Growth, Structural Change and Technological Capabilities

Latin America in a Comparative Perspective

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First Draft

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I. Introduction

The capability of a country to promote structural change, thereby exploiting the opportunities that emerge from new technological paradigms and the dynamics of demand, explains its performance in the international arena. This is particularly true under the conditions that characterize the globalization process, in which technology gives rise to new products, production processes and sectors, while others tend to decline.

In the fifties the ideas of economic development and structural change were closely related. Several authors argued that the development process implied the reallocation of production factors from sectors with low productivity to those of high productivity, in which increasing returns prevailed[3]. An increasing share of industry in the economy would produce spillover effects, backward and forward linkages and technological externalities sustaining learning and capital accumulation[4].

At the same time, these authors argued that the transformation of the productive structure would lead to the gradual transformation of the pattern of international specialization. Prebisch (1981, pp.37-39) emphasized that the Southern production structure implied a much higher income elasticity of the demand for imports than the income elasticity of the demand for exports, producing recurrent external imbalances in the South. Assuming low price elasticities of the demand for imports and exports, the South would have to grow at lower rates than the North to avoid external disequilibrium (Rodriguez, 1981, pp. 69-71). This implies divergence in terms of Gross Domestic product (GDP) per capita between North and South. Changing the pattern of exports towards manufactures would allow the South to correct these unbalances and achieve higher rates of economic growth.

New contributions in the 1960s to the theory of technology and trade gave support to this view on structural change and development (Posner, 1961; Freeman, 1963; Hirsch, 1965; Vernon, 1966). This approach stresses international asymmetries in technological capabilities as the main determinant of trade flows and patterns of specialization. Technology is not regarded as a free good and it is acknowledged that it confers a significant advantage to the innovator country. Moreover, in a dynamic context, asymmetries in technological levels and

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[3] Hirschman, Prebisch, Rosenstein-Rodan, Gerschenkron, Chenery and Sirkin are among the classical authors in development theory. For a discussion of their contributions see Ray (1998, Chapter 5).

[4] New growth theory assumes a diversified production structure and increasing returns in R&D intensive sectors to explain sustained positive rates of growth of per capita income in the long term. The structural change is modeled by the creation of new capital assets, the increase of labor division in the economy and/or the improvement of the good quality. The innovations generated in a R&D intensive sector explain the existence of a more diversified and dense production structure and the presence of increasing returns mechanisms. It would not be exaggerated to affirm that "the old" subjects as: externalities, indivisibilities, spillovers and increasing returns are evoked in the "new growth theories" (Grossman and Helpman, 1992; Krugman, 1991; Aghion and Howitt, 1998; Ray, 2000; Ros, 2000).

innovative capabilities mainly explain the evolution of the pattern of specialization and growth[5].

In turn, the evolutionary approach gives emphasis to the role of technological change in shaping structural change and growth (Dosi *et al* 1990). Economies that are able to absorb new technological paradigms and transform their sectoral composition towards a higher participation of Research and Development (R&D) intensive activities will achieve convergence. Some important implications emerge from this approach.

First, the theory would predict persistent asymmetries among countries in the production processes they are able to master. Thus, at any point in time, one can draw two major testable conjectures: (i) different countries can be unequivocally ranked according to the efficiency of their average techniques of production and, in the product space of the (price-weighted) performance characteristics of their outputs, irrespectively of relative prices, and (ii) there will be no significant relationship between these gaps and international differences in the capital/output ratios. Wide differences will be in place in terms of the capability to develop new products and to imitate after they have been introduced into the world economy. Indeed, the international distribution of innovative capabilities regarding new products is at least as uneven as that regarding the production processes.

Second, the process of development and industrialization are strictly linked to inter- and intra-national diffusion of "superior" techniques. At any point in time there is likely to be only one or at most very few "best practice" techniques of production which correspond to the technological frontier. In the case of developing economies, the process of industrialization is thus closely linked with the transfer, imitation and adaptation of established technologies from more advanced economies. The processes of adoption and adaptation of technologies, in turn, are influenced by the specific capabilities of each economy.

In this context, we suggest that evolutionary micro-theories are well apt to account for the processes by which technological gaps and national institutional diversities can jointly reproduce themselves over rather long spans of time. Conversely, in other circumstances, it might be precisely this institutional and technological diversity among countries which may foster catching-up (and, rarely, leapfrogging) in innovative capabilities and the per capita

[5] Freeman (1963) highlights the differences in the factors which determine specialization before and after the imitation process takes place. At the initial stages of the innovation process the influence of patents, commercial secrecy, static and dynamic economies of scale prevails. Once imitation occurs, the traditional process of adjustment in production cost reshapes specialization. In Hirsch (1965) and Vernon (1966), technological asymmetries are associated as well with distinct phases in the evolution of a technology and the specific international distribution of innovative capabilities. Innovative capabilities are the main competitive asset explaining the production of new commodities in the advanced countries. Over time, technology evolves toward a mature phase characterized by standardization of products and processes. When this happens productivity improvements and production cost advantages in the mature technology are basis for trade.

incomes. The importance of the institutional dimension for evolutionary theories of production and innovation should come as no surprise and it is supported by growing evidence from both micro and macro patterns of technological change. After all, at the micro level, technologies are to a large extent incorporated in particular institutions, the firms, whose characteristics, decision rules, capabilities, and behaviors are fundamental in shaping the rates and directions of technological advance. This approach supports the concept of "national innovation system" as a relevant dimension for understanding the relative performance of countries in international competition (Cimoli and Dosi 1995; Freeman, 1987; Nelson, 1993).

The paper is organized in three sections. Section I develops a simple model of convergence and divergence based on international trade and the dynamics of the technology gap. It takes as a point of departure the models by Cimoli (1988) and Fagerberg (1988) and extends their results by suggesting a new specification for the influence of the technology gap on specialization and growth. The model also allows for making some testable predictions about how technology, specialization and convergence are related. These predictions are tested on the basis of a panel data analysis of the determinants of economic growth for a large sample of countries. We find a strong association between economic growth and technological capabilities, from one hand, and economic growth and the pattern of specialization, on the other.

Section II offers a more detailed analysis of the economic structure of a subset of countries, with a focus on Latin America. It discusses the transformation of the Latin America production structure and its capacity for promoting activities with higher technological contents. Evidence from 17 countries supports the empirical analysis of this section. Sector shares in total industrial value added and productivity gaps are used as proxies to describe changes in the production structure. The trade pattern is approximated by the export composition and the Adaptability Index. Technology is captured by R&D expenditures and the number of pattern granted in US patent office. Growth rates are included in the last column of the panel. After showing that most of the variables in the panel are highly correlated, the paper follows by carrying out some comparative exercises. Building on these exercises, the analysis demonstrates that countries that move in favor of R&D intensives sectors achieve higher rates of growth in the long term and improve their specialization and adaptability to global demand. The analysis also shows that a virtuous link between exports and growth requires an increasingly robust capacity to reduce the technology gap in relation to more advanced economies.

Section III introduces taxonomy where two groups of countries are identified in term of how they pursue economic rents. One strategy is defined by a pattern of specialization that depends on the competitive advantages conferred by natural resources. The other strategy is based on activities that generate higher shares of R&D and knowledge spillovers. The Latin American countries have followed mainly the first type of strategy which, in some cases, has been able to generate significant economic growth rates. However, it is argued that the strategy that generates rents from activities that create and diffuse knowledge is the one which allows for achieving convergence in the long term. Finally, in section IV the main conclusions of this work are summarized.

II. A Model of Convergence and Divergence

Ricardian trade models with a continuum of goods are particularly useful for analyzing the role of technology in international trade. They offer a direct link between Keynesian (demand-led) growth, the Balance-of-Payments constraint, and technological and structural change. In these models, countries specialize on the basis of their sectoral differences in labor productivity arising from technological asymmetries. Countries that are closer to the technological frontier show much higher levels of productivity in high-tech, innovation-driven sectors than laggard countries. On the other hand, productivity differences will be lower in sectors in which technology is already standardized and the technological frontier moves slowly. This gives rise to a pattern of specialization based on the dynamics of innovation and diffusion of technology in the international economy.

But there is another field in which Ricardian models offer a promising avenue for research, namely the study of convergence and divergence in the international economy. In effect, in a model with two countries, one of which is the technological leader (North) and the other the follower (South), current account equilibrium implies that relative North-South income must be a function of the number of goods each country produces, *i.e.* a function of the pattern of specialization of the two countries. The evolution of relative income through time, which amounts to convergence or divergence in the international economy, will depend on the how technological change redefines the location of production. If the South is able to expand the range of good it produces towards more dynamic sectors (in the sense that they feature higher levels of demand and productivity growth), there will be convergence. Thus, the analysis of convergence and divergence arises naturally within the framework of the Ricardian model.

Ricardian models may help to build a bridge between two traditions, namely the Schumpeterian tradition, with its focus on technology and structural change, and the Keynesian tradition of Balance-of-Payments-constrained growth models, with it focus on the role of the demand side in promoting growth. In the Keynesian tradition, the pattern of specializations is embedded in the income elasticities of the demand for exports and imports (McCombie and Thirlwall, 1994, chapter 3). This implies a direct link between specialization and demand, but this is not made explicit in the model. Ricardian models permit to look at the elasticities as the outcome of a process of structural change. They then become a function of the parameters that define the relative rates of technological innovation and diffusion in the international economy.

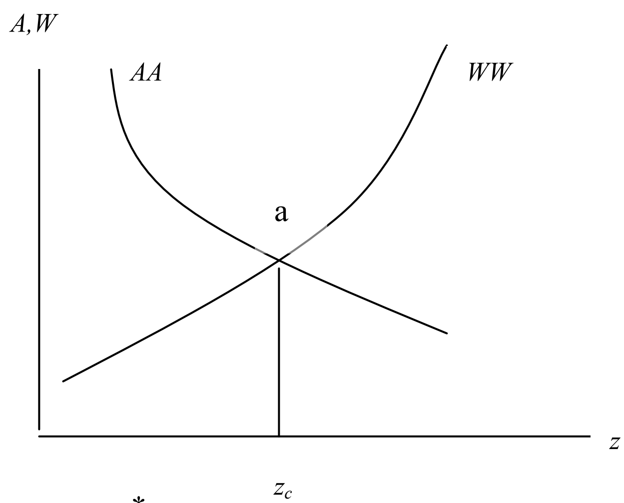
It is worth mentioning that the empirical evidence on trade and convergence suggests that it is necessary to look more carefully at the impact of trade on the pattern of specialization. In conventional models international trade is expected to contribute to convergence by encouraging a more efficient allocation of resources and the adoption of new technology (see for instance Barro and Sala-i-Martín, 1994). Therefore, there should be a positive association between openness and economic growth. But this perspective is challenged by the literature pointing out that convergence and openness have not always gone hand by hand (Easterly, 2001; Rodríguez and Rodrik, 2001). This will depend on whether openness is complemented by local efforts for technological learning and on the adoption of policies favoring a more dynamic pattern of specialization (Cimoli and Correa, 2005; Fagerberg, 1994; Hausmann and Rodrik, 2003; UNCTAD, 2003).

a) The Ricardian Model and the Technology Gap

The Ricardian model was proposed originally by Dornbush *et al* (1977), and subsequently revisited by Cimoli (1988) and Dosi *et al* (1990) from a Neo-Schumpeterian perspective, which is adopted here. Figure 1 summarizes the basic model and shows how the pattern of specialization is defined. The international economy is formed by two countries, North (N) and South (S), which differ in terms of their technological development, being the North the more advanced country. Both countries compete in the production of a large number of goods. Comparative advantage depends on relative labor requirements defined as $Az = \frac{a_z^*}{a_z}$, where a^*_z are hours per worker required to produce one unit of good z in the North and a_z are the hours per worker required to produce one unit of the same good in the South. Relative labor requirements are a function of technology. The subscript $z \in [0,1]$ is defined in such a way that goods are ranked in a descending order in terms of the comparative advantage of the South. The declivity of the *AA* curve reflects the rate at which the South looses its comparative advantage as the economy diversifies towards sectors that are more intensive in technology.

To find the pattern of specialization, it is necessary to combine the curve of relative labor requirements with the curve of relative wages. The *WW* curve represents relative wages $W = w/w^*$ between South (w) and North (w^*). Assuming that labor is the only factor of production, the exchange rate is constant and equal to 1, and the goods market is perfectly competitive, the South will produce the goods for which $A>W$. It is then clear that the South will produce goods from zero to the borderline good z_c, while the North will produce goods from z_c to *1* (see Figure 1).

Figure 1. The Ricardian model



The curve $A = \dfrac{a^*}{a}$ gives the relative labor requirements for producing one unit of good *z* in the North (*a**) and the South (*a*). The curve $W = \dfrac{w}{w^*}$ gives the relative nominal wage between South (*w*) and North (*w**).

It is assumed that the position of the *AA* curve depends on the technology gap defined as $G = \dfrac{Tn}{Ts} \geq 1$, where *Tn* and *Ts* are the technological levels of North and South, respectively. The evolution of the technology gap depends on the relative rates of innovation in the North and diffusion towards the South. Following Fagerberg (1988) and Narula (2004), technological spillovers from North to South are assumed to be a linear function of the inverse of the technology gap and the learning efforts in the South[6]:

$$(1)\quad \hat{G} = \rho - \mu\left(1 - \frac{1}{G}\right)$$

[6] A more realistic assumption would be that of a nonlinear relationship between technological spillovers and the technology gap, as suggested by Verspagen (1993, chapter 5). Still, the linear assumption keeps the model much simpler and helps to highlight how changes in the technology gap are related to changes in specialization and growth, which is the basic theme of this paper. Moreover, as suggested by Narula (2004), it can be assumed that the economy has already developed the minimum technological capability required to enter the catching-up stage. In this stage, the velocity of learning is an inverse function of the technology gap. See also the classical paper by Nelson and Phelps (1966), which focuses on the role in international technological diffusion of one dimension of the NSI, namely the accumulation of human capital.

Where $\hat{G} = \frac{\dot{G}}{G}$ the proportional growth rate of the technology gap, ρ is the exogenous rate of growth of knowledge in the North and μ is the domestic effort the South deploys for mastering Northern technology. Both parameters are positive and constrained so that $\mu > \rho > 0$.

Although the model is aggregate and not micro-founded, the parameters that define the evolution of the technology gap can be easily interpreted in the light of the Schumpeterian literature on social capabilities (Abramovitz, 1986) and National Systems of Innovation (Freeman, 1987). The parameters ρ and μ reflect the amount of resources allocated to R&D and the institutional setting in which technological learning proceeds in both countries. There is considerable evidence pointing out that imitation does not occur automatically, but it is the result of investments in learning that may vary considerably across countries (Cimoli and Katz, 2002). These differences are reflected in μ. Alternatively, the parameters of the model can be seen as the equilibrium result of a micro process in which economic agents choose to become either innovators or bureaucrats, as in the Sah and Stiglitz (1988) model. In this case, the South will reach an equilibrium featuring a larger proportion of bureaucrats than the North, and this explains the asymmetry between North and South in terms of technological learning. The stability of the technology gap implies:

$$(2) \quad \frac{\dot{G}}{G} = 0 \Rightarrow G^* = \frac{\mu}{\mu - \rho}$$

Equation (2) gives the equilibrium value of the technology gap (G^*) as a function of the parameters that define the effort for innovation in the North and for imitation in the South. It is straightforward that in equilibrium the gap will not be fully closed.

b) Productivity, wages and diversification

Now the role of the technology gap in shaping the pattern of comparative advantages will be addressed. It is assumed that the technology gap affects the position of the curve A, as in the following equation:

$$(3) \quad \frac{a^*(z)}{a(z)} = A(z) = \alpha - \beta G - bz$$

Where α, β and b are positive parameters and $\alpha > \beta + b$. A reduction in the technology gap shifts the *AA* curve to the right, increasing the relative labor requirements of the North for all goods *z* produced in the international economy. To complete the model it is necessary to make assumptions about how the *WW* curve behaves. The discussion will begin with the simplest assumption, namely that nominal wages are constant and therefore *WW* is horizontal – in other words, the relative nominal wage remains constant as z increases[7]. Constant nominal wages can be justified on the grounds that the labor market in the large North is fairly impervious to changes in competitiveness in the small South, while the abundant supply of labor in the South allows it to boost employment rather than nominal wages when the economy grows[8]. Therefore:

$$(4)\ \frac{w}{w^*} = W = h$$

Where $0 < h \leq \alpha - \beta$. Since in equilibrium A must equal W, it is possible to get the pattern of specialization of (the set of goods produced in) South and North as a function of the technology gap.

$$(5)\ z_c = \frac{\alpha - \beta G - h}{b}$$

If the technology gap is in equilibrium, then using equation (2) in (5) yields:

$$(5\ )\ z_c = \frac{(\alpha - h)(\mu - \rho) - \mu\beta}{(\mu - \rho)b}$$

This equation gives the pattern o specialization as a function of the exogenous parameters of the model. The partial derivative of (5) with respect to μ is unambiguously positive, suggesting that the Southern economy can diversify its economy by heightening its imitative effort. On the other hand, if the rate of innovation in the North suffers an exogenous positive shock, while the South keeps its imitative effort at about the same level as before, then the technology gap and the number of goods produced in the North will be expanded at the expense of employment in the South. After having specified how the technology gap affects specialization, it is necessary to look at how specialization shapes North-South relative income levels. This requires the study of the conditions necessary for international current account equilibrium.

c) Specialization and the external constraint

Equilibrium in the international economy (with no capital flows) requires the current account of the two countries to be balanced. It will be assumed that consumers spend exactly the same percentage of their nominal income in each type of goods z. If the South produces goods for which $0 \leq z \leq z_c$ (and hence the North produce goods for which $z_c < z \leq 1$), then z_c will be the percentage of the nominal income consumers in both North and South spend on goods produced in the South. If the exchange rate is fixed an equal to the unity, then Southern exports will equal the Northern nominal income (y^*) times z_c (Obstfeld and Rogoff, 1996, p.240).

[7] On the other hand, as will be discussed later, despite nominal rigidity, real wages may be increasing as a result of the rise of productivity in both the North and South countries.
[8] Under these assumptions, it is the level of employment in the South that endogenously adjusts so as to completely absorb the impact of changes in international competitiveness.

Symmetrically, Southern imports will equal the Southern nominal income (y) times ($1-z_c$) (the latter being the share of the nominal income of the South that goes to buy Northern goods). Then, for having current account equilibrium it is necessary that $(1- z_c)y = z_c\, y^*$. This allows one to write the equilibrium condition in the international economy as follows:

$$(6)\quad y = \frac{z_c}{1 - z_c} y^*$$

Equation (6) gives the nominal income in the South which is consistent with external equilibrium as a function of the Northern nominal income and the degree o diversification of the Southern economy (the number of goods whose production is located in the South in relation with the total number of goods). This represents a Ricardian version of Thirlwall's Law (McCombie and Thirlwall, 1994, chapter 3), in which the elasticity parameters of the demand functions for exports and imports have been replaced by parameters that reflect the productive diversification of the South. But the message is strictly the same, namely the economy will be constrained by external equilibrium, and if it fails to pass the test of international competitiveness, the result would be either less employment or lower wages. Since z_c depends on the technology gap (equation 5), then equation (6) can be written as:

$$(7)\quad \frac{y}{y^*} = \frac{u(G)}{b - u(G)}$$

where $u(G) = \alpha - \beta G - h$. This equation poses the relative North-South nominal income as a function of the technology gap. The impact of changes in the technology gap on relative nominal incomes can be found by taking the partial derivative of (7) with respect to G:

$$(8)\quad \frac{\partial (y / y^*)}{\partial G} = \frac{-b\beta}{(b - u(G))^2}$$

which is unambiguously negative. It is also clear from equation (6) that nominal incomes will be equal in North and South only in the special case in which the two countries produce exactly the same number of goods, $z_c = ½$.

d) Convergence and Divergence

By differentiating equation (6) with respect to time, it is possible to analyze how the evolution of the North-South relative income level is related to changes in the pattern of specialization:

$$(9)\quad \hat{y} - \hat{y}^* = \frac{\hat{z}_c}{1 - z_c}$$

where hats on variables denote rates of growth ($\hat{y} = \dot{y} / y$). This equation stresses that for convergence to occur the South must be diversifying its economy. Moreover, as changes in specialization respond to changes in the technology gap, income convergence must be related as well to technological convergence. This can be readily seen by differentiating equation (7) with respect to time:

$$(10)\ \frac{y}{y^*}(\hat{y}-\hat{y}^*)=\frac{-b\beta\dot{G}}{(b-u(G))^2}$$

where dots on the variables denote derivates with respect to time (*i.e.* $\dot{G}=\frac{dG}{dt}$). Equation (10) shows that convergence ($\hat{y}-\hat{y}^* > 0$) will occur when the technology gap closes ($\dot{G} < 0$).

So far the discussion has focused on nominal convergence. But this expresses as well the evolution of convergence in real terms, as the assumptions of the model imply that it is valid the Principle of Purchasing Power Parity in its strongest version (the Law of One Price). In effect, nominal wages are constant in both countries and therefore they do not affect prices; consumers spend their nominal income in the same goods, and in exactly the same proportions; perfect competition assures that productivity growth fully translates into lower prices; and the exchange rate is constant. As a result, rates of inflation are exactly the same in the two countries at any moment, and the evolution of the North-South relative income in nominal terms will be the same as the evolution of relative income in real terms:

(11) $\hat{y}_R-\hat{y}^*_R=\hat{y}-\hat{y}^*+(\hat{p}^*-\hat{p})$, and for $\hat{p}=\hat{p}^*$, then

$$(12)\ \hat{y}_R-\hat{y}^*_R=\hat{y}-\hat{y}^*=\frac{\hat{z}_c}{1-z_c}$$

where the subscript *R* indicates that the variable is expressed in real terms. An example helps to illustrate how the adjustment after a shock in one of the exogenous parameter (see Annex 1).

e) Flexible Relative Nominal Wage

So far it was supposed that nominal wages were constant and that changes in nominal income reflected changes in the level of employment in the South. Now it will be assumed that there is full employment in both economies and the relative nominal wage adjusts to respond to changes in international competitiveness. Since labor is the only factor of production, whose amount is constant, it is true that $y = wL$ and $y^* = w^*L^*$. Therefore, the current account equilibrium condition defined by equation (6) can be written as follows:

$$(13)\ wL=\frac{z_c}{1-z_c}w^*L^*$$

The value of z_c as a function of *G* can be found using equations (3) and (13) and the equilibrium condition $A=W=\frac{w}{w^*}$ (given *L* and *L**):

$$(14)\ z_c = \frac{f(G) - \sqrt{[f(G)]^2 - 4b(\alpha - \beta G)}}{2b}$$

Where $f(G) = \alpha - \beta G + b + c > 0$, and $c = (L^*/L)$. Although equation (14) looks a bit more complicated than equation (5), it does not affect the basic results already discussed in the preceding section. In particular, relative income levels continue to be described by equations (6) and (7), while the rate of nominal and real convergence are described by equations (9) and (10). The only difference is that convergence in this case is related to changes in the relative nominal wage (while employment remains constant), which endogenously respond to the diversification of the Southern economy. Therefore:

$$(15)\ \hat{y} - \hat{y}^* = \hat{w} - \hat{w}^* = \frac{\hat{z}_c}{1 - z_c}$$

If one makes the additional assumption that the North is big enough so as to be unaffected by structural change in the South, then nominal wages in the North will remain constant and the effects of the new technology policy will be fully translated into an increase of nominal wages in the South. In this case, the mechanism of convergence will be a reduction in the gap between real wages in North and South. The Ricardian model gives rise to two testable predictions. These predictions stem from equations (6), (7), (9) and (10) and can be summarized as follows:

a) *GDP per capita growth will be positively related to technological capabilities, represented in the model by the parameter μ*;

b) *GDP per capita growth will be positively associated with the diversification of the export structure towards technology-intensive sectors*.

f) Empirical Evidence

The empirical evidence is based in econometric estimations for two different panel data models: i) a two-year panel data (using the years 1990 and 2000) and ii) a 14-year panel data (including data for the whole period 1990-2003). The two-year panel data design aims at assessing the role played by the National System of Innovation in economic growth. The 14-year panel data tests the role played by the pattern of specialization.

The ArCo index, suggested by Archibugi and Coco (2004), is used as a proxy for the parameters of technological learning. This Index is based on three indicators related to three dimensions of the NSI: (*Ia*) the creation of technology; (*Ib*) the technology infrastructure and (*Ic*) the development of human skills. ArCo is defined as a linear combination of these three indicators[9]. The ArCo Index is a broad indicator of technological efforts that seems more adequate for developing countries than the traditional proxies, patents per capita and R&D investments as a percentage of the GDP. In these countries the largest part of technological learning takes the form of minor innovations and improvements on foreign technology which cannot be patented. In addition, they are based on the so-called informal activities of R&D which are not recorded in the statistics of R&D activities (Katz, 2000). Thus, assessing the capacity to learn in developing countries cannot rely exclusively on variables that measure formal technological outputs and inputs. As mentioned, the ArCo index is available only for two years, 1990 and 2000.

The second panel data (14-year series) addresses the role of international specialization. As proxies for the degree of export diversification are used three variables: the terms of trade, the participation of agricultural raw materials[10] in total exports and the participation of high-technology exports[11] in total exports. The terms of trade equal the capacity to import minus the export of goods and services in constant prices. The first econometric tests performed are based on the following equation:

$$(17)\ \hat{y}_{it} = \alpha_i + \beta_i ArCo_{it} + \varepsilon_{it}$$

Where $\hat{y}_{it}$ is the rate of growth of GDP per capita of country *i* at *t* and ArCo is the indicator of technological capabilities calculated by Archibugi and Coco (2004)[12]. The results in Table 1 show random and fixed effects econometric estimations. Estimated parameters suggest that the Schumpeterian approach to Ricardian model is consistent with empirical evidence. In all cases the coefficient of the technological learning index is positive and significant. As stressed by the Schumpeterian literature, catching-up in the international economy in terms of both technology and real incomes is a function of what has been broadly defined as the national system of innovation or social capabilities.

The Balance-of-Payments constrained approach in turn suggests that technological learning affects growth largely by allowing for the diversification of the export structure of the country towards more dynamic sectors. In other words, the demand-side of the growth

[9] The variable (*Ia*) includes number of patents per capita obtained in the United States and per capita number of scientific papers published by the residents of the country; (*Ib*) is a combination of three variables that seek to capture the development of the technological infrastructure: internet penetration, telephone penetration and electricity consumption; and (*Ic*) is a proxy for investment in human capital, including mean years of schooling, tertiary science and engineering enrolment, and the literacy rate.
[10] Agricultural raw materials comprise section 2 (crude materials except fuels) excluding divisions 22, 27 and 28 (crude fertilizers and minerals excluding coal, petroleum, and precious stones and metal ores and scrap) of the Standard International Trade Classification (SITC).
[11] The high-technology exports comprise exports from sectors that are intensive en R&D, namely aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.
[12] The rate of growth of GDP per capita is calculated on the basis of constant local currencies converted into U.S. dollars from the World Bank (2005). GDP per capita is defined by gross domestic product divided by midyear population.

equation must not be neglected. To test this hypothesis, we estimated the following econometric model:

$$(18)\ \hat{y}_{it} = \alpha_i + \beta_i PS_{it} + \varepsilon_{it}$$

Where *PS* is a vector of three variables: terms of trade, participation of agricultural exports in total exports and participation of high-technology exports in total exports are used as proxies for the dynamism of the pattern of specialization (see Table 2)[13]. It is assumed that high-tech exports represent dynamic items in international trade, while agricultural exports tend to generate less technological externalities and also face a lower income elasticity of demand. Table 2 shows the estimation. They are, indeed, consistent with the hypothesis that specialization matters for growth. All coefficients are significant and have the expected signs.

Table 1. Economic Growth and Technological Capabilities

Variables / Estimation	Pooled Regression OLS	Fixed Effect	Random Effect	Fixed Effect with time dummies
Constant				
Technological Learning	5.44**	3.46**	4.73**	4.36**
(Arco)	(0.35)	(0.37)	(0.25)	(0.61)
R2	0.71	0.57	0.63	0.58
Observations	174	174	174	174

Notes: ** significant at 5%

Table 2. Economic Growth and Specialization

Variables / Estimation	Fixed Effect *(1)*	Fixed Effect *(2)*	Random Effect *(3)*	Random Effect *(4)*
Term of Trade	0.017***	0.017	0.009	0.010
	(0.014)	(0.027)	(0.027)	(0.029)
Agricultural Exports	-0.011	-0.10	-0.11**	-0.12**
	(0.09)	(0.08)	(0.04)	(0.03)
High Tech Exports	0.037**	0.038	0.034**	0.033**
	(0.012)	(0.019)	(0.011)	(0.010)
R2	0.12	0.24	0.13	0.16
Obs.	770	770	770	770

Notes: ** significant at 5%; ** * significant at 10 %.
(2) Estimation with time dummies. (4) Estimation with regional dummies.

With these econometric estimations we found empirical evidence for the Ricardian model discussed previously. However, future research with more data availability is necessary to robustness checks[14].

[13] Databases were obtained from UN COMTRADE Database and World Bank (2005).
[14] The authors are currently working on assembling new data and variables availability for a new estimation round.

III. Structural change and Technology in Latin America

This section compares the evidence on technological and structural change in Latin American with respect to a subset of countries in the last 30 years. The main purpose is to probe the arguments presented in the first section with more detailed data on the economic structure and the dynamism of exports. The following variables are considered: i) Structural change, ii) R&D expenditures, iii) Relative labor productivity in the manufacturing industry; iii) Accumulated number of per capita patents registered in the US patent office, iv) Changes in the international pattern of specialization (Adaptability Index); and v) Economic growth (for details and definitions, see Annex 2).

The sample is composed by 17 countries of which seven are from Latin America, representing more than 90% of the regional economy. The United States are taken as a benchmark with which the evolution of productivity and of the economic structure is compared. Table 3 present the correlation matrix between the following variables: GDP growth, the intensity of structural change, relative labor productivity with respect the technological frontier, R&D expenditure relative to the GDP, per capita number of patents in the USPO and changes in the Adaptability Index.

Table 3. Matrix of Variable Correlations

Variables	Structural Change[a]	Productivity Gap[a]	R&D	Patents	Adaptability Index[a]	GDP Growth
Structural Change[a]	1	0.63	0.52	0.36	0.63	0.70
Productivity[a] Gap		1	0.44	0.26	0.53	0.31
R&D			1	0.89	0.07	0.27
Patents				1	0.09	0.18
Adaptability Index[a]					1	0.46
GDP Growth						1

Source: Own elaboration based on Annex 2.
[d] Variation rates.

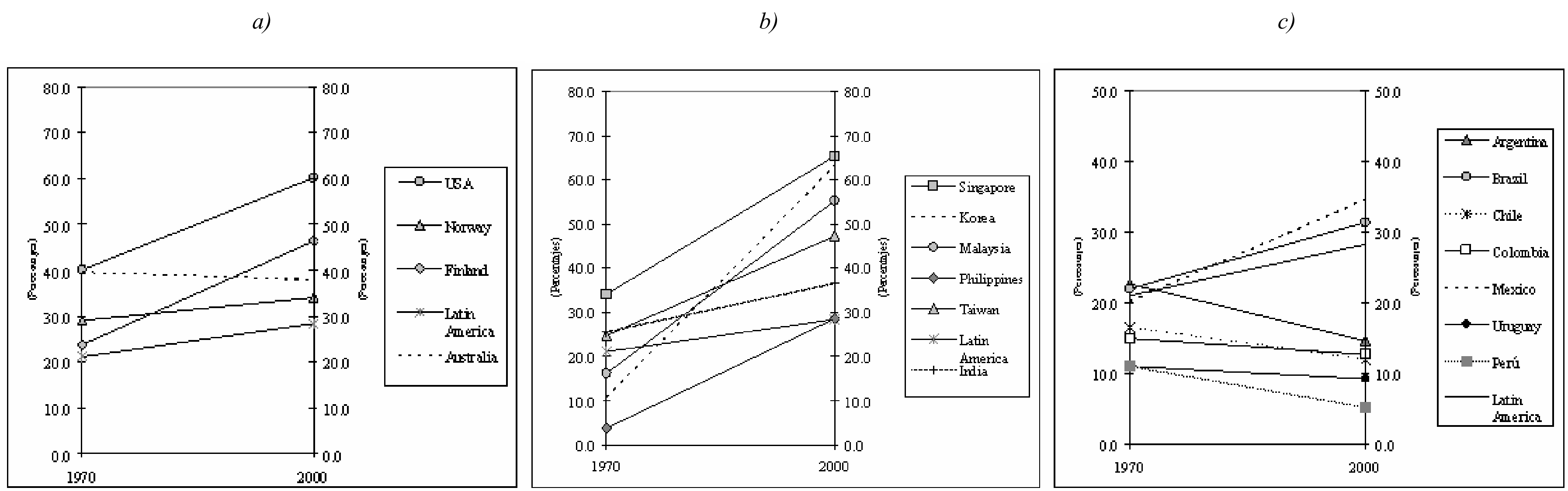
A first clear result indicate that the intensity of structural change, measured according to the participation of R&D intensive sectors in the total industrial added value, is highly correlated with the growth rate of GDP. At the same time, the intensity of the structural change is also closely correlated with the R&D expenditure relative to GDP and the Adaptability Index. Thus, the economies that increased the share of the R&D intensive sector and invested more in technology were those that grew more. Moreover, the high correlation between R&D and the other variables confirm that the number of patents granted is not the best indicator of the technological effort. In the case of developing countries a larger part of that effort is oriented to incremental and adaptive innovations, and not toward new products or processes that can be patented.

It is important to note that the correlation coefficients between the technological variables and economic growth are not as high as the correlation coefficient between growth and the economic structure. This suggests that the effects of the technological variables on growth are mediated by structural change. In other words, technological efforts can affect growth mainly when they are anchored in the productive system.

Sectors are divided in three different categories: natural resources intensive, labor intensive and R&D intensive (see Annex 2). When we look at the countries in the sample reported in Annex 2, it can be observed that the United States, Finland, Korea, Malaysia, Singapore and Taiwan were those in which there was a higher increase in the weight of R&D intensive sectors in the industry. On the other hand, in Latin America the importance of natural resources intensive sectors was slightly reinforced. The decrease in the participation of the labor intensive sectors in the industrial total added value is a common characteristic of all countries, with the only exceptions of Philippines and Peru.

Figure 2 presents the participation of R&D intensive sectors in the industry between 1970 and 2000. Figure 2a compares Latin America with US, Norway, Finland and Australia. The weight of R&D intensive sectors increased in the mature economies, like the US and Finland, from 40% to 60% and from 23.8% to 46.4%, respectively. On the other hand, the intensity of structural change was not significant in Latin America. In this region, in the lapse of 30 years, the participation of the RDI sectors increased from 21.1% to 28.3%. A similar pattern is observed in Norway, where the weight of the R&D sectors increase only from 29.1% to 34.1%. In both cases natural resource intensive sectors play a leading role on their production systems. From figure 2b it can be observed that the participation of R&D sectors is much higher in Korea, Singapore and Malaysia, where they represent the 63%, 65.4% and 55.3%, respectively. When one focuses the analysis in Latin America, the trajectories of each country show differences. In figure 2c it is possible to appreciate that the relevance of the R&D sectors in Argentina, Colombia, Peru and Uruguay has decreased, whereas in Brazil and Mexico has increased.

Figure 2. Participation of R&D intensive sectors by regions and countries, 1970 and 2000
(Percentages)



Source: Own elaboration based on Annex 2.

In Figures 3 structural change is observed from a different angle[13]. In the Y-axis it is represented the accumulated sector share of the Natural resource intensive, Labor intensive and R&D intensive sectors at two different moments (1970 and 2000).[14] In the X-axis are represented the values corresponding to labor productivity in each sector. The move of the curve towards the right expresses productivity changes in each of the sectors considered.

Figure 3a) compares Latin America with the US. It is observed here that productivity jump reached by US industry was much greater than that obtained in Latin America for all the sectors. Nevertheless, the differences are not limited to productivity, but they also concern the composition of the productive system and the intensity of the structural change. In US the R&D intensive sectors represent 60% of the industrial value and show higher productivity in comparison with the other sectors. The same does not occur in Latin America, where sectors with higher productivity, and those that contribute most to the generation of total manufacturing value added, are those intensive in natural resources. Although in some countries in the region there was an increasing participation of R&D sectors, this is clearly less marked than the one that occurred in US and in the Asian countries that converged.

The simultaneous increase of R&D sectors in the industry and of productivity levels is the source of the virtuous process that generates and diffuses knowledge. Firms and sectors interact absorbing products and improving their production processes with greater technological content (Dalum, Laursen and Verspagen, 1999). This perception is endorsed in many other works. Abramovitz and David (2001), for example, explain variations in the growth pattern of the United States between 1800 and 1900 as a result of the modification in the source of labor productivity growth, which reduced the importance of the physical capital and tangible goods[15]. The United States left the pattern intensive in natural resources to adopt a pattern based on the creation of knowledge and the diffusion of intangible capital, driven by the accumulation of technological and organizational capabilities.

The relevance of the sector specialization also finds empirical support in the cases of Korea, Singapore, Taiwan and Hong Kong (Nelson and Pack, 1999). These authors demonstrate that higher growth rates in these countries derived from a substantial modification of their production structure, increasing the participation of RDI sectors and leading to a greater capacity to diffuse knowledge toward the rest of the economy.

[13] Recent studies on the region reach similar conclusions when productivity is measured both as labor productivity and as total productivity of the factors (Stalling and Peres, 2000)

[14] Naturally, these quotas should sum 100 along the curve, while the relative participation of each sector is obtained by difference.

[15] Abramovitz interprets economic growth in the United States of America throughout the last two centuries as the product of interaction of two key elements: i) what the author calls "global determining dynamics" terms that is referred to the process, of a transnational character, of development and diffusion of knowledge, and ii) the specific characteristic of the national and regional context of the United States, characterized by a dynamic and flexible social organization.

Figures 3b) and 3c) compare structural change in Korea with the cases of Brazil and Mexico, respectively. Both countries present a modest performance compared to Korea. Nevertheless, it has to be noted that the trajectories of Brazil and Mexico imply different strategies. In Brazil, the size of the market and the active policies of the seventies supported the development of the RDI sectors (Ferraz, Kupfer and Iootty, 2004), whereas in Mexico foreign direct investments (FDI) and the integration to global productive systems were the dominant strategies (Capdevielle, 2005; Mortimore and Vergara, 2003).

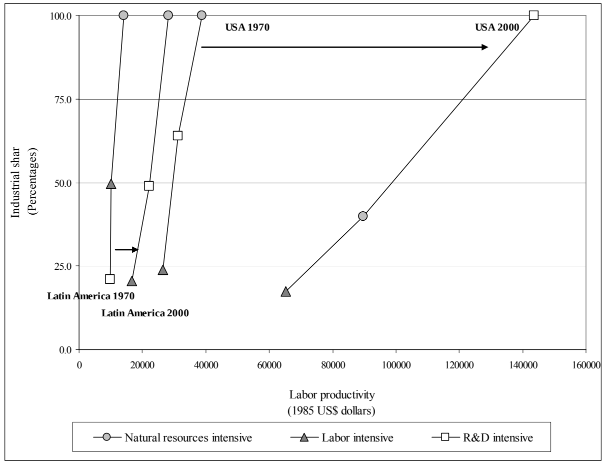
From the sixties, the strategy of Korea –the first plan of industrial development goes back to 1962- was oriented to the creation and accumulation of technical capabilities. Korean structural change resulted from a deliberate strategy to direct industrialization towards sectors that had been identified by the government as having a higher potential for growth and learning. Industrial and commercial policies in the country were aimed at creating relative advantages in sectors that benefited from a highly dynamic world demand. Figures 3b) and 3c) show the significant transformation of Korea regarding the sector composition of production and exports, and the gains in productivity it achieved between 1970 and 2000.[16]

Figure 3d) present the cases of Chile and Finland. At the beginning of the seventies in both countries the NRI sectors dominated the production system, representing 61.7% in Chile and 52% in Finland. In the three following decades Finland experienced a radical upgrading of its structure by increasing the participation of the R&D intensive sectors. In effect, they represented 23.8 % of total industrial added value in 1970 and 46.4 % in 2000, while still maintaining a significant weight of the Natural resources intensive sectors (40.4 % in the 2000). Conversely, in Chile the pattern of specialization in natural resources was reinforced, the Natural resource intensive archive the 67.5 % in 2000, while the R&D intensive generated 12 % of the value added in the same year. It is not less significant the persistence of the asymmetry in productivity levels.

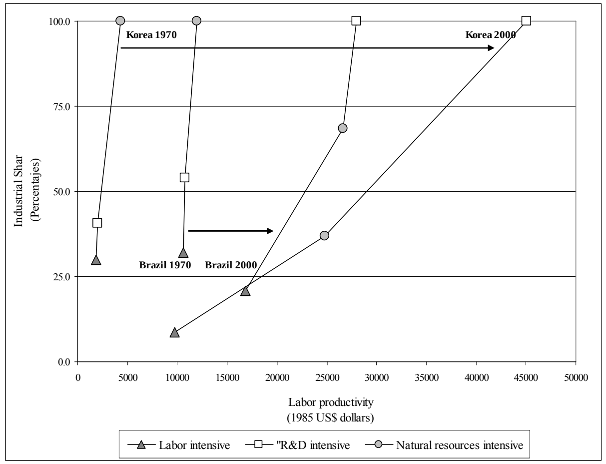
[16] Some authors have discussed the relative importance of capital accumulation (see, for instance, Krugman, 1994) and technical change (Nelson and Pack, 1999) as the main determinant of the impressive increase in production in South East Asia.

Figure 3. Structural Change and Productivity, 1970-2000
(Percentages and dollars)

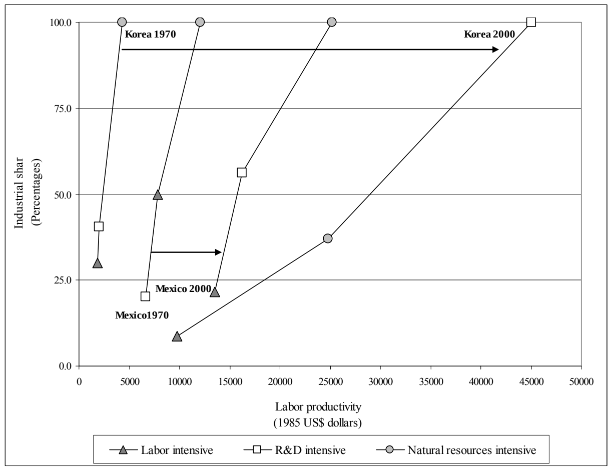
a) Latin America and US



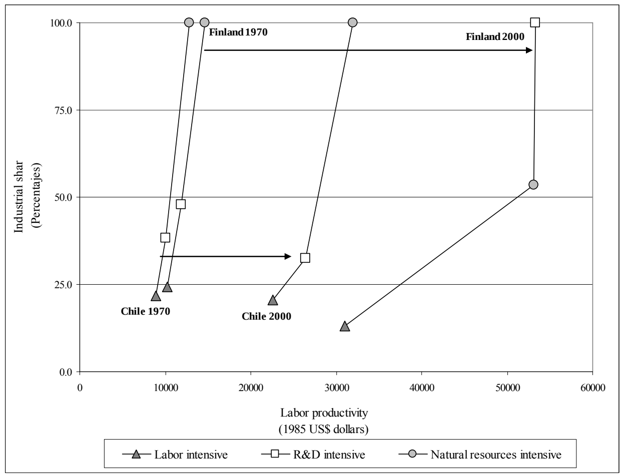
b) Brazil and Korea



c) Mexico and Korea



d) Chile and Finland



Source: Own elaboration based on *Programa de Análisis de Dinámica Industrial* (PADI), ECLAC.

Figure also 4 shows that most Latin American countries are concentrated in the south-western quadrant, characterized by a low participation of R%D intensive sectors and by a reduced R&D expenditure (around 0.5% of the GDP). In sum, it can be concluded that countries that have experienced structural change show, simultaneously, higher R&D expenditures and increasing patent activity, as it is the case of Finland and the countries of Southeast Asia. In the cases of Korea, as mentioned previously, and Finland, structural change stemmed from the application of a set of long term policies directed to the accumulation of technological capabilities. Policy makers in Korea have anticipated and chosen those industries that faced a dynamic world demand, fomenting a selective distortion of prices. In the case of Finland subsidies to high technology sectors were introduced in order to foment structural change. In both cases what it was put into practice was a selective intervention of the State that oriented the industrial structure in favor of higher of the R&D intensive sectors (Kim, 1993; Ormala, 2001).

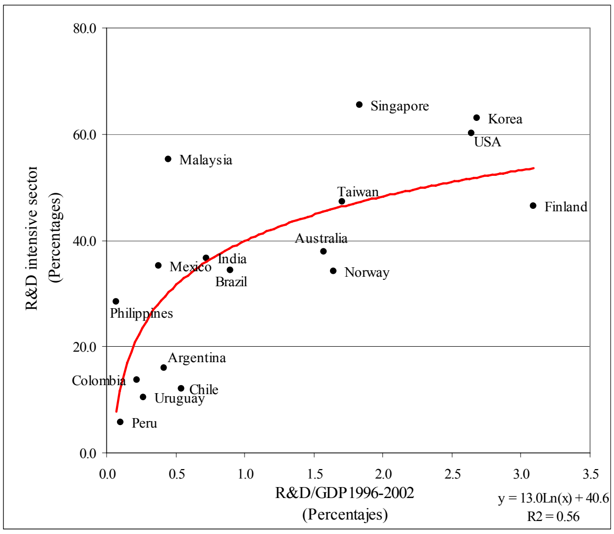
IV. Reinforcement of International Specialization

This section analyses the effect of structural change on specialization and growth. In general, the region has specialized according to two different patterns. The trend of these aggregate variables reflect the reinforcement of a specialization pattern that in fact remains oriented to products whose comparative advantage is based on natural resources and low wages. Orthodox authors have a priori argued that trade liberalization and market de-regulation would automatically induce a shift in the Latin American production structure. In fact, within this overall picture, one can observe that most Latin American economies have followed the expected path, changing their specialization on the basis of their factors endowments: natural resources and labor. Geographically, two separate patterns appear to have emerged for the Mexican Gulf and the Southern Cone. Southern Cone countries (such as Argentina, Brazil, Chile and Uruguay) have intensified their specialization towards natural resources and standardized commodities. These are now highly capital-intensive industries with low domestic value added. Firms producing for local markets -the labor intensive and the engineering intensive– have suffered the most, as a result of trade liberalization and market de-regulation efforts. Conversely, countries such as Mexico and the Central American nations have greatly integrated in global chains their manufacturing and assembly activities based on cheap labor. The emerging specialization pattern has impacted the capacity of achieving the equilibrium of current account (ECLAC, 2002; Cimoli and Correa, 2005; Mortimore and Peres, 2001; Reinhardt and Peres, 2000).

Changes in the dynamism of international specialization can be described by the evolution of the Adaptability Index (see Annex 2). When this index is greater than one, it means that the participation of dynamic products (in the international demand) in exports exceed the participation of the non dynamic ones. Here, it is assumed that a virtuous specialization requires an increase in the adaptability through time.

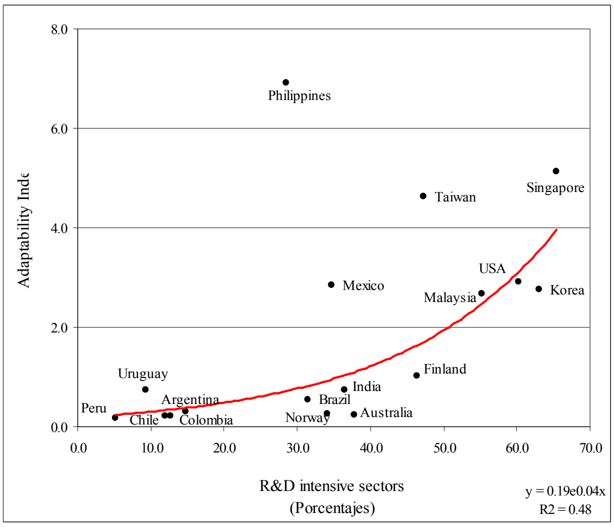
Figure 5 shows the relation between the participation of R&D intensive sectors and the Adaptability Index. It can be observed that the countries specialized in high technology show a higher Adaptability Index value (Southeast Asia and the US), whereas those specialized in the segments of medium and low technologies are characterized by a smaller value of this index (Latin America, excluded Mexico). Although the positive tendency of this curve is an interesting result in itself, it is also worthwhile discussing how countries are positioned. In particularly, it is interesting to compare the cases of Mexico and the Philippines with those of Korea and Malaysia.

Figure 4. R&D Intensive Sectors and R&D
(Percentages)



Source: Own elaboration based on Annex 2.

Figure 5. R&D Intensive Sectors and Adaptability Index
(Percentages)



Source: Own elaboration based on Annex 2.

Mexico, Malaysia and Korea show similar adaptability, but with different participation of the R&D intensive sectors. This share is more elevated in Korea and Malaysia than in Mexico. These differences are explained because in Mexico adaptability derived mainly from exports originated from assembly activities highly integrated in the global production chain, with low R&D expenditures and scarce generation of spillovers. Capdevielle (2005) indicates that in Mexico the *Maquila* industry has not increased its productivity and has not displayed strong linkages with the rest of the economy. In that sense, the more integrated activities with exports shows less technologically dynamism.[17] Conversely, in Korea and Malaysia the most dynamic exporting sectors have at the same time greater weight in the industrial structure, which reveals a higher degree of integration. Note that some countries that show low adaptability have high R&D expenditures relative to the GDP, as in the case of Australia and Norway. The low adaptability of those countries suggests that R&D expenditures reinforce the external insertion in Natural resource sectors, instead of promoting the transformation of the specialization pattern. At the figure 5, Philippines stand out as a singular case and reach a high degree of adaptability with a reduced participation of R&D sectors (28,5%). Similarly to the Mexican case, FDI and assembly activities explain the increase of R&D sectors and the integration to the global production chains.

To synthesize the empirical evidences presented and capture the relation between structural change, specialization and technological dynamics, a typology is presented of the country insertion in the global economy (see Table 4). Four quadrants are defined on the basis of the sector that predominates in the industrial structure (Natural resources or R&D intensive) and R&D expenditures relative to the GDP.

Table 4. Growth Based on Factors Endowment or Technological Capabilities: A Typology

	Natural resources intensive sectors [a]	**R&D intensive sectors** [b]
High R&D	Australia Norway	Korea, Taiwan, United States, Finland, Singapore
Low I+D	Argentina, Brazil, Chile, Colombia, México, Peru, Uruguay, Philippines, India	Malaysia

Source: own elaboration.
[a] The main industrial sectors in these countries are natural resources intensive, see Annex 2.
[b] The main industrial sectors in these countries are R&D intensive, see Annex 2.

Growth and productive specialization can be based on two types of strategy. The first one seeks to take advantage of the economic rents conferred by a privileged access to abundant factors of production, namely cheap labor or a favorable natural resources endowment. Countries that follow this strategy will tend to concentrate their efforts in maintaining or extending their participation in RNI sectors. In some cases, especially when

[17] Ciarli and Giuliani (2005) reach to similar conclusion for the case of Costa Rica. The exports have been diversified toward the sectors electronics components and medical instrument, on the base of foreign direct investment, but this has generated few technological and productive linkages with other companies.

natural resources are abundant but labor is scarce, important technological efforts can be made leading to high levels of labor productivity. Some productive linkages can arise spontaneously, but if those countries do not encourage structural changes more actively their specialization pattern will not create incentives to incorporate more sophisticated technological activities.

The second strategy identified looks after economic rents in knowledge activities, which must be continuously recreated as new paradigms arise and/or imitators gradually erode the dominant position reached by the innovator. Dynamic advantages predominate as described by Schumpeter. Although the initial advantage can be based on some abundant factor, the strategy of these countries is to promote aggressively structural changes in their production system (high participation of the R&D sectors).

The analysis above suggests that a strategy based on a higher participation of R&D intensive sectors is able to generate higher rates of growth than the strategy that seeks for rents provided by the relative resource abundance. However, if a country benefit from their natural resource, this does not necessarily lead to the *dutch disease*. For that reason it is assumed that societies face options and can choose a growth trajectory among others. This election is more important in the long term that the initial endowment. Abundance of recourses can give rise to a high per capita income during a certain period, but in the long term the rents derived from these resources can be eroded. Growth it is only maintained if backward and forward linkages are created, as it was anticipated by “staples theory” and the Hirshmanian forward and backward linkages (Hirschman, 1977).

V. Conclusions

The paper discusses the conditions for international convergence in a North-South Ricardian growth model in which the pattern of specialization depends on the technology gap. It is argued that convergence requires strong local efforts at technological learning in the South (a strengthening of the National System of Innovation) with a view to reducing the technology gap and diversifying the export structure towards more dynamic sectors in terms of technology and demand growth. This is formalized by assuming that comparative advantages are a function of the initial technology gap and the relative efforts at innovation in the North, and catching-up in the South. The results are consistent with the Schumpeterian hypothesis linking growth to technological capabilities. In addition, it is also consistent with the Keynesian (demand based) perspective that growth requires the transformation of the pattern of specialization with a view to easing the Balance-of-Payments constraint.

Technological learning reshapes international competitiveness and allows the country to exploit the opportunities opened by growth. Moreover, these technological efforts are mediated by the transformation of the production structure. A structural change that promotes sectors that create and diffuse technology can capture the opportunities emerging from the dynamics of international demand. Growth convergence requires that the economies are able to transform their productive structure, and look for rents generated by knowledge and learning activities. In that transformation, R&D intensive sectors must reach an increasing weight in the industry being a source of externalities and spillovers.

The existence of abundant natural resources or cheap labor can maintain high rates of growth during a certain period, without being necessary a great effort in R&D. However, changes in the international economy and in patterns of demand may put in evidence the vulnerability of this strategy, which is unable to capture the opportunities offered by technological progress in the long term. On the other hand, as a result of its cumulative nature, rents derived from knowledge can be recreated and redefine the conditions for entering in new markets. When the source of economic rents is the relative abundance of resources, it is more difficult to respond to a negative shock since the technological capabilities necessary to readapt the production system to the new context are lacking.

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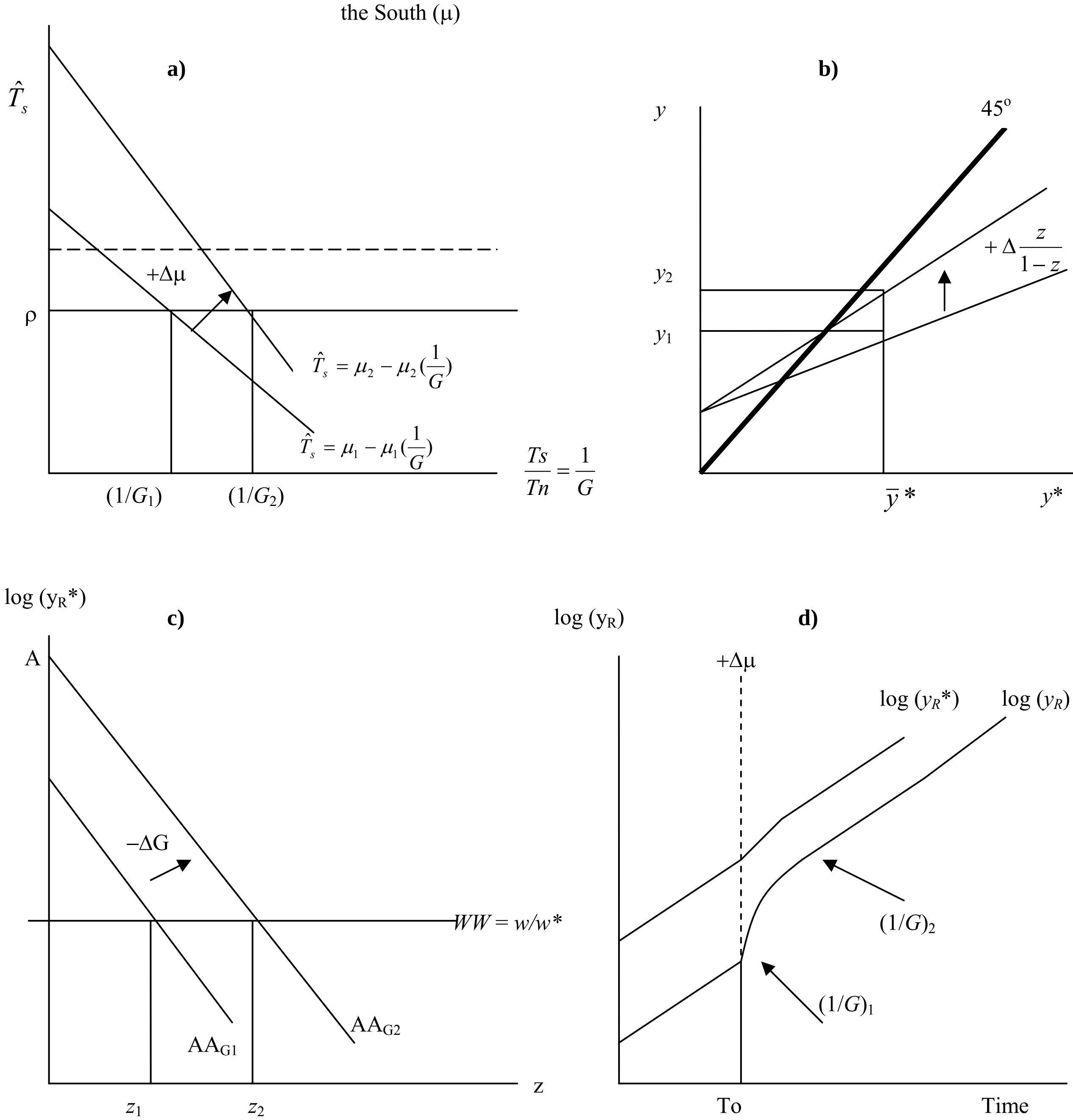
Annex 1. Effects of an Increase in the Technological Learning Effort in the South

Figures A1 show the co-evolution of the technology gap, the pattern of specialization and growth in real terms after a positive shock on the rate of technological learning in the South, given, for instance, by a change in policies that increases Southern technological efforts (from μ_1 to μ_2). The policy-induced rise in μ shifts the $\hat{T}s$ curve to the right, thereby starting a gradual process of reduction of the technology gap as it moves towards its new (lower) equilibrium level. In Figure a) this is represented by an increase in the inverse of the equilibrium technology gap ($1/G$), from ($1/G_1$) to ($1/G_2$), where $G_2 < G_1$. As the technology gap falls, the pattern of specialization changes and new activities are taken over by the South: this is represented by an increase in the borderline good z, from z_1 to z_2 (that correspond, respectively, to the equilibrium levels of the technology gap G_1 and G_2). The new equilibrium level of z implies that nominal income in the South will be higher for any nominal income in the North, without compromising external equilibrium. For simplicity, in Figure c) the nominal income in the North is assumed to exogenously given at $\bar{y}*$. As the North is a big country whose levels of employment and nominal wages are little affected by changes in Southern exports, this simplification does not compromise the validity of the exercise. Given $y*$, it is easy to pinpoint the equilibrium nominal income in the South using equation (6). The 45^o line gives the set of points for the special case in which zc = ½ and nominal incomes in North and South will be exactly the same (perfect convergence).

Figure d) looks at the dynamics of convergence. It plots the natural logarithm of real incomes in North and South against time and traces the impact on growth of the change of policy in the South in favor of faster technological learning. Initially, the technology gap is in equilibrium at G_1 and both countries grow in real terms at the same rate as the exogenous rate of technological progress in the North. Thus, ρ is the angular coefficient of the parallel straight lines that represent the logarithm of real income in North and South plotted against time. At the moment T_0, μ jumps from μ_1 to μ_2. As the South begins to diversify its production structure ($\hat{z} > 0$), employment grows in the South ($\hat{L} = \frac{\hat{z}}{1-z}$), giving rise to a higher nominal income, thereby reducing the distance with respect to nominal income in the North. Real income in the South moves upwards as well, reflecting both the increase in nominal income due to the expansion of employment and the fall in the price levels (related to the acceleration of productivity growth in the South). This increase in real income in the South is higher than in the North, since the latter only benefits from the fall in the inflation rate (the difference, which represents the convergence rate, being precisely the growth of employment in the South). Thus, the new policy in the South brings about a process of convergence in terms of both technology and income levels ($\dot{G} < 0$ and $\hat{y}_R - \hat{y}_R* > 0$). After some time the effect of the shock is absorbed, the technology gap and the pattern of specialization stabilize again, and both countries are back to their previous growth path (in which they grow at the same exogenous rate given by technical progress in the North).

Figure A1. Convergence Effects of an Increase in the Technological Learning Effort in the South (μ)



Note:
Figure a) describes the impact of an increase in □ (+□□) on the equilibrium technology gap. Figure b) depicts how the fall in the technology gap (-□*G*) affects the pattern of specialization, leading to the diversification of the economy (from z_1 to z_2). This in turn eases the current account constraint, as represented in Figure c). Figure d) shows the evolution through time of real income in North and South. It can be seen that the reduction in the technology gap produces a period of convergence leading to a smaller income per capita difference between North and South in equilibrium.

Annex 2. Development Patterns

Countries	INDUSTRIAL STRUCTURE				TRADE					TECHNOLOGY		GROWTH			
	1.- Structural Change			2.- Productivity Gap	3.- Export Specialization			4.- Adaptability Index		5.- R&D (%GDP)	6.- Patents	7.- GDP Growth (per cápita)			
	Sectors	1970	2000	1970-2000	Categories	1985	2002	1985	2002	1996-2002	Acum.1977-2003 (mill/inhab.)	1970-1980	1981-1990	1991-2003	1970-2003
Latin America[a]	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	50.3 28.6 21.1	51.0 20.6 28.3	-1.7	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	73.3 7.9 12.2 4.3 2.3	43.6 13.9 25.1 14.4 3.0	0.22	0.98	0.37	5,425 (13.4)	6.0 (2.5)	1.2 (-0.9)	3.5 (1.4)	3.66 (1.36)
Argentina	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	54.8 22.6 22.7	69.9 15.4 14.7	-0.4	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	77.7 10.9 8.0 2.7 0.7	71.8 8.6 16.3 2.1 1.2	0.16	0.30	0.42	1,072 (29.8)	3.04 (1.42)	-1.38 (-2.75)	3.10 (2.08)	1.76 (0.44)
Brazil	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	46.0 32.0 22.0	47.7 20.8 31.4	-1.5	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	61.3 13.4 21.3 3.2 0.8	53.2 11.6 23.1 10.0 2.1	0.23	0.55	0.90	1,599 (9.1)	8.53 (5.98)	1.65 (-0.33)	2.32 (0.93)	4.13 (2.20)
Chile	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	61.7 21.8 16.6	67.5 20.5 12.0	-1.4	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	92.2 1.4 2.9 0.4 3.1	88.5 2.8 6.1 0.7 1.9	0.05	0.22	0.54	214 (14.3)	2.99 (1.33)	3.95 (2.28)	5.68 (4.18)	4.30 (2.70)
Colombia	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	51.0 34.0 15.0	59.7 27.6 12.7	-1.2	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	88.9 4.3 4.3 0.5 2.0	66.2 12.0 14.5 2.72 4.5	0.11	0.22	0.22	208 (4.7)	5.66 (3.21)	3.60 (1.48)	2.51 (0.62)	3.85 (1.71)
Mexico	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	50.0 29.8 20.2	43.7 21.6 34.7	-1.6	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	56.6 6.6 22.9 10.9 3.0	17.3 14.3 38.5 26.0 3.9	0.46	2.85	0.38	2,166 (21.2)	6.69 (3.62)	1.88 (-0.22)	2.85 (1.23)	3.81 (1.58)
Peru	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	57.5 31.4 11.1	60.7 34.0 5.2	-4.7[b]	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	86.5 7.10 3.9 0.5 2.0	79.4 14.6 2.6 0.5 2.9	0.4	0.18	0.10	114 (4.2)	3.86 (1.06)	-0.48 (-2.64)	3.78 (1.96)	2.55 (0.32)
Uruguay	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	56.7 32.3 11.0	69.6 21.1 9.3	-1.4	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	41.3 22.3 5.1 0.6 30.7[g]	59.9 24.1 9.4 3.6 3.0	0.43	0.75	0.27	52 (15.8)	2.99 (2.58)	0.15 (-0.48)	1.46 (0.79)	1.57 (1.01)
Australia	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	37.9[c] 22.5[c] 39.6[c]	40.5 21.7 37.8	-1.8[c]	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	83.5 3.2 6.1 3.0 4.2	73.9 5.1 9.8 5.4 5.8	0.10	0.25	1.57	14,725 (775.0)	3.17 (1.49)	3.06 (1.53)	3.54 (2.34)	3.28 (1.82)

Korea	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	59.3 29.9 10.7	28.5 8.6 63.0	4.0	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	12.8 47.0 24.2 14.7 1.3	12.7 15.3 32.1 38.0 1.9	1.11	2.76	2.68	29,437 (626.3)	7.40 (5.47)	8.74 (7.48)	5.83 (4.92)	7.19 (5.85)
US	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	36.0 23.9 40.1	22.4 17.4 60.2	.	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	29.8 6.5 34.5 25.0 4.2	19.7 10.8 34.9 30.6 4.0	1.40	2.92	2.64	2,132,548 (7,353.6)	3.01 (1.94)	3.27 (2.30)	3.00 (1.79)	3.08 (1.99)
Philippines	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	84.5 11.6 3.9	59.8[d] 11.6[d] 28.5[d]	2.9[d]	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	51.4 18.5 6.5 21.5 2.1	10.4 11.4 7.8 68.6 1.8	0.76	6.92	0.07	240 (2.96)	5.73 (2.87)	1.80 (-0.61)	3.28 (1.01)	3.64 (1.14)
Finland	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	52.0 24.2 23.8	40.4 13.2 46.4	0.5	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	57.5 14.4 20.7 6.3 1.1	39.5 8.5 20.2 29.4 2.4	0.36	1.03	3.09	10,008 (2,001.6)	4.05 (3.74)	3.06 (2.62)	1.91 (1.56)	2.94 (2.58)
India	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	39.2 35.2 25.6	40.0 23.5 36.5	-0.2	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	58.2 34.5 4.4 1.9 1.0	42.6 38.9 11.4 5.7 1.4	0.34	0.73	0.72	1,669 (1.7)	3.27 (0.94)	5.81 (3.59)	5.61 (3.80)	4.91 (2.81)
Malaysia	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	51.0 13.9 16.1	35.2 9.4 55.3	-2.2	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	67.6 6.4 7.4 17.3 8.7	18.2 8.6 13.8 58.0 15.2	0.34	2.68	0.45	356 (14.8)	7.70 (5.16)	6.03 (3.11)	6.32 (3.82)	6.68 (4.04)
Norway	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	47.8 23.1 29.1	49.8 16.1 34.1	-2.5	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	74.1 4.9 16.0 3.7 1.3	78.6 3.2 11.3 5.2 1.7	0.20	0.27	1.64	4,610 (922.0)	4.55 (3.98)	2.63 (2.26)	3.22 (2.64)	3.48 (2.96)
Singapore	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	46.6 19.3 34.1	17.1 17.6 65.4	-0.9	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	36.5 8.9 18.8 32.3 3.5	15.9 5.1 16.3 58.4 4.3	0.92	5.12	1.83	2,098 (49.9)	9.35 (7.70)	7.44 (4.94)	6.06 (3.38)	7.53 (5.24)
Taiwan	1. N. Resources intensive 2. Labor intensive 3. R&D intensive	42.7[c] 32.6[c] 24.7[c]	38.0 14.6 47.3	0.2[c]	1. Natural resources 2. Low tech. 3. Medium tech. 4. High tech. 5. Others	13.6 46.8 21.3 17.0 1.3	6.2 19.6 24.6 47.8 1.8	1.65	4.62	1.71[e]	40,746 (1,852.1)	10.2	8.1	6.3[f]	8.4[f]

Source: own elaboration. For source details, see Annex 2.

[a] Correspond to Latin American countries included in the table.

[b] Correspond to 1996, and 1970-1996 for productivity gap.

[c] Correspond to 1980, and 1980-2000 for productivity gap.

[d] Correspond to 1996, y 1970-1996 for productivity gap.

[e] 1996-1998 average.

[f] Average value until 1996.

Annex 3. Database Sources

1. Structural Change

Industrial structure is classified in three sectors: Natural Resource, Labor and R&D intensive. Structural change is measured by the change in the participation of the R&D intensive sector between 1970 and 2000. Statistic information comes from the *Programa de Análisis de la Dinámica Industrial* (PADI, ECLAC) for Argentina, Chile, Brazil, Colombia, United States and Mexico; and from the INDSTAT3 Industrial Statistics Database from the United Nations Industrial Development Organization (UNIDO, www.unido.org) for Malaysia, Taiwan, India and Singapore; and from STAN Database, Industrial Structural Analysis of the Organization for Economic Cooperation and Development (OCDE, www.ocde.org) for Australia, Korea, Spain, Finland and Norway. According to the International Standard Industrial Classification (ISIC rev.2), industrial sectors are classified as follow:

a) Natural resource intensive: 311, 313 y 314; 331, 341, 351, 353, 354, 355, 362, 369, 371 and 372.

b) Labor intensive: 321,322, 323, 324, 332, 342, 352, 356, 361 and 390.

c) R&D intensive: 381, 382, 383, 384 and 385.

For Singapore and countries whose information comes from STAN database, it has been excluded the sectors 361 and 362. There are also some differences by country:

Australia: 355 including in labor intensive and 371/372 including in natural resource intensive sectors.

Korea: 352/356 sectors including in natural resource intensive, and 371/372 in R&D intensive.

Finland and Norway: 355 including in labor intensive and 371/372 in R&D intensive.

2. Productivity Gap

It corresponds to the annual average growth of the ratio between a country labor productivity and US labor productivity for 1970-2000. (ie, average rate of growth of $A=Prod._{i}/Prod._{us}$). (*Source: PADI, ECLAC*).

3. Export Specialization

Correspond to the export composition, according to groups of products (*Source: TradeCan 2005, ECLAC)*. The products groups are defined as followed:

a) Natural resources: contains basic products of simple processing (includes concentrates) and natural resources manufacture exports.

b) Low technology manufactures: contains products of textile and apparel cluster plus other associated to paper, glass and steel, and jewelry.

c) Medium technology manufactures: contains products of automotive, processing and engineering industries.

d) High technology manufactures: products of electronic cluster and pharmaceutical products, turbines, airplanes and instruments.

4. Adaptability Index

The adaptability index is defines as I=Xd/Xe; where Xd is the participation of the dynamic products in the exports of each country, and Xe is the participation of the stagnated products (ie.,Xd+Xe=100). The dynamic products are those that increased their participation in the world-wide imports between 1985 and 2002, whereas stagnated ones are those that reduced it. (Source: TradeCan 2003).

5. Research and Development (R&D)

It Corresponds to R&D average expenditure over GDP between 1996 and 2002. *(Source: United Nations for the Education, Sciences and Culture (UNESCO, www.unesco.org) and Latin American Network of Indicators of Science and Technology (RICYT, www.ricyt.org).*

6. Patents

It corresponds to the number of patents by "inventions" granted by the Office of Patents and Trademark from the United States to residents of each country between 1977 and 2003. Between parentheses, number of patents by million inhabitants is specified. *(Source: Office of Patents of the U.S.A, www.uspto.gov).*

7. Growth

Corresponds to the Gross Domestic Product average growth *(Source: WDI, World Bank)*.