SPECIALIZATION, WAGE BARGAINING AND TECHNOLOGY IN A MULTIGOODS GROWTH MODEL[a/]

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Abstract

The paper develops the Ricardian multigoods model in several directions with a view to studying the relationship between the technology gap, the pattern of specialization and the institutional framework that organizes technological learning and wage bargaining. The international economy is formed by two countries, the North (technological leader) and the South. The evolution of the North-South technology gap depends on the initial level of the gap (which defines the potential for imitation in the South) and on the degree of diversification of the economic structure of the South (that gives rise to technological externalities). The South-North relative wage responds to the bargaining power of labor unions. The interaction between the technology gap and relative real wages endogenously defines the pattern of specialization, which is related to economic growth through the condition of equilibrium in current account (external constraint).

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Introduction

Patterns of specialization are shaped by the process of technical change and reflect leads and lags in innovation and the international diffusion of technology. A useful short-cut to describe these leads and lags is the evolution of the technology gap. Changes in the technology gap give rise to international asymmetries in productivity, costs and quality of the goods produced, thereby redefining dynamic comparative advantages. Still, the relationship between the technology gap and the pattern of specialization does not go just from the former to the latter, but also from specialization to technology. This point is a central tenet of both the Latin American structuralism[1] and the Schumpeterian-evolutionary approach to economic growth. From this perspective, the rates of learning and technical progress are different in different sectors of the economy. Countries whose production and export structures already feature a strong presence of high-technology sectors are as well more likely to experience higher rates of technical change and growth.

The aim of this paper is to highlight the structuralist dimension of technological learning within the context of a multigoods model in which growth is constrained by equilibrium in current account. The model is developed to make explicit the influence of changes in the number and type of goods produced on learning, trade and growth. The paper consists of four sections, besides this introduction and the concluding remarks. The point of departure, in Section 1, is the Ricardian model originally suggested by Dornbush, Fisher and Samuelson (DFS) (1977) and subsequently revisited from a Keynesian-Schumpeterian perspective by Cimoli (1988,1992) and Dosi *et al* (1990). We extend the Ricardian model to discuss how the evolution of the technology gap (leads and lags in innovation and diffusion) and the relative North-South wage interact with the pattern of specialization in a context of imperfect competition in both the labor and goods markets. Thus, we include Schumpeterian and structuralist dimensions along with wage bargaining in the process of defining comparative advantages, dimensions which are not considered in the original DFS model.

[1]See Prebisch (1963). A comprehensive analysis of this school of thought can be found in Rodriguez (1980).

Section 2 discusses how the pattern of specialization analyzed in section 1 affects the relative North-South rate of growth. The link between specialization and growth is provided by the condition of equilibrium in current account. In order to specify this condition we define two demand functions for exports and imports, which render different results from the point of view of economic growth. One of these demand functions allows the model to produce equal growth in equilibrium, albeit with different income levels. The other demand function gives rise (under certain assumptions) to unequal growth and is consistent with Thirlwall´s Law (Thirlwall, 1979). In both cases the income elasticities of the demand for exports and imports are a function of the pattern of specialization, represented by the number and type of goods produced by the South.

Finally, section 3 addresses how changes in the institutional framework organizing learning and wage bargaining influence the pattern of specialization, growth and the relative North-South real wage. The effects of these changes are analyzed in terms of variations in the parameter values of the model. Exercises of comparative dynamics suggest that technological policy can play a key role in international convergence or divergence. In addition, it shows that when increasing returns are very significant, an initial competitive advantage due to lower wage costs may be conducive to higher rates of learning in the South and to the reduction of the technology gap.

1. Technology, Relative Wages and Specialization

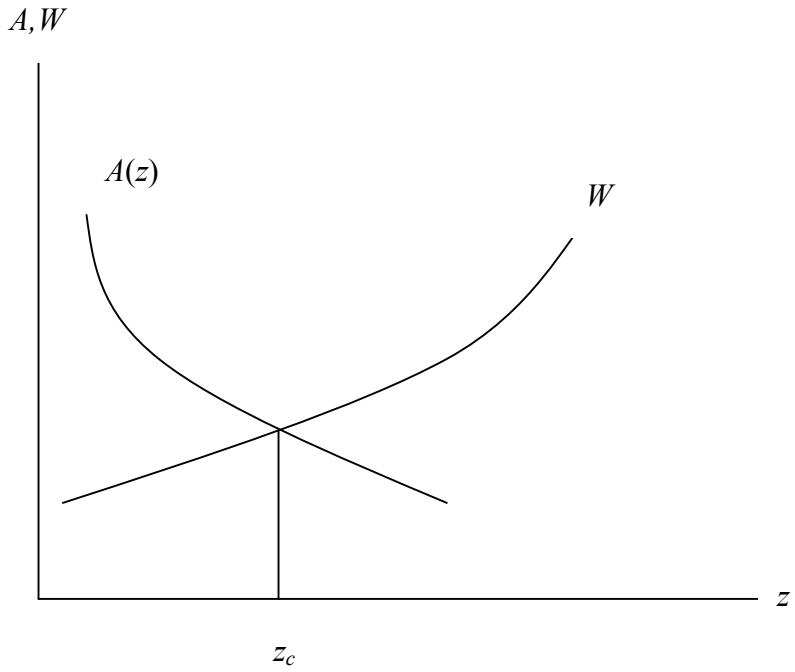
a) The Basic Ricardian Model

This section presents several extensions to the DFS model, related to the dynamics of the technology-gap and imperfect competition in the goods and labor markets. The international economy is formed by two countries, North (N) and South (S), which differ in terms of their technological capabilities. The North is more advanced, having already reached the technology frontier, while the South lags behind. Both countries are open to international trade and compete in the production of a very large number of goods, using

labor as the single factor of production. Comparative advantage depends on relative labor requirements defined as $Az = \frac{a_z^*}{a_z}$, where a^*_z are the 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 the technology gap. In other words, productivity varies in accordance with the distance of the South with respect to the international technological frontier (represented by the technological capabilities of the North).

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 (*i.e.* a lower index z denotes a good whose production is relatively more efficient in the South). This implies that the curve $A(z)$ (which plots relative labor requirements $A(z) = a_z^*/a_z$ against the index numbers z) falls monotonically (see figure 1). Why is the relative labor requirement different for different goods? It is assumed that the South has its higher comparative advantages in low-tech goods. As production becomes more technologically-intensive, the productivity gap between North and South increases for a given technology gap. As a result, the ranking of goods from the point of view of comparative advantages mirrors the ranking of goods from the point of view of their technological intensity. The same distance with respect the technology frontier implies a larger difference in productivity between North and South in the case of high-tech goods. The declivity of the $A(z)$ curve expresses the rate at which the South looses comparative advantages as the economy diversifies towards sectors that are more intensive in technology.

Figure 1. Specialization in the Ricardian Model



To find the pattern of specialization, it is necessary to combine the curve of relative labor requirements with the curve of relative wages. The W curve plots relative South-North wages against the number of goods z produced in the South. Relative wages are defined as $W = w/w^*e$, being e the nominal exchange rate (units of the Southern currency per unit of foreign currency), w are Southern nominal wages (in Southern currency units) and w^* Northern nominal wages (in Northern currency units). The W curve monotonically increases with z because the diversification of the Southern economy increases the demand for labor (more on this below).

Under perfect competition, unit costs and prices will be lower in the South whenever $a_z w < a^*_z w^* e$, that is when $A(z) > W$. This means that in an open international economy the South will specialize in the goods for which $A(z) > W$. It is then clear in figure 1 that the South will produce goods from zero to the borderline good z^e, while the North will produce goods from z^e to 1.

In this paper we remove the assumption of perfect competition in both the goods and labor markets and allow for two classes in the economy, labor and capitalists. There is still just one factor of production (labor); capitalists in this case are the class who owns the initial funds necessary to hire workers and organize production. They set prices by adding a mark-up ($m > 1$) over unitary labor costs. In addition, the labor market is the arena of negotiation between the two classes, as it is usually assumed in the Kaleckian tradition (see for instance Blecker, 1999). The relative South-North nominal wage is formed out of a bargaining process between labor and capital. For simplicity, the mark-up is assumed to be the same and constant for all the goods produced in both North and South. This leaves the relative productivity and the relative nominal wage as the only factors affecting international competitiveness. In effect, it will be true that a certain good z will be produced in the South if $mwa_z < m^* w^* a_z^* e$, where m and m^* represent the mark-up in South and North, respectively. Rearranging terms, the good will be produced in the South if $A(z) > mw/m^* w^* e$. It is straightforward that such a condition boils down to $A(z) > W$ when $m = m^*$. The following section discusses how the dynamics of W and A (which

emerges from the interaction between specialization and technological learning) defines the relative South-North income and growth.

b) The Dynamics of the Technology Gap

Relative labor requirements (the $A(z)$ curve) depend on technological asymmetries (leads and lags in innovation and the international diffusion of technology), as represented by the technology gap. The latter is defined as $G = \frac{Tn}{Ts} \geq 1$, where *Tn* and *Ts* are the technological levels in North and South, respectively. The evolution of the technology gap, in turn, is driven by the relative rate of innovation in the North with respect to that of technological diffusion towards the South. Following Nelson and Phelps (1966), Fagerberg (1988, 1994) and Narula (2004), technological spillovers from North to South are assumed to be a positive function of the technology gap[2]. In addition, technological learning in the South also depends on the level of diversification achieved by the Southern economy[3]. Basically, a larger *z* implies a larger participation of technologically advanced sectors in the economic structure of the South, giving rise to higher rates of learning. Formally:

$$(1)\ \hat{G} = \frac{d(T_N / T_S)}{dt}\frac{T_S}{T_N} = a - cG - bz$$

The parameters *a*, *b* and *c* are defined by the characteristics of the National System of Innovation of the South. A National System of Innovation (NSI) is the set of formal and informal institutions that coordinate the interactions among several heterogeneous agents (such as firms, research institutes, universities) involved in the process of learning, and

[2] It would be more realistic to assume 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 the paper. Moreover, it can be assumed that the economy has already developed the minimum technological capabilities required to enter the catching-up stage (see Narula, 2004). In this stage, the velocity of learning increases with the technology gap.

[3] Some sectors are the main loci of innovation, while others play a more passive role. Pavitt (1984) offers a classical typology of sectors regarding their position in the flow of innovation and diffusion of technology. The idea that the structures of production and exports matter for growth is a long-standing point raised by the Latin American structuralism. See on this Prebisch (1963, 1981), Rodríguez (1977,1980) and ECLAC (2007, chapter 2 and 4). A similar idea within a Kaldorian framework can be found in Pugno (1996).

which contribute to shape the intensity and direction of technical change[4]. Each country has its NSI, whose features and efficacy in promoting technical change vary widely. Clearly, in the case of developing countries, institutions are fragile and the NSI fails to foster learning with the same intensity as the NSI of a developed economy. This fragility is captured by the parameters of the model. The parameter *a* is the exogenous rate of growth of the technology gap, *b* represents the ability of the South to take advantage of the stock of knowledge of the technological leader, and *c* captures learning effects associated with a more diversified economic structure. While the parameters *a* and *b* are expected to be always positive, the sign of *c* is less clear-cut. If $c > 0$ a higher technology gap favors a higher rate of learning in the South. This implies that the South has already reached the minimum technological level required to start a process of catching up with the technological leader. But if this is not the case then $c < 0$ and the gap would not represent an opportunity for learning in the South; on the contrary, it would reinforce Southern technological backwardness. Throughout this paper we assume $c > 0$. The more developed is the NSI of a certain developing economy, the higher will be the value of the parameters *c* and *b*, and the lower will be the value of the parameter *a*.

The technology gap affects the position of the $A(z)$ curve according to the following equation:

$$(2)\ \frac{a^*(z)}{a(z)} = A(z) = \gamma - \alpha G - \beta z$$

where α, β and γ are positive parameters. A reduction in the technology gap *G* shifts $A(z)$ to the right, increasing the relative labor requirements of the North relative to that in the South for all goods produced in the international economy. This specification of the curve $A(z)$ implies that technical change affects relative labor productivity in the production of the different goods in exactly the same proportion. Although this is a strong assumption, it makes the model more tractable and will be kept it in the rest of the paper.

[4] For a detailed discussion of the concept of NSI see Freeman (1987, 1995) and Lundvall (1992). For a historical approach see Abramovitz (1986). A discussion of the shortcomings of the NSI in developing countries can be found in Fransman and King (1984), Albuquerque (2007) and Cimoli and Porcile (2008).

It is important to stress that the model is intended to discuss North-South trade and growth and therefore it does not hold when $G < 1$, that is, when the South overcomes the North from a technological point of view. Moreover, if the technology gap is completely eliminated ($G = 1$), there would be no productivity differences between countries in any sector ($A = 1 , \forall z$) and hence the pattern of specialization would be indeterminate. There still will be room for trade as a result of differentials in the wage levels, but which country produces which goods is completely insubstantial (DFS, 1977). In this specific case, the pattern of specialization is defined by chance and history, as discussed in more detail in an Appendix at the end of the paper.

c) Relative Wages and Specialization

The relative South-North wage ($W = w/w^*e$) stems from the bargaining process between capitalists and workers, whose outcome depends on their relative strength. A high technology gap implies that the Southern economy faces a disadvantage as regards productivity levels, which constraints labor demands for higher wages. Unions will realize that jobs are at risk if the relative wage increases in this context and will therefore curb their demands. On the other hand, a larger z favors the bargaining power of unions, since the rate of economic growth and the demand for labor increases with z. Labor will therefore become a relatively scarcer factor, inclining the balance of forces in favor of labor unions. Formally:

(3) $W = -uG + vz$

In equation (3) u and v are positive parameters defined by the institutional framework of industrial relations. In particular, if labor supply in the South is abundant (short) and/or the prevailing institutional framework restraints (favors) labor unions, then u will be high (small) and v small.

Whenever $W < A(z)$, there will be an opportunity for the South to increase the number of goods it produces. This can be formally represented as:

(4) $\hat{z} = \zeta (Az - W)$

ζ is positive and represents the velocity with which the South reacts to the opportunity of expanding the production of goods for which it has comparative advantages. For simplicity it is assumed that $\zeta = 1$. The pattern of specialization will be in equilibrium when $A(z)$ equals W and hence $\hat{z} = \dot{z}/z = 0$. Using equation (2) and (3) in (4), we get a new differential equation which gives the evolution of the pattern of specialization as a function of the productive structure and the technology gap:

(5) $\hat{z} = \gamma - \alpha G - \beta z + uG - vz$

To simplify notation, we define $f \equiv \beta + v$ and $g \equiv \alpha - u$:

(6) $\hat{z} = \gamma - fz - gG$

While f is a positive number, the signal of g is ambiguous. If the variation of the gap has a stronger effect on the relative wage than on relative productivity, then $u > \alpha$ and g will be negative. In equation (6) this means that an increase in the gap favors the diversification of the Southern productive structure (lower wages overcome the negative effect of a lower relative productivity). On the other hand, if $u < \alpha$, g is positive and an increase in the gap leads to a less diversified structure of Southern exports. The second case appears to be more realistic and therefore g will be assumed a positive number in the rest of the paper.

Equations (1) and (6) form a system of two differential equations. To study this system we will first analyze the isoclines. The isocline GG (see figure 2) is obtained by imposing $\hat{G} = 0$ in equation (1):

$$(7)\quad G = \frac{a - bz}{c}$$

The isocline *ZZ*, corresponding to $\hat{z} = 0$ in equation (6), is the following:

$$(8)\quad G = \frac{\gamma - fz}{g}$$

The equilibrium values of *G* and *z* that satisfy $\hat{G} = \hat{z} = 0$ are:

$$(9)\quad z^e = \frac{\gamma c - ag}{cf - bg}$$

$$(10)\quad G^e = \frac{af - \gamma b}{cf - bg}$$

G and *z* are constrained to lie in the closed interval [0,1]. Since $cf > bg$, for having a meaningful equilibrium it is necessary that $\gamma c > ag$ and $af > \gamma b$. The Jacobian matrix of the system of differential equations formed by equations (1) and (6) is as follows:

$$(11)\ J = \begin{vmatrix} -c & -b \\ -g & -f \end{vmatrix}$$

The trace of matrix (11) is $(-c - f)$, a negative number under the assumptions of the model ($c > 0$, $f > 0$), while the determinant is equal to $cf - gb$. The system will be stable if the determinant is positive which is always true if $cf > gb$. The latter condition holds under the assumption that in equilibrium *G* and *z* must be positive. Note that if the country has not reached the catching up stage then $c < 0$ and the system would be unstable[5].

The model can be used to analyze the endogenous dynamics of the technology gap and the pattern of specialization in a North-South context. Specialization is based on inter-industry trade, since the model comprises an infinite number of goods, each of which can be

[5] In this case the determinant would be negative and the equilibrium a saddle point.

competitively produced in just one country (except in the case of the borderline good z^e, which is produced in both countries). This emphasis on inter-industry trade is consistent with the idea that North-South trade is mostly of the inter-industrial type. However, if it is admitted that goods with similar indexes z pertain to the same industry (*i.e.*, goods whose indexes are arbitrarily close to z^e can be considered goods produced in the same industry), then there would be room for intra-industry trade within an interval of z^e. Of course, the dimension of this interval depends on how loosely the term "industry" is defined: the broader this definition, the larger the interval and the larger the scope for intra-industry trade.

In the next section, we associate the dynamics of technology and specialization with economic growth by focusing on the conditions for current account equilibrium. This allows us to introduce more rigorously the role of the demand-side in the model – which takes the form of the Balance-of-Payments constraint. By doing so we will be able to discus how (supply-side) Schumpeterian learning affects growth, which is through the rate of growth of exports and imports.

2. Current Account Equilibrium and Economic Growth

The model assumes that there is no capital flows. Therefore, the current account in the two economies must be in equilibrium. To discuss the conditions required for current account equilibrium it is necessary first to specify the aggregate demand function and the demand for exports and imports. Aggregate demand equals total nominal income in each country. To find aggregate demand we begin with the nominal income generated by the production of each good z, $p_z y_z$, where p_z is the price and y_z the quantity of z. Recalling that prices are defined by a mark-up rule ($p_z = mwa_z = mwL_z / y_z$), then the nominal income in the production of each good z will be:

(12) $p_z y_z = mwL_z$

Since we assume that *m* and *w* are the same for all the sectors of the economy, then total nominal income will be $\int_{z=0}^{z=z^e} mwL_z dz = mw \int_{z=0}^{z=z^e} L_z dz = mwL$, where *L* is total labor employed in the South and z^e is the number of goods the South produces. Symmetrically, total nominal income in the North will be $m^* w^* L^*$. Total wages in the South are equal to *wL*, while total profits amount to $wL(m-1)$ (and Northern wages and profits are *w*L** and $w^* L^* (m^* - 1)$, respectively).

By definition current account equilibrium requires that the value of total exports equals that of total imports (in the same currency). In the following discussion we will assume that the nominal exchange rate *e* is constant and equal to the unity. Such an assumption aims at simplifying the model with a view to highlighting the role of the technology gap in growth and specialization, which is the focal point of the paper.

To analyze the demand for exports and imports in each country it is necessary to make some assumptions regarding the specific form of the demand curve. Firstly we adopt the simplest specification, in which each of the *z* goods has an equal share in total nominal demand in North and South (see DFS, 1977). In other words, consumers spend exactly the same proportion of their income in each of the goods. Then it will be true that the share of imports in the total nominal demand of the North will be $(w^* m^* L^*) z^e$ (since the South produces all the goods up to z^e). The rest of the goods (1- z^e) will be produced in the North, and therefore the demand for imports in the South equals $(wmL)(1-z^e)$. Combining the demands for imports in both countries we obtain the condition for current account equilibrium in North and South:

$$(13) \quad mwL = \left(\frac{z^e}{1-z^e} \right) m^* w^* L^*$$

The relative South-North income *R* is:

$$(14)\ R = \frac{mwL}{m^* w^* L^*} = \frac{z^e}{1 - z^e}$$

Equation (14) gives the relative nominal income in South and North as a function of the pattern of specialization. Rearranging terms in (14) and assuming $m = m^*$, we find that relative wages are related to employment levels in North and South according with:

$$(15)\ \frac{w}{w^*} = \left(\frac{z^e}{1 - z^e} \right) \frac{L^*}{L}$$

However, we have assumed in section 1 (equation (3)) that the relative wage emerges out of the bargaining process between workers and capitalists in the labor market. Therefore, in equilibrium employment levels must adjust so that equation (15) and (3) simultaneously hold. In equilibrium it will be true that:

$$(16)\ \frac{w}{w^*} = -uG^e + vz^e = \frac{z^e}{1 - z^e} \frac{L^*}{L}$$

Since G^e and z^e are constants (as they are the equilibrium values produced by the dynamical system formed by equations (1) and (6)), equality (16) is satisfied by means of changes in relative employment in North and South (changes in L/L^*). This is consistent with the idea that nominal wages are rigid and hence quantities adjust. Formally:

$$(17)\ \frac{L}{L^*} = \frac{z^e}{1 - z^e} \left(\frac{1}{-uG^e + vz^e} \right)$$

Taking the derivative of equation (17) with respect to z^e we obtain the following result:

$$(18)\ \frac{\delta (L/L^*)}{\delta z^e} = \frac{1}{1 - z^e} \left[\left(-u \frac{\delta G^e}{\delta z^e} \right) + z^e v + \frac{\left(-uG^e + vz^e \right)}{1 - z^e} \right] > 0$$

Since $W = \left(-uG^e + vz^e\right)$ is constrained to be positive and $\delta G^e / \delta z^e$ is negative[6], then equation (18) gives a positive number. This implies that the relative employment level in the South with respect to the North increases with the number of goods z^e produced in the South.

We are interested in relative rates of economic growth. The differentiation of equation (14) with respect to time gives:

$$(19)\ \dot{R} = \left(\frac{\dot{z}^e (1 - z) + \dot{z}^e z^e}{\left(1 - z^e\right)^2} \right) = \frac{\dot{z}^e}{\left(1 - z^e\right)^2}$$

And by multiplying and dividing by z^e we obtain:

$$(19')\ \dot{R} = \frac{1}{\left(1 - z^e\right)} \left(\frac{\dot{z}^e}{z^e} \frac{z^e}{\left(1 - z^e\right)} \right)$$

Using that $R = z^e / \left(1 - z^e\right)$ and dividing both sides of equation (19′) by R, allows for finding the rate of growth of R:

$$(20)\ \hat{R} = \frac{\hat{z}^e}{1 - z^e}$$

The analysis of equations (15) and (20) leads to two interesting results regarding the interaction between growth and structural change. First, the income gap is reduced when the Southern economy diversifies its economic structure, *i.e* when $\hat{z} > 0$, since the South will be growing at higher rates than the North ($\hat{R} > 0$). When the process of structural change ceases ($\hat{z} = 0$), both economies will grow at exactly the same rate. Secondly, being $z = z^e$ and $G = G^e$ constants in equilibrium, technical change and productivity growth in

[6] This is easy to confirm by differentiating equation (8) with respect to z, which gives $-f/g$.

the South will be the same as the exogenous rates of growth of these variables in the North. However, there will still be an income gap in favor of the North if $z^e < 1/2$.

The type of demand function we assumed so far implies that all goods enter with the same weight in total nominal consumption. But other demand functions can be defined as well, which produce different results[7]. We will replace the initial demand function by one in which the share of goods in total expenditure increases exponentially with the number of goods z. Under this new specification, the aggregate demand up to good z is given by $(wmL)^z$. Recalling that the South produces goods up to z^e, the condition for current account equilibrium becomes:

$$(21)\quad (wmL)^{1-z^e} = (w^* m^* L^*)^{z^e}$$

The right hand side of equation (21) is the Southern demand of imports and the left hand side is the Northern demand of imports. Taking logs in equation (21) and rearranging terms we get:

$$(22)\quad (1-z^e)\ln(wmL) = z^e \ln(w^* m^* L^*)$$

Differentiating both sides of equation (22) with respect to time and assuming m and m^* constants, then we have the dynamic condition for equilibrium in current account:

$$(23)\quad -\dot{z}^e \ln(wmL) + (1-z^e)(\hat{w}+\hat{L}) = \dot{z}^e \ln(w^* m^* L^*) + z^e(\hat{w}^*+\hat{L}^*)$$

In equilibrium $\dot{z} = 0 \Rightarrow z = z^e$ and therefore equation (23) becomes:

$$(24)\quad \hat{R} = \frac{\hat{w}+\hat{L}}{\hat{w}^*+\hat{L}^*} = \frac{z^e}{1-z^e}$$

[7] For a discussion of different demand patterns and development see Azevedo Araujo and Teixeira (2004).

Clearly, this specification of the demand function has very significant differences respecting the specification used in equation (14). In particular, equation (24), at variance with equation (20), may entail unequal growth between South and North in equilibrium (*i.e*, even when z = z^e and $\dot{z} = 0$, $\hat{R}$ may be different from zero). The diversification of the economy leads to differences in growth rates, not just in income levels. In effect, the South will be falling behind the North if $z^e < 1/2$.

Moreover, equation (24) is equivalent to the equation known as Thirlwall´s Law[8], in which the ratio between the rate of growth of one country and the rest of the world in equilibrium is given by the ratio between the income elasticity of the demand for imports (ε) and exports (π). Since $z^e = \varepsilon$ is the income elasticity of the demand for Southern exports, and $\left(1 - z^e\right) = \pi$ is the income elasticity of the demand for imports in the South, equation (24) represents Thirlwall´s Law[9]. The key role of demand in relative growth is highlighted by this result. In effect, depending on how the demand function is defined, we have very different implications for economic growth of with the same technology gap and pattern of specialization. The pattern of specialization is endogenous, supply-side (i.e. technology plus productive structure) driven, but the demand functions define how a specific pattern translates into economic growth. At the end of the day, both the Schumpeterian and Keynesian sides of the growth equation must be taken into account in the model.

3. Technological policy and wage bargaining

The framework presented above can be used to discuss the role of economic policy in long run growth. Industrial, technological and income policies can alter the structural parameters of the model, thereby changing the equilibrium values of *G* and *z*. To the extent that *z* defines the rate of growth with current account equilibrium in the South, then economic policy contributes to explain convergence and divergence.

[8] Azevedo Araujo and Lima (2007) offers an interesting multigoods model in which Thirlwall´s Law is derived from a Pasinettian framework.

[9] It should be observed that in equilibrium purchasing power parity holds (as it does in Thirlwall´s Law). Relative prices are constant in North and South and hence the real exchange rate is constant too.

With a view to addressing more rigorously this point, the isoclines corresponding to $\hat{G} = 0$ and $\hat{z} = 0$ are written down bellow (see section 1):

(25) $G = \frac{a}{c} - \frac{b}{c} z$

(26) $G = \frac{\gamma}{g} - \frac{f}{g} z$

The curves defined by equations (25) and (26) are labeled as *GG* and *ZZ* curves, respectively (see figure 2a). The *GG* curve gives all the combinations of *G* and *z* that make $\hat{G} = 0$, while *ZZ* give the combinations for which $\hat{z} = 0$. The position of these curves shifts when the structural parameters of the system vary. As mentioned, such shifts are related to changes in policy.

We will take first the case of a new policy that fosters technological efforts in the South by raising autonomous investments in R&D and/or the levels of human capital. This policy reduces the value of *a*: the rate of technological divergence between North and South for given values of *z* and *G* then goes down. As a result, the *GG* curve shifts to the left and a new equilibrium is obtained, with a lower *G* and a higher *z*. The latter, in turn, gives rise to a higher rate of growth. Figure 2b represents the income growth ratio between South and North as a function of the number of goods produced in the South in equilibrium (corresponding to equation (24) in section 2). The increase in Southern autonomous investment in technology (represented by a fall in *a*) leads to a process of convergence in both technological capabilities and growth. Figure 2a shows that the number of goods produced by the South increased from z_1 to z_2 out of the change in policy, and this in turn increases the relative rate of growth of the South from R_1 to R_2. The horizontal line $\hat{R} = 1$ indicates the minimum degree of diversification that would be required for avoiding divergence.

Figure 2a. Technology Policy and the Pattern of Specialization: The Case of a Fall in *a*

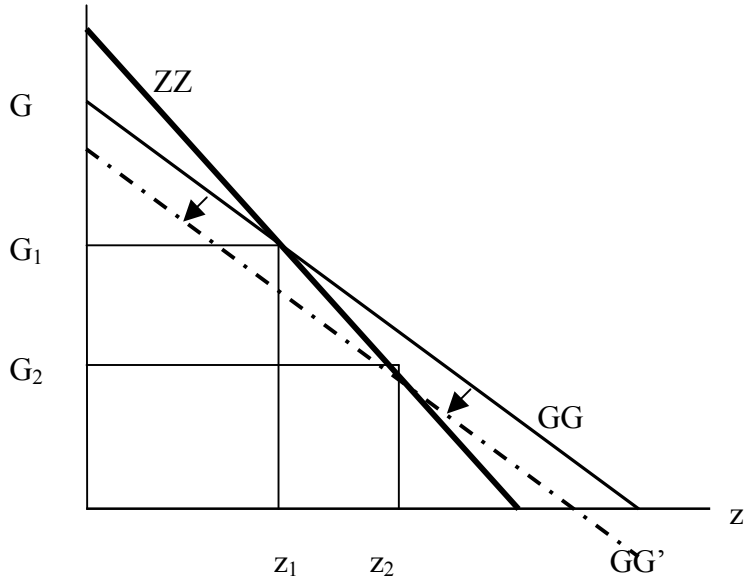
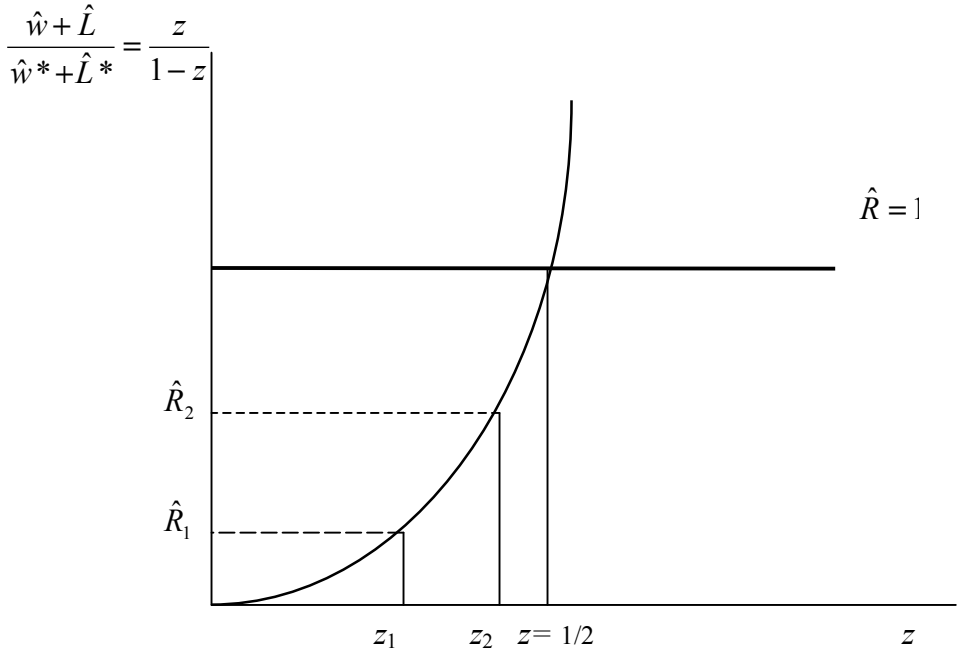


Figura 2b. Convergence, Divergence and Structural Change



The situation represented in figures 2a-2b is what Fajnzlyber (1990) considered a rise in "authentic competitiveness", defined as the simultaneous increase in the diversification of exports and real wages. The export drive is based on faster technological learning, not in lower relative wages. In the example provided above, the fall of G and the rise of z both contribute to raise the Southern relative wage along with the increase in exports. In effect, by substituting G and z in equation (3) by its equilibrium values given by equations (9) and (10), we can have the equilibrium value of W as a function of the exogenous parameters of the model:

$$(27)\ W = -uG + vz = -u\left(\frac{af - \gamma b}{cf - bg}\right) + v\left(\frac{\gamma c - ag}{cf - bg}\right)$$

Taking the partial derivative of equation (27) with respect to a renders:

$$(28)\ \frac{\delta W}{\delta a} = -\frac{(\gamma c - ag)(ub + cv)}{(cf - bg)^2}$$

The result of equation (28) is a negative number since $\gamma c > ag$. Hence, a fall in a (higher investments in R&D in the South) boosts the Southern relative real wage. It should be observed, however, that it is not always possible to reduce a. In many developing countries institutional constraints, the lack of the minimum capabilities required to effectively learn from the technological frontier, along with hysteresis phenomena, may impede the upgrading of the NSI (Setterfield and Cornwall, 2002; Cimoli and Porcile, 2008). As a result a very high technology gap will remain as major barrier to growth.

What happens if export diversification comes from a fall in the bargaining power of Southern labor unions, which reduces the South-North relative wage? This may occur, for instance, if it is approved a new legislation granting fewer rights to workers or making easier to hire and fire workers bypassing unions' resistance. It may also happen when there is a spurt in labor supply because of an inflow of migrant workers coming either from the countryside or from abroad. Such a situation resembles what Fajnzylber (1990) labeled as

"spurious competitiveness": the increase in exports is not related to higher productivity but to the deterioration of labor welfare (as compared to that of Northern workers)[10]. Yet in the context of our model this may not be necessarily the case. There are some dynamic effects that the model may help to identify which qualifies this view.

In effect, assume that institutional change reducing labor's bargaining power elicits a fall in the parameter v (and hence in f), out of which z^e increases and G^e goes down, as represented in figure 3a. The new equilibrium values for the technology gap and productive structure enhances the relative wage, while the fall in v reduces it. Which of these two forces would prevail? An answer can be obtained by taking the partial derivative of equation (27) with respect to v.

$$(29)\quad \frac{\delta W}{\delta v} = \frac{(\gamma c - ag)(cf - bg - ub - cv)}{(cf - bg)^2}$$

The signal of this derivative is ambiguous and depends on whether the inequality $cf > b(g + u) + cv$ is satisfied or not. Recalling that $f \equiv \beta + v$, $g \equiv \alpha - u$, such inequality boils down to $c\beta > b\alpha$. If it is valid, then a reduction in the bargaining power of Southern workers brings about a reduction in the relative wage. This will be clearly the case when there are no increasing returns stemming from structural change, *i.e.* when the diversification of the economy provides no stimulus to learning and productivity growth; in this case b will be equal or very close to zero. On the other hand, when increasing returns are significant and b is high, then the inequality will show the opposite signal. The latter would be a somewhat paradoxical result, since less bargaining power for Southern labor raises the relative wage in the South. Still, two different moments can be identified in this process. The initial fall in the relative wage will produce higher spurious international competitiveness. But it would subsequently favor the upgrading of the economic structure in the South. The latter in turn brings about learning externalities that reduce the technology gap and fosters authentic competitiveness. At the end of the day, when the international economy reaches a new

[10] The definition we used here is more restrictive than that set forth by Fajnzylber (1990). For this author spurious competitiveness implies lower wages in the South. In our model the focus is on the relative wage. Thus, if wages in the South increases less than in the North there will be spurious competitiveness.

equilibrium, the South will display a lower technology gap and a higher relative wage than at the initial moment.

The movement from spurious to authentic competitiveness can be seen in figure 3a and 3b using the curves W and $A(z)$ presented in section 1. The initial fall in v makes W rotate and shift to the right (from W_1 to W_2), while the consequent change in G (from G_1 to G_2) and z (from z_1 to z_2) shifts Az to the right (from $A(z_1)$ to $A(z_2)$). When b is large enough, the shift of $A(z)$ is so strong that it produces a new equilibrium with both a higher relative wage and a more diversified pattern of exports in the South. On the other hand, if b is zero, the $A(z)$ curve would not shift at all and the relative wage would necessarily fall.

Figura 3a. Institutions Regulating the Labor Market: The Case of a Fall in *v*

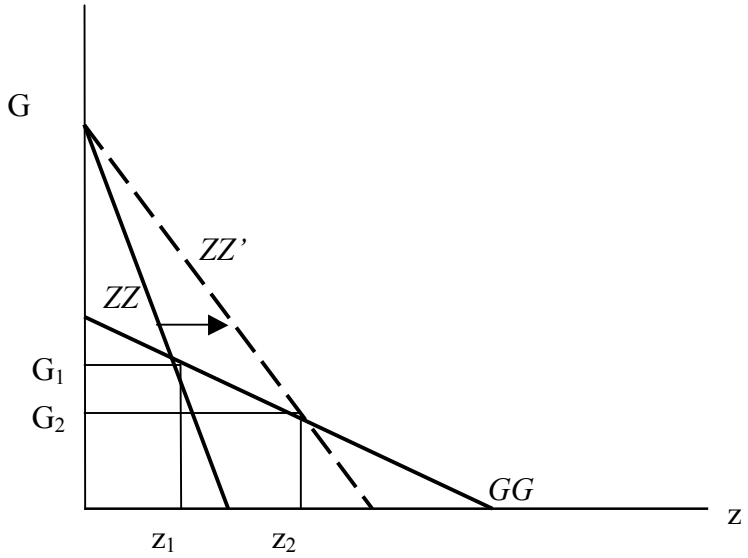
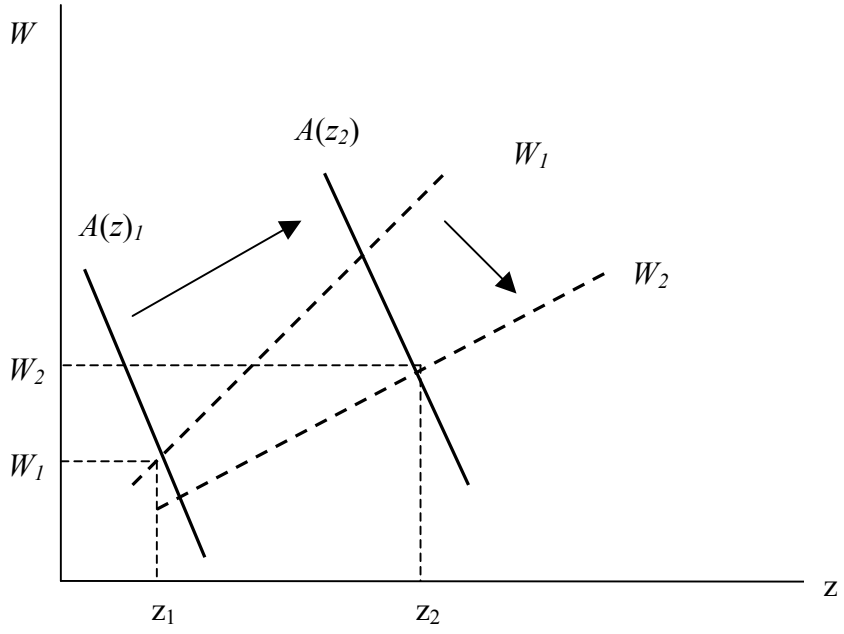


Figure 3b. From Spurious to Authentic Competitiveness: The Case of a Large *b*



The process described above is far from automatic. The parameter *b* that defines the intensity of increasing returns critically depends on education and technology policy. These variables (taken as exogenous in the model) define the extent with which the diversification of the economy gives rise to different forms of learning (such as learning by doing, learning by investing and learning by interacting; see Rosenberg, 1982, chapter 6). In this sense, it is important to recall that *b* is not just a technological parameter, but a specific dimension of the National System of Innovation.

Concluding remarks

This paper presented a North-South model in which the technology gap and relative wages interact with the pattern of specialization to produce convergence or divergence in the international economy. The idea that the technology gap affects the pattern of specialization has a strong tradition in the Schumpeterian literature on growth and trade. At the same time, the Latin American structuralist tradition argues that specialization has an effect of its own on the rate of technological progress. We combined these views in a model in which the technology gap and the pattern of specialization are endogenously determined. In turn, the condition of current account equilibrium is used to analyze how the pattern of specialization leads to economic growth, and to convergence or divergence in the international economy. It is shown that different demand functions entail very different consequences for economic growth. In particular, Thirwlall´s Law, a key result of the Keynesian growth literature, is obtained when the income elasticity of the demand for exports increases along with the number of goods *z* produced by the economy. In this case the pattern of specialization may lead to unequal growth in equilibrium. Moreover, even in the case in which all goods have the same income elasticity of demand, the pattern of specialization affects the relative North-South income. Both countries will grow at the same rate in equilibrium, but there still be an income gap which cannot be closed.

The structural parameters of the model depend on the institutions defining both the intensity of technological learning and the relative bargaining power of capital and labor in the South. As regards learning, the features of the National System of Innovation explain

the capacity of the South to take advantage of its technological backwardness so as to enhance the process of catching up. In addition, they define the extent in which the diversification of the Southern economic structure (towards technology-intensive sectors) creates externalities that contribute to reduce the technology gap. The values of the parameters governing the dynamics of the technology gap vary with institutional change in South and North. Thus, for instance, a change in policy leading to a strengthening of the National System of Innovation in the South leads to a fall in *a* (the parameter giving the autonomous rate of growth of the technology gap). This in turn brings about a simultaneous increase in exports, economic growth and relative wages, which has been labeled "authentic competitiveness".

The paper extends the DSF model to a framework in which there is imperfect competition in both the labor and goods markets. In these conditions, relative employment in North and South adjust so as to be compatible with the relative wage emerging from wage bargaining. Institutional change affecting the process of wage bargaining will alter the parameter values of the labor market, in the same vein as changes in the NSI alter those of learning. But policies affecting the institutions of the labor market have less clear-cut implications for relative wages than technological policy. When institutional changes weaken the power of labor unions, growth may be enhanced by means of "spurious competitiveness": higher rates of growth are elicited by a fall in the relative wage. If the learning parameters related to increasing returns are sufficiently high, a lower relative wage at the initial moment may generate a process of structural change which will subsequently raise the South-North relative wage in equilibrium. In other words, under certain conditions (strong technological externalities stemming from the diversification of the productive structure), the comparative advantage provided by lower wages may turn into a comparative advantage based on technological capabilities.

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Appendix: The Case of the Closure of the Technology Gap

The suggested model applies to a North-South context in which $G < 1$. Still, it can be extended to a situation in which the technology gap is completely closed. With a view to discussing this specific case, we will assume that the function $A(z)$ is discontinuous at $G=1$. At this point $\beta = 0$, $\gamma = 1 + \alpha$, and therefore $A=1$ for all goods. Is trade possible when there are no differences in productivity across sectors? Since the relative wage of the South increases as the South produces an increasing number of goods, at a certain point (represented by the good z^e) the relative wage of the South will equal the unity (see figure A.1). This is the borderline good for the South, after which production will no longer be competitive. Recalling that $A=G=1$, equation (3) becomes:

(A.1) $W = -u + vz^e = 1$

(A.2) $z^e = \dfrac{1+u}{v}$

In other words, trade will emerge from the fact that no country could competitively produce all goods without raising its relative wage above the unity. On the other hand, although the total number of goods produced by the South is clearly determined, the type of goods produced is not defined because the $A(z)$ curve collapses. It is no longer possible to build a meaningful ranking of the continuum of goods and there are no constraints on the type of goods each country produces. Another implication of this scenario is that the potential for trading goods pertaining to the same category (intra-industry trade) is no longer limited to an interval around z^e, but it could take place within a certain interval of any of the goods produced in the South.

Last but not least, it is important to stress that even if there are no differences in terms of productivity, the relative income may still differ between the two countries. When each good responds for the same share in total demand, relative income will be given by equation (14). In equilibrium we have:

(A.3) $$R = \frac{mwL}{m^* w^* L^*} = \frac{z^e}{1 - z^e}$$

Therefore, with no technology gap, equal incomes in South and North requires that $v = 2(1 + u)$. But v and u are exogenous parameters and therefore equal productivity does not necessarily lead to equal income levels.

Figure A.1. The number of goods produced in the South when G=1