms of use, even though information on fiscal incentive laws is quite easily accessible in many cases. Fiscal incentives are powerful tools to foster selective development of S&T activities because they allow prioritising in a simple way[26]. Risk capital is an indirect form of fostering science and technology development. Public institutions act as a convoy for private financial resources that flow, through risk capital operations, to business activities consenting to convert technologically advanced projects into operating production entities[27]. Albeit their worldwide-recognized role in favouring technological development, risk capital businesses are hardly found in Latin America and the Caribbean[28]. Scant development of financial markets and institutions and strong uncertainty and volatility of regional macro setting could partly account for the low presence of risk capital operations in Latin America, due to the close linkage existing between this form innovative and risky business support and financial markets.

Intellectual property management

A rising topic related with S&T policy is intellectual property (IP) management. There have been several changes in this domain in recent times. On the one hand, there have been changes in international IP management, such as the TRIPS agreement in 1994, and the wave of bilateral free trade agreements (FTA) and bilateral investment treaties (BIT) containing IP provisions[29]. On the other hand, a changing attitude towards patenting and privatization of knowledge emerged. In the US, the Bayh-Dole act of 1980 introduced the possibility for universities to patent discoveries obtained through federal funds[30]. After the adoption of

26. In effect they are being used to foster institutional infrastructure development and maintenance, as in the case of Mexico, and to promote patenting related activities as it is happening in Brazil since the year 2002, when tax deductions for enterprises that carry out R&D activities were doubled if the business units are granted the patent for which they applied for.

27. Risk capital industries are based on private capitals but need public policies to create a favourable environment, to foster liquidity in financial markets, to promote adequate regulatory and incentive systems and to encourage public and private agents involvement in innovation and technological upgrading.

28. The Argentine Program to support technology base enterprises and risk capital, the Brazilian INOVAR Project and the Risk Capital Portal, the Colombian fund for risk capital investments, the risk capital initiative of the multisectoral investment bank in Salvador and the Mexican capital risk fund for technological development are some regional initiatives in terms of risk capital financing.

29. See Cimoli, Coriat and Primi (2009)for an analysis of recent changes in IP regimes.

30. Beyond the reflection that this provision would foster the dissemination of university research to production, various analysts have raised concerns regarding the drawbacks of the so-called "privatization of scientific activities", which entails rising costs to access basic research results, augmented patenting overheads and amplified risks and costs of legal controversies (Correa, 2003). In reality, the "public nature" of knowledge is definitively shifting towards the private and club goods domain, where access is ruled by given market mechanisms, thus incrementing access barriers to basic research's results.

TRIPS most Latin American and Caribbean countries introduced substantial changes in IP regimes. The expansion of the IPRs resulted in the introduction of minimum standards, in the increasing number of patentable products and processes and in the license to import already patented products by means of including this activity under the umbrella of "sufficient exploitation" (ECLAC, 2002).

Beyond the increasing relevance of the issue of IP for innovation and development, and the entrance of new actors in the patent game, still the main actors are the US, Japan and a group of European countries. In the case of Latin America and the Caribbean the scant patent dynamism is understandable considering the prevailing production structure and the reduced innovation efforts carried out by domestic agents[31]. There are policies supporting patenting and protection of IP. What is mainly lacking is a generalized effort towards innovation. There is a parallelism between the divergence in the patenting patterns and the asymmetry of industrial specialization between the region and the technological frontier. Local innovation processes are basically adaptive in nature and rarely encompass inventions and scientific discoveries. Moreover, regional R&D expenditure is modest and current patenting systems are not yet adapted to local production structures' necessities.

More recently, developing countries started to recognize the relevance of IP for their catching up. They have pushed for a change in IP governance, both at the bilateral and multilateral level, rather for a change in terms of organizational behavior of institutions dealing with IP management[32]. Intellectual Property systems are a complex governing arena whose operating mechanisms are not easily manageable. Effective IP management requires proper infrastructure and institutions and actors' preparedness, as well as suitable legal architecture and enforcing mechanisms. In the current open economies setting there are three main areas that are of strategic importance for intellectual property management.

The first one regards IP management. Latin America and the Caribbean lack strong negotiation capacities and specific skills for elaborating regionally coordinated policy proposals (Drahos, 2002). In most cases countries depend upon external assistance to design IP legal frameworks, thus generating a strange situation where regional counterparts in negotiations are the very same regional policy advisors. The increasing proliferation of bilateral agreements keeps a tight rein on the regional capabilities of profiting from existing policy spaces of TRIPS agreements. For instance, developing countries make scanty use of the Bolar exception, which is actually allowed within the TRIPS agreement and which consents firms to carry out experimental research and development to produce generic products without incurring in a patent's violation[33]. Others windows of opportunities residually used by regional

31. The region is a minor actor in the most relevant patenting office, the USPTO. Latin America and Caribbean applications for patents represent only the 20% of Korean ones, and, moreover regional patenting pattern is deeply asymmetrical with respect to those of advanced or catching up economies. Latin America and the Caribbean mostly patent in traditional sectors (mechanics and chemicals) while those related to new technological paradigms (like telecommunications, biotechnology, genetics and electronics) are at the hub of developed and catching up countries patenting patterns (Aboites and Cimoli, 2001). In addition, in South East Asia the number of patents of residents is growing at a higher rate than those of non-residents, while in Latin America and the Caribbean non-residents lead the scene. In this scenario, patenting systems are turns out to be powerful tools in the hands of foreign companies.

32. For a critical discussion on the development agenda presented to WIPO see De Beer (2009).

33. The Bolar Exception. This clause, also known as "early working", allows generic producers to import, manufacture and experiment on patented products before the patent expires, thus making possible scientific and technological progress in the countries of the region.

economies are: i) compulsory licensing[34], which plays a marginal role in regional intellectual property activities due to the lack of suitable institutional infrastructure and trained personnel, which make compulsory licensing costs exceed potential benefits, ii) parallel imports[35] that allows a reduction in prices and a higher integration at the regional level and, iii) utility models[36], a patenting mechanism more adaptable to the idiosyncrasy of the innovation activity in the region. In addition, the whole set of institutions dealing with IP in the region is short of effective management capabilities (IPRC, 2002; Lopez, 2003). Moreover, most research and development centers, universities and enterprises lack specific departments or professional teams to deal with IP rights and protection of R&D results, thus creating negative effects on the incentive structure of researching activities[37].

The second issue has to do with the IP domain. Countries need to define their own policy towards patentable subject matter (this is especially relevant in the case of biotechnology and biopharmaceuticals, as for publicly funded research).

The third issue relates to globalization and the existence of dominant positions in global and domestic markets. Patents are increasingly used to foster products or services commercialization and to regulate access to markets, thus being converted into "pure objectives" rather than strategic tools. Actually, patents, which in nature are supposed to guarantee innovation appropriation, are mostly used as barriers to control competitors' entrance in the market arena and to maintain dominant monopolistic positions, thus creating incentives for moral hazard and anticompetitive behaviors. In this respect, another structural weakness emerges: in the region prevails a "traditional" usage of competition policy that basically acts as a tool for protecting consumers' interests. In contrast, in the open economies context competition policy is a crucial collateral instrument for promoting regional upgrading in international network hierarchies and for managing IP rights in order to avoid restrictive practices and improper use of rights. Actually, mergers and acquisitions transactions are explained to a great extent by willing of patenting control and above all aim to gain dominant position in international markets (De Janvry, Graff, Sadoulet and Zilberman, 2000). In the biotechnology field, for instance, less than 10% of obtained patents effectively circulate in markets (Platt, 2001).

34. Compulsory licenses. Through this instrument, a license for the use of a patented technology may be granted by the government of the country where the patent is registered if the user has unsuccessfully tried to obtain such a license on the terms laid down in article 31 of the TRIPS agreements. The use of compulsory licenses, however, comes up against some conditions which are difficult to fulfill, and it often happens that the potential producer lacks the know-how to carry out reverse engineering and does not have access to a market big enough to enable him to get back his investment.

35. Parallel imports. Before a patent runs out, countries can take advantage of products manufactured under license in other countries or for other markets, thus making possible their importation at a lower price.

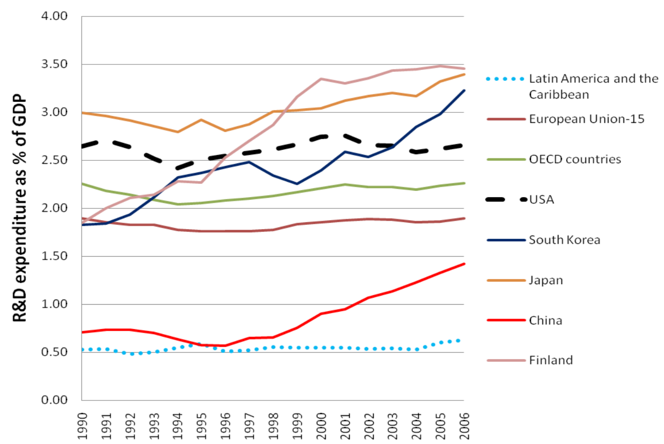
36. Utility models. This is a mechanism —also known as "little patent"— which permits the patenting of incremental innovations or improvements in designs, products and production processes.

37. In Chile, for instance, according to a recent case study, less than 5% of enterprises and less than 12% of institutions hold a team to deal with intellectual property affairs and protection of R&D results; and the outsourcing of R&D outcomes protection to specialists is far more marginal, only 3.2% of Chilean enterprises and 6.5% of universities make use of it (Santibanez, 2003).

3.2. Resources allocated to S&T

World expenditure on R&D follows a rising trend, and still the US, Japan, Germany, France and the UK represent around 66% of total investment in R&D. Latin America is still a marginal actor accounting for less than 2% of world expenditure. There is a persistent gap in R&D expenditure as % of GDP between Latin America and the rest of the world. While regional share of R&D spending in GDP steadily accounts for 0.5 of GDP, technologically mature countries like OECD ones, the USA and Japan spent, on average, respectively 2.3%, 2.7% and 3% of GDP in R&D.

Figure 2. R&D Expenditure as percentage of GDP in a comparative perspective, 1990-2006



Source: RICYT 2008 and OECD MSTI (Main Science and Technology Indicators) 2008.

Within the country sample presented in figure 2 Finland and South Korea are the most dynamic countries having amplified the gap respect to the region. At the beginning of the nineties Finland R&D expenditure share in GDP was equal to the average share of European countries, but throughout the following 12 years Finland increased the share of R&D spending in GDP to 3.5%. During the nineties South Korea strengthened technological capabilities as well, increasing R&D efforts from 1.9% to almost 3% share in GDP, due to effective technology policies combined with a technology oriented specialization pattern.

Latin American R&D spending is not homogeneously spread among regional countries. More proactive countries in terms of R&D spending are Brazil, Mexico, Argentina, Chile and Cuba, which as a whole account for almost 80% of regional spending (see table 3).

Table 3. Expenditure on Research and Development (as percentage of GDP) by countries

Countries	1990	1995	1998	2000	2002	2004	2006
Latin America	0.49	0.58	0.45	0.56	0.64	0.53	0.63
Argentina	0.36	0.42	0.41	0.44	0.39	0.44	0.49
Bolivia	..	0.36	0.29	0.28	0.26	..	..
Brazil	0.76	0.87	..	1.04	..	0.83	1.02
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
Costa Rica	..	0.21	0.21	..	0.21	0.41	..
Cuba	0.7	0.47	0.54	0.52	0.62	0.56	0.41
Ecuador	..	0.08	0.09	..	0.1	..	0.15
El Salvador			0.09			..	..
Honduras	..	..	..	0.06	..	0.06	..
Jamaica	..	..	..	..	0.08	..	..
Mexico		0.31	0.38	0.37	0.34	0.36	0.36
Nicaragua	..	..	..	..	0.07	..	..
Panama	0.38	0.38	0.34	0.4		0.24	..
Paraguay	..	..	..	..	0.1	0.08	0.09
Peru	..	..	0.1	0.11	0.1	0.15	..
Trinidad and Tobago	..	..	0.13	0.11	0.14	0.15	0.22
Uruguay	0.25	0.28	0.23	0.24	0.22	..	0.36
Venezuela	..	..	0.35	0.34	0.29	..	..
OECD countries	2.25	2.06	2.13	2.21	2.22	2.19	2.26
Finland	1.88	2.28	2.88	3.4	3.46	3.45	3.45
Israel	..	2.96	3.42	4.88	..	4.41	4.74
Japan	2.97	2.9	2.95	2.99	3.12	3.17	3.4
South Korea	1.87	2.5	2.55	2.65	2.91	2.85	3.22
USA	2.65	2.51	2.6	2.72	2.67	2.59	2.67
Russian Federation	..	0.9	0.92	1.05	..	1.15	1.07

Source: RICYT 2008 and OECD MSTI (Main Science and Technology Indicators, 2008)

The asymmetry in terms of R&D efforts of Latin America with respect to more industrialized countries persists when looking at the distribution of R&D expenditure by financing and performance sectors (see table 3 and 4). In Latin America governments are the major financing source for R&D spending, accounting for 52% of gross domestic expenditure, while in more developed areas the public sector finances around 30% of total R&D spending[38]. The foreign sector scantly contributes to R&D financing in advanced economies as in the case of most Latin American countries with the exception of small economies like Panama, El Salvador and Paraguay where 55%, 22% and 23% of total R&D spending is respectively financed by foreign financing sources.

38. Within the set of countries displayed in table 4, only the Russian Federation displays a pattern similar to Latin America, with enterprises financing only 33% of total expenditures and government accounting for almost 60% of total R&D disbursement.

Table 4. Research and Development Expenditure by financing sector, 2006 (percentages)

	Government	Enterprises	Higher Education	Non-profit organizations	Foreign
Latin America and the Caribbean	**52.52**	**39.5**	**6.44**	**0.34**	**1.2**
Argentina	66.9	29.4	1.4	1.6	0.8
Bolivia (2002)	20.0	16.0	31.0	19.0	14.0
Brazil	50.1	47.9	2.0	..	..
Chile (2004)	44.5	45.7	0.8	0.3	8.7
Colombia	43.3	39.6	11.3	2.8	3.1
Cuba	60.0	35.0	..	..	..
Ecuador	72.2	18.2	4.2	1.2	4.3
El Salvador (1998)	51.9	1.2	13.2	10.4	23.4
Mexico (2005)	49.2	41.5	7.3	0.9	1.1
Panama (2005)	38.6	0.4	1.4	0.7	58.9
Paraguay (2005)	74.9	0.3	8.6	2.0	14.2
Uruguay	40.0	32.8	26.9	..	0.3
Trinidad and Tobago (2002)	48.2	34.5	17.3	0.0	0.0
Venezuela	62.3	14.3	23.4	..	..

	Government	Enterprises	Other sectors	Foreign
United States	29.1	65.2	5.7	..
Total OECD	28.5	63.9	4.7	..
EU-15	33.4	55.6	2.5	8.5
Finland	25.1	66.6	1.2	7.1
Japan	16.2	77.1	6.4	0.4
Korea	23.1	75.4	1.2	0.3
China	24.7	69.1	..	1.6
Singapore	36.4	58.3	0.9	4.4
Israel (2005)	17.8	75.4	3.5	3.3
Russian Federation	61.1	28.8	0.7	9.4

Source: RICYT 2008 and OECD MSTI (Main Science and Technology Indicators) 2008

Differences between the region and more advanced economies also exist in terms of R&D spending by sector of performance. The business sector is still a residual actor in R&D performance in Latin America, where it accounts for 40% of total expenditure, even though it augmented its share from the 20% of the 80s. On the other hand, almost 70% of R&D spending is carried out by enterprises in OECD countries, USA, Japan, South Korea, Singapore, China and in the Russian Federation. Furthermore, deep heterogeneity emerges within regional countries. In Argentina, Brazil, Mexico, Paraguay and Uruguay enterprises carry out more than 30% of total R&D spending, while in Ecuador and Colombia the participation of the private sector in R&D execution is the lowest. Divergences in terms of efforts and type of R&D activities carried mirror the asymmetry in specialization patterns between the region and more advanced economies. Most regional R&D activities concentrate on applied and basic research, while little is spent on experimental development in Latin America. In contrast, in the USA, one of the world's leaders in S&T, experimental development accounts for more than 50% of total expenditure (table 6).

Table 5. Research and Development Expenditure by sector of performance, 2006 (percentages)

	Government	Enterprises	Higher Education	Private non-profit
Latin America and the Caribbean	**20**	**40.9**	**37.1**	**2**
Argentina	40.7	30.4	26.5	2.5
Bolivia (2002)	21	25	41	13
Brazil (2004)	21.3	40.2	38.4	0.1
Chile (2004)	23	26.6	41.8	8.6
Colombia	8.3	22.2	52.8	16.7
Costa Rica (2004)	17	28	34	21
Ecuador	75.5	19	4.2	1.3
Mexico) (2005)	23.2	46.9	28.7	1.1
Panama (2005)	37.1	..	8.6	54.2
Paraguay (2005)	14.6	38.5	35.4	11.5
Peru (2004)	25.6	29.2	38.1	7.1
Trinidad and Tobago (2004)	54.3	23.7	21.9	..
Uruguay (2002)	19.4	49	31.6	0
United States	11.3	71.0	13.5	4.2
Total OECD	11.4	69.1	17.2	2.6
EU-15	12.7	63.9	22.3	1.2
Finland	9.3	71.3	18.7	0.6
Japan	8.3	77.2	12.7	1.9
Korea	11.6	77.3	10.0	1.2
China	19.7	71.1	9.2	..
Singapore	10.3	65.7	23.9	3.7
Israel	5.3	77.2	13.7	0.3
Russian Federation	27.0	66.6	6.1	..

Source: RICYT 2008 and OECD MSTI (Main Science and Technology Indicators) 2008

Table 6. Expenditure on Research and Development by type of activity, 2006, percentages

	Basic Research	Applied Research	Experimental Development
Argentina	28.1	42.7	29.2
Bolivia (2002)	47	40	13
Chile (2004)	35.7	49	15.3
Colombia (2001)	24	47	29
Cuba	10	50	40
Ecuador	22.1	69.9	8
Honduras (2001)	34.5	40.2	25.2
Mexico (2003)	26.5	32.2	41.3
Panama (2005)	22.5	52	24.5
Paraguay (2005)	11.7	76.1	12.2
Uruguay	20.9	65.7	13.3
USA	18.6	23.1	58.3

Source: RICYT 2008

3.3. Pragmatism and coordination in technology policy

Regarding what countries have learned and what they should learn on S&T policy management we can identify four major issues which should be relevant for future policy shaping exercises:

I. Going beyond pure supply and demand incentives

Framework conditions are crucial in determining firms' technological behavior through codified and non-codified networks;[39] actually enterprises never act alone and perform in a setting where they are expected to interact and maintain channel of communications on a continuum basis with other economic and non-economic agents like other enterprises (which could be partners or competitors), universities, public institutions and nongovernmental and civil society organizations. Pure supply-side or demand-side oriented technology policies are clearly not enough to stimulate innovation in economies where production and management are increasingly carried out within networks[40]. There is a need for a policy mix which combines: horizontal policies (fostering human capital formation and supporting diffusion and assimilation of foreign knowledge), vertical and selective policies (encouraging cooperation and articulation among universities, research centers and enterprises and prioritizing production activities, thus fostering technological accumulation and innovation through the creation of dynamic asymmetries) and competition policies (promoting domestic agents' upgrading in international hierarchies), (Cimoli and Primi, 2004; ECLAC; 2004).

II. Handling knowledge as a "club good"

In open economies the relevance of networks has increased. National innovation systems face global incentives and pressures in the development of local organization and production processes. Access to networks does not automatically guarantee the possibility of profiting from potential technological spillovers. The positioning in international value chains and in international network hierarchies determines economic agents' capacity of retaining technology and innovation and of profiting from technological interactions. A dominant position in production networks guarantees the control of knowledge de-codification mechanisms. Knowledge is losing its traits of a public good. Increased relevance of networks and changes in production organization make knowledge more similar to a club good, i.e. an asset non rival in consumption but excludable in use (Cimoli, 2002; Yoguel, 2003).

III. Building up institutional capabilities

Policy formulation and implementation involve continuous learning and trial and error processes. The best evolution paradigm should synchronize the strengthening of domestic

39. In the more industrialized countries the debate on technology and innovation policies had been focused on the importance of networks, linkages and interactions between agents as major stimuli for innovation and technology transfer since the decade of the eighties. In Latin America it is only recently that there is a pressing need to take these issues into consideration in technology policy planning and implementation. (Teece, 1989; Metcalfe, 1995).

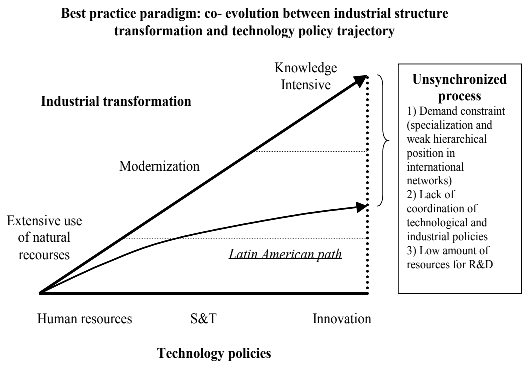
40. Collective interaction favors scope economies in knowledge accumulation and innovation through technological interrelations and complementarities between firms and institutions devoted to science and technology (Arthur, 1989; Dosi, 1998). And networks, through links and interactions foster externalities and increasing returns in production processes and industrial organization (Cimoli and Dosi, 1995; Dosi, 1998).

institutional capacities in policy making with the upgrading in production specialization patterns. As countries improve institutional capacities and develop more complex and articulated production structures they face different incentives for technological upgrading and policy articulation. The re-composition of domestic production structure toward a more technologically intensive vector leads the private sector (the demand side) to prioritize knowledge and innovation and to consequently increase the demand for it. There are no generic blue prints for an optimal technology policy. Policy goals, instruments and capabilities must be tailored to country specific context and time requirements and they have to cope with local financial constraints. The mix of suitable policies should take into account regional specificities and should be designed on the basis of a renewed and more pragmatic technology policy model which needs new institutional settings for policy management and implementation.

IV. Linking innovation policy with production development

Disposing of a well designed policy is not a sufficient guarantee. A key factor of success for any technology policy is the matching of its goals with production structure needs and effective demand. The co-evolution and synchronization between industrial transformation and progression in innovation policy's goals and technological capabilities should be constantly searched for. The demand for knowledge is created, but it also determines the effectiveness of the technology policies (see figure 3). Economies generally go through deep structural transformation in their production structure. Mature and catching up countries have shifted from an extensive specialization pattern, in which countries industrialized exploiting abundant factors, like natural resources and labor, to intensive patterns based on learning and knowledge. Between the (tangible) resource extensive pattern and the knowledge intensive one, the modernization phase occurred; enterprises adopted more capital intensive processes and increased efficiency in production through incremental innovations imitative practices. S&T policies should be in line with those transformations accompanying the creation of the needed capabilities (human resources, absorptive capacities, and endogenous technological capabilities). In Latin America and the Caribbean production structure transformation and technology policy have evolved following divergent and unsynchronised patterns. Strengthening regional capabilities of designing and implementing technology and innovation policies and increasing domestic efforts in S&T activities is needed. However, this should be done in accordance with a medium and long term production development strategy.

Figure 3: A challenge for Latin America and the Caribbean: closing the gap with technology policy and industrial transformation



Source: authors' elaboration

4. Thinking about technology policy in a crisis scenario: some concluding reflections

As concluding remarks we would like to focus on what the current financial crisis might add to the discourse on S&T policies. A price shock forces the firm to readapt and redefine its capabilities by reorganizing the production process (Ferraz, Kupfer and Serrano1999, Cimoli and Porcile 2008). Although this re-adaptation encompasses the whole production apparatus, its impact has a strong sectoral component. Firms which are operating on the technological frontier (and which are usually located in frontier economies) will have to restructure and redirect their investment planning and activities. Some of them will shut down given product lines, and will reduce investment in new and risky projects, but they will maintain investment in core activities, especially those based on R&D capabilities and efforts. Other firms might even increase their investments in R&D due to technological foresight exercises indicating that certain technologies will maintain the leadership in the post-crisis scenario. Those firms might even bring about a process of creative destruction moving forward towards a new production mix. In contrast, in peripheral economies – which were in the process creating endogenous technological and production capabilities – short term competitive pressures would lead firms to reduce investments in R&D and in risky and uncertain innovations. This reduces the technological base with which those economies will face the post-crisis scenario. A sort of lock-in process emerges, in which countries which should invest the most in supporting the creation of endogenous technological capabilities are led to invest less as a result of short term pressures. They will tend to prioritize a deepening in their current specialization pattern, and this implies less future growth than a response that focuses on technological learning and productive diversification. The short term response would reinforce their backwardness and their marginal position in the global economy.

Actually, responding to the shock crisis it is easier said than done. Re-adaptation and change are costly, and require time and resources. The speed, and the direction of change, with which the firm responds to the shock it is crucial to remain competitive in the market. And, obviously, not all firms will be able to respond swiftly enough. The effects of the re-adaptation of capabilities and production and investment strategies on productivity will not be immediate. There will be a time-lag, and during this time, the economy will necessarily experiment a slowdown in productivity growth. Clearly, the time for re-adaptation depends on many factors, such as the specificities of the assets of firms, the kind of routines in the firm's management strategy and the general characteristics of the human capital-- i.e. there is some degree of stickiness in technological and production capacities of firms which determines the time and direction of the re-adaptation process
In a very simplified way we could argue that the discourse on S&T policy in Latin America in the context of the current financial crisis should take into account at least the three following issues:

I. Capabilities in new paradigms in science, technology and production that will lead the resurgence from the current crisis, and will determine the repositioning in the global economy.

We are facing a momentum of "crossing" of new technological paradigms which are about to reconfigure the way in which business is carried out. The ICT paradigm has already reached a substantial penetration (especially in frontier economies), and there are emerging paradigms, the biotech, the nanotech and new materials, which are at their early stage of application. The full potential of these technologies, each one alone and the joint potential of them, all has not yet been exploited and probably, not even completely defined and understood. Those technologies will radically transform the way in which production, organization and trade are carried out, will create new products, services and processes, and will need different institutions to manage, apply and diffuse them. The process of application and diffusion of those paradigms is uneven and it is filtered by the accumulated capabilities of each firm (and country). It is quite reasonable to expect that the potentialities of the new technologies will be at the basis of the new expansive cycle that will come about after the crisis.

In this respect, those that have the deeper understanding of the nature of this current crisis are business analysts and the CEOs of high tech firms which are urged to take decisions regarding which investments to maintain and which lines of business need to be shut down. It is highly probable that in the near future (and probability for a quite long period of time) new profits and gains will emerge from investments in new technologies and knowledge, rather than from speculative behaviour in financial markets. This perception, which is diffused in some business sectors, determines that, for example, businessmen in the IT related business, which is a sector that has been, and still is, strongly hit by the current crisis, are reconfiguring their portfolio investment and are cutting down expenditures, but maintaining invariant the investment in core high tech activities and R&D. Research and knowledge capabilities are difficult to reconvert and recover, and the perception that knowledge will be the assets that will determine the repositioning of powers in the post crisis, justify maintaining investments in those assets even in a crisis scenario. Of course it is not a matter of "spending for the sake of spending" as might be possible in a "bonanza" momentum. It is time for a "smart spending" (just to quote Gates). But "smart" in this context is, more than ever, a synonymous for technology, knowledge and intangibles asset, not for cost-effectiveness and efficiency in investment.
However, looking at the crisis as a "creative destruction" momentum in the current capitalistic development, should not lead to naive stand viewing the crisis as straightforward opportunity. Opportunities will be strictly linked with capabilities in new paradigms and technologies. Countries which master relevant knowledge in the new paradigms, countries that will have the human capital in those areas, countries with big high tech firms, will have an easier way out of the crisis, than countries which were at the margins of the knowledge game in the pre-crisis scenario. Likewise, there will be windows of opportunities for all, but they will be understood and possibly profited only by firms (and countries) which follow a knowledge-centred development strategy and which will prioritize the construction of scientific and technological capabilities also in this crisis context. It is highly probable that in the future the basis for competitiveness of firms will be largely redefined. New demands will ensue, and probably there will be a redefinition of porduction with a shift of poriorities towards environmental sustainability and welfare concerns.

II. Facing the crisis thinking about future: the need "more than ever" of active industrial and technological polices.

In recent days astronomic amounts of money have been dropped in the financial system to avoid its collapse while resources and assets evaporate. For many analysts, it is time to rethink the institutions and rules governing the financial markets. We argue here that it is also urgent to rethink policies in the fields of technology and industrial diversification, particularly in catching-up economies. More specifically, we argue that all the reasons that impose the need of intervention in the financial system are as well present in the industrial system, and that the importance of adopting policies for the development of technological capabilities cannot be neglected in times of financial crisis – on the contrary, they are more necessary than ever. And, this is more necessary if we think at the world that after the crisis will be extensively shaped by capabilities in knowledge and technology.

III. A “smart policy mix”: measures to avoid the destruction of production and technological capabilities and new incentives for the accumulation and adoption of new technologies.

In order to gain an understanding of learning dynamics and to take advantage of new technologies and the restructuring of production in the global scenario, it is necessary to look both at sectors dynamics and at the trajectories of individual firms. This means that it is necessary to adopt a variety of policies and instruments. Opportunities available in different sectors depend on their respective sectoral dynamics and reflect the learning processes associated with the spread of technological paradigms (such as ICTs, biotech, nanotech and new materials).

Sectoral responses are heterogeneous. Sectors in which competitiveness depends on relative abundance of natural resources -and export natural resources and “commodities”- are mainly affected by prices and speculative forces in the financial market; and this crisis showed it clearly. Similarly, the low tech sectors (textile-clothing, shoes) suffer the impact of falling demand and prices, but their volatility is lower than in commodities. Policies are required to avoid the social impact (unemployment) of the contraction of these activities, so as to sustain a modernization process incorporating new technologies and human capital -and, in the case of medium and small firms, to sustain the dynamism of local networks, clusters and districts.

In the medium tech sectors (mechanical engineering sector, chemistry), the competitive challenge is to learn how to adapt production techniques. These processes are complex and require human capital with high competences and recourses to exploit the opportunities arising from new technologies. A critical concern for policymakers is to foster the adaptation process, the incorporation of new technologies (ICT, bio and nanotech), as well as support R&D investment and the interaction with the public sector.

Finally, policies for high tech sectors require an important dose of courage, particularly, in developing countries. Science is a crucial input, and attention should be given to all those research activities in universities and research centers which are the vehicle for creating and transferring technology and allowing the upgrade of the private sector. Private and public laboratories are central in this process. If the crisis implies a reduction in the flow of funding to these activities, without doubt the catching up countries will be led to a situation in which they will be unable to “read”, transfer and adapt the new technologies. As a result, the technology gap will increase. Again, the failure to adopt industrial and technology policies implies the risk of losing the next long wave of structural transformation and the advantages that the new paradigms bring with them.

References

Aboites, J and Cimoli, M, "Intellectual Property Rights and National Innovation Systems. Some Lessons from the Mexican Experience", presented at the DRUID-Nelson and Winter conference, Aalborg, 12-15 of June 2001 (http:// www. business.auc.dk /druid/conferences/nw/). Revue d' Economies Industrielle, N. 99, pp. 215-233.

Alcorta, L. and Peres, W. (1997), "Innovation systems and technological specialisation in Latin America and the Caribbean", Research Policy 26 (1998) 857-881, Elsevier.

Amsden, A. (1989), Asia's Next Giant: South Korea and the Last Industrialization, New York, Oxford University Press.

Arthur, B. (1989), "Competing technologies, increasing returns and lock-in by historical events", Economic Journal, 99(1).

Bisang, R. and Malet N. (2000), "El Sistema nacional de innovación de la Argentina", Proyecto Instituciones y mercados, Comisión Económica para América Latina y el Caribe (CEPAL)/Sociedad Alemana de Cooperación Técnica (GTZ), marzo.

Bonelli, R. (2000), "Fusões e aquisições no MERCOSUL", CEPAL, Brasilia.

Cantwell, J. and Santangelo, G. D. (2003), "M&A and the global strategies of TNCs", DDPE, CEPAL, Santiago, Chile.

Capdevielle, M. (2004), "Crecimiento y heterogeneidad estructural en México", paper for the ECLAC/BID Project, Santiago, Chile.

Capdevielle, M., Casalet, M. and Cimoli, M., (2000), "Sistema de innovación: el caso mexicano", Proyecto Instituciones y mercados, Comisión Económica para América Latina y el Caribe (CEPAL)/Sociedad Alemana de Cooperación Técnica (GTZ).

Casalet, M., (2003), "Políticas científicas y tecnológicas en México: evaluación e impacto", FLACSO, sede México.

Chesnais F. (1995), "Some Relationships Between Foreign Direct Investment, Technology, Trade and Competitiveness", en Hageddoorn J. (ed.) (1995), "Technical Change and the World Economy", Edward Elgar, London.

Cimoli, M, Coriat, B. and Primi, A. (forthcoming), Intellectual property and industrial development: a critical assessment, in The Political Economy of Capabilities Accumulation: the Past and Future Industrial Policies for Development', edited by M.Cimoli, G. Dosi and J. E. Stiglitz, Oxford University Press, forthcoming.

Cimoli, M. (ed), (2000), "Developing innovation system: Mexico in the global context", Continuum-Pinter Publishers, New York-London.

Cimoli, M. (ed.), Heterogeneidad structural, asimetrías tecnológicas y crecimiento en América Latina, CEPAL, Naciones Unidas-BID, LC/W 35, Santiago, Chile.

Cimoli, M. and Dosi, G., (1995), "Technological paradigms, pattern of learning and development: an introductory roadmap", in Journal of Evolutionary Economics, vol. 5, n.3, pags. 243-268.

Cimoli, M. and Katz, J. (2003), "Structural reforms, technological gaps and economic development: a Latin American perspective", in Industrial and Corporate Change, vol. 12, number 2, pp. 387-411.

Cimoli, M. and Porcile, G. (2008), Volatility and Crisis in Catching-up Economies: Industrial Path-Through Under the Stickiness of Technological Capabilities and "The Red Queen Effect, ECLAC-UN Working Paper.

Cimoli, M. and Primi, A., (2004), "Las políticas tecnológicas para la creación y difusión del conocimiento en América Latina y el Caribe', mimeo, División de Desarrollo Productivo y Empresarial, CEPAL.

Cimoli, M., Dosi, G. and Stiglitz, J. E. (2008), The Future of Industrial Policies in the New Millennium: Toward a Knowledge-Centered Development Agenda, LEM Working Paper, 2008/19, and forthcoming in The Political Economy of Capabilities Accumulation: the Past and Future Industrial Policies for Development', edited by M.Cimoli, G. Dosi and J. E. Stiglitz, Oxford University Press, forthcoming.

Cimoli, M., M. Holland, G. Porcile, A. Primi and S. Vergara (2006), "Growth, Structural Change and Technological Capabilities Latina America in a Comparative Perspective", LEM (Laboratory of Economics and Management) Working Paper Series 2006/11, Universidad de Pisa.

Cimoli, M., Coriat, B. and Primi, A. (2009), Intellectual property and industrial development a critical assessment, in Cimoli, M., Dosi, G. and Stiglitz, J. E. (eds) (2009), The political economy of capabilities accumulation: the past and future of industrial policies for development, Oxford University Press.

Cimoli, M., M. Holland, G. Porcile, A. Primi and S. Vergara (2006), "Growth, Structural Change and Technological Capabilities Latina America in a Comparative Perspective", LEM (Laboratory of Economics and Management) Working Paper Series 2006/11, Universidad de Pisa.

Cimoli, M., N. Correa, G. Porcile, A. Primi, S. Rovira, G. Stumpo, S. Vergara, (2009), Creative destruction and the out-of-crisis roadmap: some scenarios for Latin America, ECLAC-UN, Division of Production, Productivity and Managment, Internal document, mimeo.

Correa, M. (2003), "Políticas para Propiedad Intelectual", documentos de la "Reunión Regional OMPI- CEPAL de Expertos sobre el Sistema Nacional de Innovación: Propiedad Intelectual, Universidad y Empresa", Santiago, Chile.

Crespi, G. and Katz J. (2000), "Sistema Nacional de Innovación de Chile", Proyecto Instituciones y mercados, Comisión Económica para América Latina y el Caribe (CEPAL)/Sociedad Alemana de Cooperación Técnica (GTZ), marzo.

De Beer, J. (ed) (2009), Implementing the World Intellectual Property Organization's Development Agenda, Laurier University Press, Canada.

De Janvry A., Graff G., Sadoulet E. and Zilberman D., "Technological Change in Agriculture and Poverty Reduction", University of California, Berkley. Concept Paper for the WDR on Poverty and Development 2000/ 2001, (2000) (http://www.worldbank.org/poverty/wdrpoverty/backround/dejanvry.pdf).

Dosi, G., (1988), "Sources, procedures, and microeconomic effects of innovation", Journal of Economic Literature, 26, págs.1120–1171.

Dosi, Sylos Labini and Orsenigo, 2003.

Drahos, P. (2002) "Developing Countries and International Intellectual Property Standard Setting", Comisión Backround Paper 8, .(http://www.iprcommission.org).

ECLAC (2008).

ECLAC (Economic Commission for Latin America and the Caribbean) (2002), Globalization and development (LC/G.2157(SES.29/3)), document prepared for the Twenty-ninth session of ECLAC (Brasilia, Brazil, 6-10 May), Santiago, Chile.

ECLAC, (2004), Productive development in open economies, LC/G.2234(SES.30/3, Santiago, Chile.

ECLAC (2008), Strucutral change and productivity growth 20 years later: old problems, new opportunities, (LC/G.2367(SES32/3), Thirty Second Session, ECLAC, Santiago, United Nations Publications.

Ferraz, J. C., Kupfer, D. and Serrano, F. (1999), macro/micro interactions : economic and institutional uncertainties and structural change in the Brazilian industry, Oxford Development Studies, vol 27, 3, October, 1999.

Freeman, C., (1987), "Technology policy and economic performance: lessons from Japan", Pinter Publisher, London.

IPRC, 2002, "Integrating Intellectual Property Rights and Development Policy" (2002), Comisión sobre Derechos de Propiedad Intelectual (CDPI, 2002).

Jaramillo Salazar, H., (2003), "Políticas científicas y tecnológicas en Colombia: evaluación e impacto durante la década de los noventa", Trabajo realizado para la CEPAL, Bogotá, Colombia.

Jomo K. S. (1997), "Southeast Asia's misunderstood miracle: industrial policy and economic development in Thailand, malasya and Indonesia", Westview Press.

López, A., (2003), documentos de la "Reunión Regional OMPI- CEPAL de Expertos sobre el Sistema Nacional de Innovación: Propiedad Intelectual, Universidad y Empresa", documentos de la "Reunión Regional OMPI- CEPAL de Expertos sobre el Sistema Nacional de Innovación: Propiedad Intelectual, Universidad y Empresa", Santiago, Chile.

Mendes De Paula, G., Ferraz, J. C. y Iootty, M. (2002), "Economic liberalization and changes in corporate control in Latin America", Developing Economics, vol. XL, n. 4., diciembre 2002.

Metcalfe, S., (1995), "The Economic Foundations of Technology Policy", en Stoneman, P. (ed.), Handbook of the Economics of Innovation and Technical Change, Blackwell, Oxford.

Mortimore, M y Peres, W. (2001), "La competitividad empresarial en América Latina y el Caribe", revista de la CEPAL, n. 4, agosto 2001, p.37-59.

Nelson, R. (ed), (1993), "National systems of innovation', Oxford University Press.

Pacheco, C. (2003), "As reformas da Política Nacional de Ciência Tecnologia e inovaçao no Brasil, 1999-2002", Trabajo realizado para la CEPAL, Campinas, Brasil.

Patel P. and Pavitt, K., (1991), "Large Firms in the Production of the World. Technology: an important case of non–globalization", Journal of International Business Studies, 22, págs. 1–22.

Primi, A. (2009), Science, technology and innovation policy in Latin America: a tale of a (slow) learning process, ECLAC-UN, Division of Production Productivity and management, Forthcoming.

Reinhardt, N. and Peres, W. (2000), "Latin America's new economic model: micro responces and economic restructuring", World Development, 28(9).

Teece D., (1989), "Strategic Technology and Public Policy", Selected Papers, Edward Elgar, London.

Tigre, P., Cassiolato, J. E., De Souza Szapiro, M. H. and Ferraz, J. C., (2000), "Câmbio estructural e sistemas nacionales de inovação: O caso Brasileiro", Proyecto Instituciones y mercados, Comisión Económica para América Latina y el Caribe (CEPAL)/Sociedad Alemana de Cooperación Técnica (GTZ).

Vargas Alfaro, L. and Segura Bonillla, O., (2003), "Políticas industriales, científicas y tecnológicas en Costa Rica y Centro América", Centro Internacional en Política Económica para el Desarrollo Sostenible (CINPE), Universidad nacional, Hereida, Costa Rica.

Wade, R. (1990), "Governing the market: economic theory and the role of government in Est Asian industrialization", Princeton, NJ, Princeton University Press.

WIPO, (2004), Proposal by Argentina and Brazil for the Establishment of a Development Agenda for WIPO, WIPO, Geneva, doc. N. WO/GA/31/11.

Yoguel, G. (2003), "La política científica y tecnológica argentina en las últimas décadas: algunas consideraciones desde la perspectiva del desarrollo de procesos de aprendizaje", Trabajo realizado para la CEPAL, Buenos Aires, Argentina.