A model of capital accumulation with external restriction and structural change: theory and the Brazilian experience

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Resumo

Entre as economias desenvolvidas e em desenvolvimento, a economia brasileira foi a mais dinâmica em termos de crescimento econômico do pós-guerra até os anos 1980, quando um severo constrangimento externo interrompeu esta tendência. Propomos nesse artigo um modelo baseado em Kaldor, onde estabelecemos uma relação entre acumulação de capital, hiato tecnológico e restrição externa ao crescimento de longo-prazo para economias periféricas. A hipótese básica do modelo é que a acumulação de capital, sob certas condições, pode contornar a restrição externa ao crescimento dessas economias desde que o esforço de acumulação seja capaz de produzir uma mudança estrutural no sentido de aumentar a participação relativa dos setores mais dinâmicos do ponto de vista tecnológico. Essa mudança estrutural irá resultar em um aumento gradual da elasticidade-renda das exportações e numa redução da elasticidade-renda das importações, aumentando assim a taxa de crescimento do produto real que é compatível com o equilíbrio de longo-prazo do balanço de pagamentos. Ilustramos ao final do artigo que a economia brasileira do pós-guerra até o final dos anos 1970 apresentou uma elevada taxa de acumulação de capital, aprofundando o processo de substituição de importações, o que na nossa interpretação contribuiu para parcialmente permitir relaxar a restrição externa ao crescimento de longo-prazo.

Abstract

Brazilian economy was the most dynamic in terms of growth among developed and developing economies from post-War until 1980, when a severe external constraint interrupted this trend. We propose in this paper a model, based on Kaldor, where capital accumulation, technological gap and long run external constraint are connected. Our hypothesis is that capital accumulation, under certain circumstances, can overcome external constraint if the accumulation effort promotes structural change increasing the importance of sectors more technological-intensive. It is expected that the structural change in this direction will contribute to an increase in the income-elasticity of exports and to a decrease in income-elasticity of imports, resulting in the increase in the growth rate of real product compatible with the balance of payments equilibrium in the long period. The last part of the paper shows that the high investment rate observed in the Brazilian economy from the post-War until the end of the 1970s resulted in the deepening of the import substitution process, what, in our interpretation, contributed to partially increase the long run growth rate of the Brazilian economy compatible with the balance of payment equilibrium.

Key words: structural change, technological progress, industrialization, external restriction
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A model of capital accumulation with external restriction and structural change: theory and the Brazilian experience

I – Introduction

Economic development is defined, in the Latin American structuralist tradition, as a process of continuous increase in per capita income spurred by growing labor productivity resulting from the adoption of indirect production methods, i.e., methods in which there is an increasing technical division of labor among activities, which in turn increases the amount of capital per worker (Rodriguez, 2009, p.80). In other words, economic development results from technical progress, which is induced or enabled by the accumulation of capital.

In the literature about growth models, this process, however, is not analyzed from the standpoint of a typical capitalist economy, but it is assumed that there are important structural differences between groups of capitalist economies, allowing for the identification of "central" and "peripheral" countries in global capitalism. The central economies are those where the most advanced production techniques penetrate first, while the periphery is made up of economies whose production lags behind, both in technology and organization (Ibid, p.81).

Hence, important technological asymmetries can be assumed to exist between capitalist economies, which permit characterizing a technological gap. This technological gap is seen as the basic reason why growth of productivity – and consequently of per capita income – is lower in the periphery than the center, giving rise to unequal development between the two.

In this context, the elimination of the technological gap is a necessary condition for underdeveloped or peripheral economies to catch up with the developed or central economies. Since technical progress is largely incorporated in new machinery and equipment, the reduction of the technological gap presupposes a greater effort to accumulate capital by peripheral than by central economies.

However, the kind of specialization and the heterogeneous productive structure of peripheral economies can hinder this greater effort at capital accumulation. The reason is that peripheral economies are specialized in the production of primary goods mainly for export. The need for consumption of durable goods and investment in these economies is met by imports from the central economies. Since the income elasticity of these economies' exports is generally low while the income elasticity of imports of manufactures is generally high, it follows that the long-term balance of payments equilibrium imposes that the peripheral economies grow at a slower pace than the central ones. It further follows, then, that the external constraint imposed by the productive structure of the peripheral countries reinforces and perpetuates the technological gap, since it makes more difficult the effort to accumulate capital in order to sustain a relatively higher rate of growth by these countries.

Based on this general framework, the aim of this paper is to analyze the relationship between capital accumulation, the technological gap and the long term external restriction to growth of peripheral economies. Our basic hypothesis is that capital accumulation, under certain conditions, can overcome this external constraint on growth, as long as the accumulation effort is able to engender a structural change in these economies, i.e., to induce a transformation in the productive structure that increases the relative participation of more technologically dynamic sectors. This structural shift will result in a gradual

increase in the income elasticity of exports and a reduction in the income elasticity of imports, thus boosting real output growth to a level compatible with long-term equilibrium in the balance of payments.

We set up the logical consistency of these arguments through a Kaldorian growth model in which: (i) investment in the modernization of capital goods permits the absorption of new technologies, enabling the production of goods with higher technological content; and (ii) the incorporation of new technologies induces a structural shift in the economy that permits an increase in income elasticity of exports and a decrease in income elasticity of imports. Finally, we present a case study of the Brazilian economy in the 1950-80 period. During this period, we illustrate that the greater capital accumulation effort that happened allowed for a structural change that relaxed the external constraint to long-term growth.

The article is organized in six sections including this introduction. In Section II we develop a theoretical-conceptual framework that relates structural change with the external restriction. This framework is developed from the contributions of the Latin American evolutionary and structuralist literatures. In Section III we present the relation between capital accumulation and technological progress based on the Kaldor-Mirrlees growth model. In Section IV we present a hybrid growth model that integrates the external restriction, based on the post-Keynesian literature on growth with balance of payments constraints, and investment in modernization of capital equipment in a context of structural change. In Section V we discuss the Brazilian economy during 1950-1980 as a successful example of structural change induced by the effort capital accumulation, which permitted a relaxation, albeit only partial, of the external constraint to growth. Finally, in Section VI we summarize our conclusions.

II – Structural change and external restriction

The growth rate that is compatible with balance of payments equilibrium depends on the income elasticity of exports and imports. These in turn depend on the productive structure of the economy. Developed and developing countries have different productive structures reflecting the fundamental differences in their *technological qualification*, i.e., in their capacity both to produce own technical knowledge and to imitate that developed in other parts of the world (Verspagen, 1993, p.126).

These differences in technological qualification are reflected in greater participation of technologically more dynamic sectors in the productive structure of developed countries than in developing ones. Therefore, developed countries have a greater number of economic sectors in which firms operate on the so-called "technological frontier". Hence their basket of exports will be made up mainly of products with high added value and high technological content, products for which the income elasticity of exports is high. From this it follows that the so-called technological gap[1] is an important determinant of the income elasticity of exports, and thus of the rate of growth compatible with balance of payments equilibrium (Dosi, Pavitt and Soete, 1990, p.26). As a corollary of this reasoning, the growth rate that is compatible with balance of payments equilibrium tends to be higher in developed than in developing countries[2].

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[1] On the concept of the technological gap, see Fagerberg (1988).

[2] Based on an econometric model of growth and North-South trade, Dutt (2003) shows that the income elasticity of exports of countries of the North to those of the South (that is, the income elasticity of imports

The low technological dynamism of many developing countries, notably in Latin America, explains the weakness of the growth impulses provided by expansion of internal and external demand (Holland and Porcile, 2005, p.42). For developing countries to reduce the external constraint to growth they must be able to make changes in their productive structures. These changes must in turn enable alterations in the income elasticities of demand for exported products so as to reduce the degree of exposure to external imbalances.

II.1 – Structural change, specialization pattern and technology gap

Structural change can be promoted by an effort to accumulate capital that leads, through modernization of the stock of capital, to a smaller *technological gap*. The reason, as pointed out by Kaldor (1957), is that a significant part of "technological progress" is incorporated in new machinery and equipment, so that a greater effort to accumulate capital also means a greater effort to acquire and incorporate new technologies. From this it follows that the technological gap dynamic depends, among other variables, on the pace of capital accumulation. In this context, a greater capital accumulation effort will work to reduce the technological gap and thus increase the technological content of exports, in turn spurring growth of exports and the economic growth rate compatible with balance of payments equilibrium.

According to Dosi, Pavitt and Soete (op. cit., p. 199), an economy's pattern of growth is related to its pattern of technological change. Hence, considering the relative performance of countries and the balance of payments constraint, the relative level of technology applied in production not only determines each country's level of income, but also affects the possibilities for growth and the rate of capital accumulation.

The level of technological development is related to the country's pattern of specialization. Economies specialized in sectors with low income elasticity of demand are more exposed to external imbalances, which translates into lower rates of growth.

Through the development of the technological capacity, the launch of new products that represent innovations in the international market spurs exports. This in turn helps offset the higher levels of imports due to increasing income and the greater demand this generates endogenously. But innovation depends on investment in knowledge and its subsequent materialization in intermediate and final consumer goods. The emergence of new products and sectors is the result of technological change, which in turn explains structural changes. Economies that are able to develop and absorb new technologies manage to modify the sectorial composition of their industry and disseminate technological advances to the rest of the economy (Cimoli et al., 2005, p. 12).

The existence of abundant natural resources and labor can sustain high growth rates for a certain period without a great effort to invest in know-how (technology). But plentiful natural resources alone are not enough to sustain growth over the long run. This happens for two reasons. The first is that growth based on abundant factors of production does not promote structural change and increase in the productivity of the whole economy, besides

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from countries of the South) in the 1964-1995 period was 1.67, while the income elasticity of exports from the Southern countries to the Northern ones was 1.27. Therefore, the ratio between these two elasticities shows that, in long-term equilibrium, countries of the South must grow less than their Northern counterparts, thus generating a dynamic of divergence of per capita incomes over the long run.

reproducing undesirable situations of unequal income distribution, poor-quality jobs and structural heterogeneity. Second, economies specialized in natural resources are more vulnerable to changes in the international economy and shifting patterns of demand. In contrast, when the bases for growth are the incomes generated by technology and know-how, this same knowledge is an instrument that permits the economy to respond to changes in the competitive environment. Inversely, when the source of income is highly dependent on an abundant resource, the economy will tend to lack the technological capacity to adjust to new competitive situations (Cimoli et al., op. cit., pp. 32-33).

In this sense, reduction in the technological gap in the long run requires economies to be able to transform their productive structure, from a growth pattern based on income generated by the abundance of some production factor to a growth pattern based on income generated by technology. In this transformation process, the more dynamic and knowledge-disseminating sectors are expected to attain growing weight in the productive structure. The dynamic effects among sectors, along with their virtuous relationship with investment in technology, are necessary to combine rapid productivity growth with high rates of employment, reducing the structural heterogeneity that is characteristic of developing countries. According to Cimoli et al. (op. cit., p. 33), in economies with little structural change, localized increments in productivity are of little help to reduce informality and inequality.

As less developed countries make their own efforts to foster technology, their technologies or capital equipment will become more standardized, the technological disadvantage in international trade will decline and other competitive factors will gain more importance than the production costs related to the availability of labor and natural resources.

For Holland and Porcile (2005, p. 60), the reduction (or elimination) of structural heterogeneity, as well as the convergence of internal per capita income to that prevailing in the rest of the world depends on a sustained effort by each country to strengthen its technological capacities. Indeed, enhanced technological learning can generate a long-term increase in technological capacity. A possible corollary of the reduction in structural heterogeneity is the change in the productive structure in the sense of diversifying exports toward goods with more technological and demand dynamism.

Therefore, a reduction in the technological gap induces a reduction of structural heterogeneity and an increase in the wage level of developing countries vis-à-vis developed ones. International convergence – catching up – requires an increase in the technological capacity of more backward countries to reduce their distance from the technological frontier (Ibid, p. 57).

In the development of the model presented in the section IV, the technological gap is represented by the difference in the average age of the stock of capital between the backward country and the frontier[3], assuming that the internal economy's stock of capital is older than that of the frontier. Our aim with this model is to show how modernizing the domestic versus the external stock of capital can reduce the technological gap and thus obtain a faster growth rate without producing disequilibrium in the balance of payments.

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[3] According to Verspagen (1993, p.128), the technological gap is a ratio between the technological capacities of a certain country and the technological frontier. In this form, we can say that G (technological gap) is: G = T_n/T_s, where T is the technological capacity of the North (n) and South (s).

III – Investment in modernizing the stock of capital: A Kaldorian model

From the discussions presented in the previous section, we can advance the theoretical hypothesis that investment in the latest generation of capital equipment precedes structural change, since (i) technological progress is incorporated in new machinery and equipment; (ii) there is a not negligible technological gap between developed and developing countries; and (iii) there is a relation between the technological gap and the productive structure of developing countries. Therefore, one can conclude that structural change results in a faster process of capital accumulation, in which companies of the developing country acquire new capital goods and thus enhance their technological qualification, which works to close the technological gap.

To give a more formal treatment to the proposition above, we will introduce the analytical perspective of the Kaldor and Mirrlees's (1962) model in the context of growth models with a balance of payments constraint. In this sense, the idea of investment in the latest-generation of capital equipment derived from the Kaldor-Mirrlees model can be introduced in the model of balance of payments constraints by Thirlwall (1979), associating the dependence of the income elasticities of imports and exports to the average age of the economy's stock of capital. Elaborating in analytical form this association (see Section IV), we will draw a connection between the growth rate compatible with balance of payments equilibrium and the guaranteed growth rate. Therefore, we will show that an effort to accumulate capital can relax the external constraint.

The growth model developed by Kaldor and Mirrlees starts from the traditional Keynesian approach, in which companies investment decisions play a fundamental role in output growth. In *A New Model of Economic Growth*, technical progress is treated explicitly as a rate of modernization of the new 'vintage' of machines, as the main determinant of economic growth[4].

According to the Kaldor-Mirrlees model, in each period machines that are newly produced will be more productive than the ones produced in the previous period. Therefore, the machines produced today are technically better than past models. In other words, the fixed capital from the current vintage is more productive than that of preceding vintages. This assumption derives from the fact that the latest technology is incorporated in the most recent vintage. The theoretical hypothesis of this model is that the machines used in a determined vintage have the same efficiency over their useful lifetimes, but machines from the last vintage are more productive than past models.

However, a machine can be retired before it reaches the end of its useful life due to 'technological obsolescence'[5]. The minimum condition to keep the machine in operation is when the revenue generated by a worker operating this machine (P_{t-T}) is exactly equal to his remuneration (W), both in real terms[6]:

$$P_{t-T} = W_t \qquad (1)$$

Equation (1) indicates the moment the machine ceases to be profitable, that is to say the economic profit becomes zero. When the revenue of the machine reaches this point in

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[4]See also Kaldor (1957).

[5] The term employed by Kaldor and Mirrlees when the machine's profitability becomes zero. Thus the capital good will be in operation only as long as its revenue is greater than or equal to its variable costs.

[6] Where the subscript (*t-T*) means the number of years the machine has been used until today, and so *T* means the number of years the machine is designed to operate, that is, its lifetime.

time (Eq. 1), it means that it has become technologically obsolete. Profit is the stimulus for the entrepreneur to invest in 'new and more modern machines', to replace unprofitable ones and boost productivity, and consequently national income. This process throughout the economy represents investment in modernization of capital that increases economic productivity.[7]

Besides the profit incentive, the process of replacing machines, i.e., modernization of the stock of capital, can speed up when: (i) the real wage increases faster than productivity[8], and (ii) the 'technology incorporation rate' accelerates, i.e., more new machines appear in the market in a shorter period of time because of faster incorporation of the latest technical innovations. The inverse would lengthen the average economic lifetime of capital (by delaying the technological obsolescence of capital).[9] From the standpoint of international competition, a longer economic lifetime of the domestic stock of machines could impair competitiveness relatively to foreign competitors.

In summary, for Kaldor and Mirrlees the introduction of machinery and equipment of the latest generation is fundamental to determine the pace of economic growth. If, on the one hand, these investments expand productive capacity and increase aggregate productivity, on the other, by boosting demand from capital goods industry, they can accelerate the incorporation of innovations in the machines the capital goods sector produces. The capital goods sector, by its dynamic nature, plays an important role in determining economic growth and a country's type of international insertion. Hence, the process of industrialization toward more dynamic sectors can also permit technological progress to be reflected in an increase in wages instead of just a reduction in prices.

IV – An accumulation model with external constraint

In order to develop our analytical model showing that capital accumulation, under certain conditions, can overcome external constraint on growth, we shall now introduce Thirlwall's concept of growth rate of the balance of payments. A simple formalization of the concept of growth rate compatible with balance of payments equilibrium can be found in Thirlwall (1979), McCombie e Thirlwall (1994)[10] among others. For our aim, we follow from the growth rate of real output that is compatible with balance of payments equilibrium:

$$y_t = \frac{\varepsilon_t}{\pi_t} z_t \qquad (2)$$

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[7] Kaldor and Mirrlees (1962), as well as Kaldor (1957), argued that the rate of productivity growth, as well as that of technical progress itself, is endogenous to the growth rate of the investment per worker. However, part of technical progress is due to improvement in human capital.

[8] This can happen when wage goods become relatively more expensive than capital goods and when the local currency appreciates, in the case of an open economy.

[9] However, the rate of incorporated new technology depends on the nature of the capital good to which it is incorporated. Capital goods with low technological intensity tend to have a slower incorporated rate than do those that have greater technological content. For example, the rate of technology incorporated in the machinery used in the food industry is comparatively slower than that in the aeronautical industry.

[10] See also Atesoglu (1997).

Where y_t is the growth rate of output, ε_t is exports income elasticity, π_t is imports income elasticity and z_t is the rate of growth of the rest of the world income. Equation (2) is the well known "Thirlwall's law". This law, as represented, requires that the international mobility of capital is equal to zero so that countries cannot borrow to finance the deficits on current account[11]. We will assume in this paper that the current account deficit has negligible impact on the rate of growth consistent with the balance of payments (McCombie and Roberts, 2002, p 95). Thus, Equation (2) can be considered a good approximation of the external constraint to economic growth in the long run.

By assumption, capital accumulation does not affect "Thirlwall's law" since the income elasticities of exports (ε_t) and imports (π_t) depend on the productive structure, which is considered to be independent of the pace of capital accumulation. Figure 1 illustrates the equilibrium line of the balance of payments (the 45-degree line) established by equation (2). The region above this line represents an external surplus and that below it an external deficit. Point A represents a situation of equilibrium.

Figure 1: Possible combinations between y_t and z_t and the external constraint
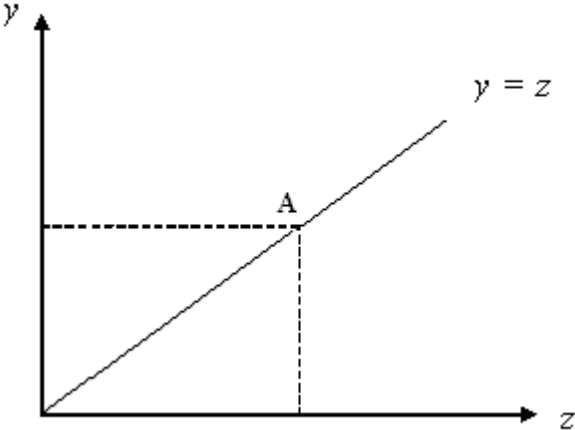
Our objective below is to endogenize the income elasticities of Thirlwall's model to make them dependent on the average age of the stock of capital in the economy, following Kaldor and Mirrlees (1962). We assume that the more modern or newer an economy's capital goods are, the greater will be the technological content of its output, and hence the greater the income elasticity of its exports and the lower the income elasticity of its imports. Therefore, it is possible to associate the growth rate compatible with equilibrium in the balance of payments and the guaranteed growth rate. An increase in the effort to accumulate capital, with an impact on the productive structure, will lead, through modernization of the industrial park, to an increase in the technological content of exports and hence an increase in the income elasticity of exports and the growth rate compatible with balance of payments equilibrium.

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[11] An extension of Thirlwall's model for an economy with capital flows has been made by Moreno-Brid (1998-1999), among others.

Thus we assume that the ratio between these elasticities is linked to the technological gap and has an inverse relation with the ratio between the useful lifetimes of capital goods in domestic economies and foreign economies:

$$\frac{\varepsilon_t}{\pi_t} = f_1\left[\frac{T_t}{T_t^*}\right], \qquad f_1' < 0 \quad (3),$$

where T_t is the average useful life of domestic capital goods, T_t^* is the average useful life of foreign capital goods, and the ratio between the two variables is a measure of the technological gap. Thus, the productive structure of both economies (domestic and foreign) will depend on the average age of the stock of capital in each one.

If $T > T^*$, that is, the time interval after which the domestic equipment is replaced, is greater than that abroad, the pace of substituting domestic capital equipment is slower than it is abroad, meaning that technical progress occurs faster abroad. This causes the technological gap between the two economies to widen[12]. With this reasoning, we can assume there is an inverse relation between the variation of the income elasticities of exports and imports and the ratio T_t / T_t^*. Suppose that occurs a fall in the income elasticity of exports ε relatively to the income elasticity of imports π. Then we assume this decline indicates that the rate of substitution of capital equipment in the domestic economy has become slower than that in the external economy, i.e., the ratio T_t / T_t^* has increased. Therefore, if $T > T^*$, then $\varepsilon < \pi$. The inverse reasoning also applies.

Based on the Kaldor-Mirrlees model (1962), we consider that:

$$T = f_2\left(\frac{w}{q}\right), \qquad f_2' < 0 \quad (4)$$

where w is the rate of increase of real wages and q is the growth rate of labor productivity.[13]

Based on Foley and Michl (1999, p.25), and assuming full utilization of productive capacity (as in the Kaldor-Mirrlees model), we can express the rate of profitability (r) as:

$$r = f_3\left(\frac{w}{q}\right), \qquad f_3' < 0 \quad (5)$$

In the sequence we can write,

$$T = f_4(r) \qquad f_4' < 0 \quad (6)$$

Considering equations (4) and (6), we have:

$$\frac{T_t}{T_t^*} = f_5\left(\frac{r_t}{r_t^*}\right), \qquad f_5' < 0 \quad (7)$$

Equation (7) shows that the ratio between the average useful lifetime of domestic capital equipment relatively to that of foreign capital equipment depends on the ratio between the domestic and foreign rates of return. If wage costs are growing faster in the

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[12] As in Cimoli (2005).
[13] It is worth noting that q is defined in physical terms. If we define a variable p, meaning the real growth rate of the revenue generated by a worker operating a machine, so q is equal to p. This observation is important because it stress that q is the revenue in physical terms.

domestic economy than they are abroad, decreasing domestic rate of return, then domestic capitalists will accelerate the investment to modernize their capital equipment to enable obtaining higher productivity, to sustain profits in the face of the upward movement in wages.

Given this hypothesis, the difference in the technological gap between two periods will show the ratio of the unit cost per domestic worker vis-à-vis the unit cost of per foreign worker. In this model, when the growth of the wage rate increases faster than the growth of worker productivity, firms will try to accelerate the modernization of their capital equipment to defend themselves against the fall in profitability[14]. In the Kaldor-Mirrlees model, wages are negatively correlated with the average useful life of machinery, making T an endogenous variable. When wages increase, T decreases, prompting firms to replace old machines with new, more productive, ones.

Assuming the existence of static and dynamic economies of scale such as that the growth of labor productivity in both economies depends on the growth rate of real output[15], so we can substitute equation (7) in equation (3) to produces:

$$\frac{\varepsilon_t}{\pi_t} = f_6\left(\frac{r_t}{r_t^*}\right), \qquad f_6' < 0 \qquad (8)$$

Then, substituting equation (8) and equation (2) leads to:

$$\frac{y_t}{z_t} = f_7\left(\frac{r_t}{r_t^*}\right), \qquad f_7' < 0 \qquad (9)$$

We finally have, according to our hypotheses about the structure of the economy, the equation of economic growth with the balance of payments constraint. Equation (9) shows that the higher the domestic rate of return is vis-à-vis its external counterpart, the slower the pace will be of modernizing the domestic stock of capital vis-à-vis the pace abroad. This implies that domestic output will grow at a slower rate than in the rest of the world. With a higher rate of return in the domestic economy, companies feel less pressure to invest to modernize the country's stock of capital. Therefore, the model assumes induced innovation as a passive element of the investment on capital expenditure. The technological gap determines the difference between the income elasticities of exports and imports, and this in turn depends on the ratio between the useful lifetimes of domestic and foreign capital equipment.

To evaluate the economy's growth dynamic, we start from the assumption that the growth rate of productive capacity (or potential output), $\overline{y}$, is proportional to the growth of the stock of capital k, according to Domar (1946). Thus we write:

$$\overline{y} = \sigma.k \qquad (10),$$

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[14] See Marquetti (2004).

[15] If we are assuming that "Kaldor-Verdoorn law" is valid, we can write: $q_t = \alpha + \lambda.y_{t-1}$ and $q_t^* = \alpha + \lambda.z_{t-1}$

So, we can substituting the rate of capital accumulation (k) for the growth rate of national output (y) in the Kaldor-Verdoorn equation, we have the following for both economies: $q_t = \alpha + \lambda.k_{t-1}$ and $q_t^* = \alpha' + \lambda.k_{t-1}^*$.

where σ determines the pace of growth and is called the social productivity of capital. Applying the relation of equation (10) to the internal and external growth rates, we have that:

$$\frac{\overline{y}_t}{\overline{z}_t} = \sigma \frac{k_t}{k_t^*} \qquad (11)$$

We assume that the growth rate of the desired stock of capital by companies has two components: one autonomous, given by g_0, and another dependent on the ratio between the domestic rate of return and that prevailing in the rest of the world[16], g_1. This comes from the hypothesis of capital mobility among countries, so that an increase in the rate of return in the domestic economy relatively to the rest of the world will induce an increase in the foreign direct investment in the domestic economy, thus boosting growth of its stock of capital. Therefore, we have:

$$\frac{k_t}{k_t^*} = g_0 + g_1\left(\frac{r_t}{r_t^*}\right) \qquad (12)$$

For there to be balanced long-term growth it is necessary for output to grow at a rate equal to growth of productive capacity. More precisely, this means that:

$$\frac{y_t}{z_t} = \frac{\overline{y}_t}{\overline{z}_t} \qquad (13)$$

From equations (11), (12) and (13), we have:

$$\frac{y_t}{z_t} = \sigma\left[g_0 + g_1\left(\frac{r_t}{r_t^*}\right)\right] \qquad (14)$$

Equation (14), illustrated in Figure 2, gives the ratio between the growth rate in the domestic economy and its counterpart rate in the rest of the world, when the domestic economy is on a balanced growth path. On this path, output and productive capacity expand at the same rate. It is thus a concept equivalent to that of the "guaranteed growth rate" of Harrod's (1939) model.

Equations (9) and (13) form a dynamic system with two equations and two endogenous variables, namely: (i) the relative structure of rates of return (ii) the relative structure of the rates of growth. Determination of the system's endogenous variables can be seen in Figure 2.

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[16] The capital accumulation structure follows the tradition of the Harrod-Domar model, which ignores financial capital, that is, there is no external financing to companies. Instead, companies finance themselves through retained earnings.

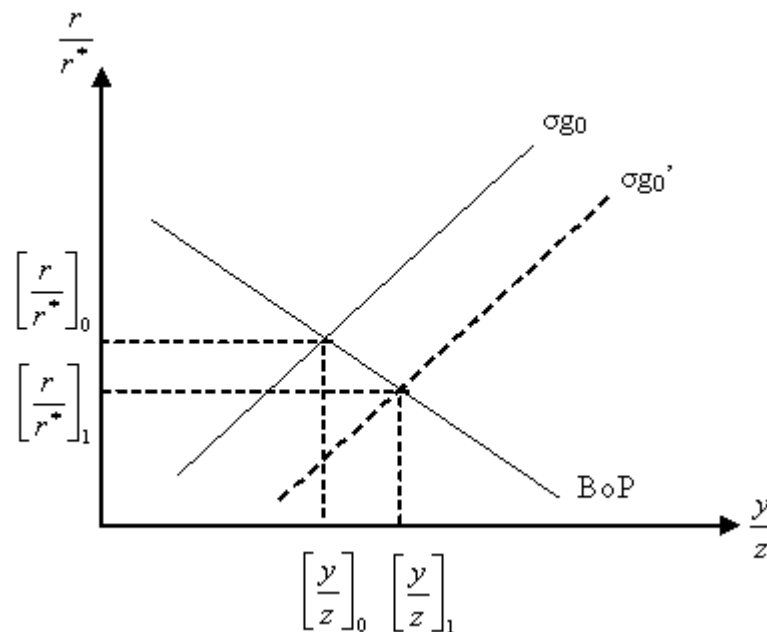**Figure 2: Balanced growth with structural change**

Figure 2 shows what happens to the growth dynamics if there is an exogenous increase in the growth pace of the desired stock of capital by firms, i.e., an increase in autonomous investment. This increase will shift the locus of balanced growth downward and rightward, thus increasing the domestic economy's growth relative to that prevailing in the rest of the world. However, this acceleration in the accumulation of capital will initially cause disequilibrium in the balance of payments, in the form of a current account deficit.

For the external equilibrium to be reestablished it is necessary for the domestic rate of return to decline relatively to that in the rest of the world, to induce investments in more modern and productive capital equipment in the domestic economy to counteract the fall in profitability. It happens that the greater investment in capital equipment will act to reduce the technological gap, thus causing an increase in the ratio between the income elasticities of exports and of imports. This causes a structural change in the domestic economy that acts to increase its growth rate compatible with balance of payments equilibrium.

From this argumentation we can conclude that the external constraint on long-term growth can be relaxed through a structural change that narrows the technological gap between the domestic economy and the rest of the world, a change that is induced by a greater effort to accumulate capital by domestic firms. It thus follows that capital accumulation is the engine that drives long-term growth for countries that are below the "technological frontier".

V – Capital accumulation and structural change: the Brazilian experience.

From the post-War until 1980, Brazilian economy grew at high rates, dragged by capital accumulation. During the three and a half decades since the end of World War II three development plans were implemented - *Plano de Metas* (1956-61), I (1968-73) and II (1974-79) National Development Plan - which contributed to promote significant changes in the productive structure of the country. In spite of these changes, Brazilian economy

continued to be rather closed (opening of the economy started in late 1980s), and so characterized by an 'inward oriented' growth pattern. As change in productive structure resulted from an import substitution strategy, with the leadership of state owned enterprises and foreign direct investment, we consider the Brazilian economy during the 1950-1980 period an interesting case to illustrate the relevance of the theoretical model, as well as the conceptual framework relating structural change and external constraint, discussed in the above sections.

Brazilian economic performance from 1947-80 – average growth rate above 6% aa - exceeded the observed in all developed and developing countries during the same period. This extraordinary rhythm of growth was interrupted by the external debt crisis in 1980-81, which brought constraints to the kind of financing employed by the development policies adopted until then.[17]

The period of accelerated growth was characterized by intense import substitution and absorption of foreign direct investment, which resulted in the consolidation of the domestic industry.[18] Table 1 illustrates the changes of the productive structure from 1947 to 1980; with industry increasing its share in GDP from 26.0% in 1947 to 44.1% in 1980. In terms of manufacturing and mining industries the share in GDP increased from 20.3% to 34.8%, respectively. Manufacture and mining industries pushed growth rate of the economy, expanding, on average, 8.6% aa from 1947 to 1980.[19]

Table 1: Brazil main sectors of activity as share (%) of GDP
(1947, 1960, 1970, 1980)

Sectors	1947	1960	1970	1980
Agriculture	21,4	18,3	12,3	10,9
Industry	26,0	33,2	38,3	44,1
Manufacturing and Mining	20,3	27,1	30,1	34,8
Civil Construction	4,6	5,0	5,8	7,3
Public Utility Industrial Services	1,1	1,1	2,4	1,9
Services	55,7	51,5	56,2	52,7

Source: IBGE-National Accounts

The augmented participation of industry in the productive structure was also accompanied by broad diversification of its structure. The 1970s marks the establishment of a well developed production structure of durable and intermediary goods, concluding an important stage of the process of import substitution.[20] The diversification in the industrial

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[17] From 1980 to 2008, the average GDP growth was around 2.7% aa, with the priorities of economic policy aiming especially to stabilize prices and control the external accounts. A new growth cycle started in 2004, but the financial crisis in the developed world suddenly interrupted this growth trend. The average growth rate of GDP in the latter period (2004-2008) was 4.7% aa, at the same time the investment rate rose from 15.5% in 2004 to 18.5% in 2008, according to the national accounts.

[18] According to Cassiolato and Lastres (2005, p. 1226), in 1980, Brazil concentrated the largest stock of foreign investment (US$ 17 billions) among developing countries.

[19] This expansion was not continuous over time, standing out the period 1963-67 as the least dynamic (average growth of 2.7% aa). From 1968 onwards begins the phase of faster growth, with industry growing 9.8% aa.

[20] In 1980, according to the Industrial Census (IBGE) more than 50% of the value added of manufacturing and mining industries were of products classified as scale-intensive (38.6%), differentiated (11.7%) and engineering-based (2.8%).

production also led to the diversification of exports: in 1964 the share of manufactured and semi-manufactured goods reached 14.0% and in 1980 this percentage increased to 57.0%.[21]

The strategy of industrialization through import substitution supported by tariff and non tariff barriers meant closing the economy and therefore the import coefficient (the share of imports in total foreign trade of the country) was around 50% until 1970, expanding in the 1970s, particularly after the first oil shock. The average coefficient of the period 1947-80 was 52%.[22]

As mentioned, economic growth driven by capital accumulation, and supported by development plans and by foreign direct investment, characterized an economic model of industrialization 'inward oriented'. The share of exports in GPD was below 10% throughout the period, unless the first two years after the War. The rate of investment, in turn, showed an upward trend, starting from 14.7% in 1947 and reaching 24.0% in 1980.

The financing of this process was done, in a large extent, with foreign investment and by state owned enterprises. It is in relation to the external sector that the Brazilian industrialization model showed its vulnerability. The large size of the Brazilian domestic market, as well as the use of protectionist policies to induce industrialization, did not contributed to the improvement of external competitiveness of the industrial sector. One consequence of this bias resulted that exports, even rather diversified, were of products with low technological content, basically.

In terms of the model summarized in Figure 2 this outcome means that the increase in the accumulation rate from the post-War period onwards increased the potential of growth of the Brazilian economy and reduced the technological gap. However, as mentioned, the acceleration in the accumulation of capital causes disequilibrium in the balance of payments in the form of current account deficits. As seen, to reestablish the foreign equilibrium in order it becomes compatible with the greater growth potential, it is necessary that the external sector becomes more competitive. Looking at the Brazilian case, this means to say that the import substitution strategy should have reached also the capital goods industry and sectors more intensive in technology, in order to increase the income elasticity of exports in relation to the income elasticity of imports. According to the Kaldor-Mirrlees model, the incentive to investment in new and more productive equipment would come from the fall in the domestic rate of return relatively to the developed economies. Our model suggests that, in the Brazilian case, domestic rates of return, due in great extent to the high degree of protection of domestic market, were kept higher in Brazil than in developed countries, and in this sense it did not contribute to the technological catch up.[23]

Following the theoretical and conceptual approach presented in section II, a productive structure that is dominated by industries with comparative advantages in the production of goods intensive in natural resources and low technology can sustain high growth rates only over a relatively short period of time. External finance can extend the period of accelerated growth, but one must pay attention to the negative effects of this process. As the external debt rises, the degree of vulnerability of the economy increases,

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[21] It is worth noting that even with the debt crisis in the 1980s, considering only manufactured exports, these amounted to more than 50% of total exports in 1981, and this percentage has remained at this level or above until 2008, when it fell to 47.0% (MDIC).

[22] In the 1980s, according to the national accounts, due to the adjustment in the production structure caused by external constraint, this average fell to 40.0%.

[23] According to the national accounts, the share of wages in total output decreased from 40.7% in 1970 to 38.4% in 1980.

and the country is susceptible to a setback in its growth rate, as external financial conditions may change unfavorably. This was the case in early 1980s when international financial markets ceased to lend to highly indebted countries like Brazil and other Latin American economies, after the Mexican default in 1982.

Figure 3 illustrates the evolution of the Trade Balance and Capital and Financial accounts from 1947 to 1985. From 1947 until the end of the 1960s, the entrance of direct investment and changes in the productive structure helped to sustain balance of payment equilibrium. From 1970s onwards, the increased absorption of external savings was made possible by the significant increase in the availability to international liquidity. The interruption of financial flows in 1982 lead to a dramatic contraction in domestic demand, in order to generate high surpluses in the trade balance to help to fulfill debt commitments. According to Castro and Souza (2004), high trade surpluses after 1982 were made possible because structural changes had occurred in the Brazilian industry, basically those engendered by the II National Development Plan. As soon as the external problem had been controlled by the middle of the decade (1984-1985), GDP grew at significant rates (growth rates of GDP in 1984, 1985 and 1986 were 5.4 %, 7.8% and 7.5% respectively). It seemed then that the economy was returning to its growth path as shown in the 1950-80 period. However, after this heroic moment that followed the recession of the early 1980s, growth rates, paraphrasing Castro (2008), were close to semi-stagnation.[24]

Figure 3: Trade and Capital and Financial Balance
US$ million
1947-1985
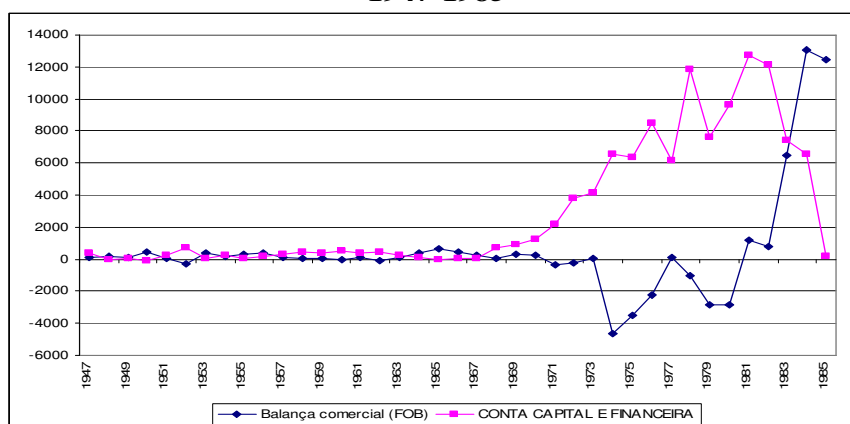
Source: BCB: Banco Central do Brasil, Balance of Payments.

So, after the debt crisis in early 1980s, Brazilian economy showed a falling rate of capital accumulation, with severe consequences to its long term rate of growth. According to the model proposed in section IV, the decrease in capital accumulation implies a decrease in the equilibrium rate of growth of balance of payments.[25] This outcome becomes

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[24] It should be remarked that during the 1980s and early 1990s Brazilian economy moved towards a high inflation regime. Because of that, real wages showed high volatility, productivity stagnated and long term investments were strongly disincentivated. According to Kilsztajn (1998), the rate of net profits in Brazil were more than twice those observed in developed countries in the 1980s.

[25] For an interpretation, having the Solow-Swan model as theoretical reference, for the stagnation of the Brazilian economy after the 1980s, see Bacha and Bonelli (2005).

more dramatic considering that world economy since the 1990s shows a greater integration. This scenario puts more weight on the need for the Brazilian economy to reduce the technological gap in order to increase its long-term growth rate.

VI – Conclusions.

In this article we have argued that the external constraint to long-term growth – represented by the ratio between the income elasticities of exports and imports – can be relaxed through an effort to accumulate capital that prompts a structural change in peripheral economies, so as to reduce the technological gap.

Based on the structuralist-evolutionary literature we have argued that a country's pattern of specialization is related to its level of technological development. Developed countries have a greater number of economic sectors where firms operate on the "technological frontier" because they have a higher base (benchmark) of technological development than do developing countries. Thus, the exports of developed countries mainly consist of products with higher added value and technological content. The technological development embodied in the production of consumer and capital goods leads to a structural composition of industry where sectors with greater technological intensity prevail. For long-term growth, we assume that the local development of technology is more consistent than importing it.

From this perspective, to close the technological gap, peripheral economies must be able to transform their productive structures, shifting toward sectors whose earnings are derived more from exploiting knowledge, in detriment to sectors whose earnings come mainly from the abundance of a production factor. In this sense, we observed that the existence of abundant natural resources and labor is, by itself, not sufficient to sustain long-run growth. Therefore, economies specialized in sectors with low income elasticity of demand are more exposed to external imbalances, translating into lower rates of output growth.

To formalize the relation between structural change and capital accumulation, we developed a model based on the contributions of Kaldor in the late 1950s and early 60s – whereby investment to modernize capital equipment permits the absorption of new technologies and hence enables the production of goods with growing technological content – and the 1970s, examining the restriction on demand imposed by the balance of payments equilibrium. The growth model proposed with these characteristics can be considered 'hybrid'. So the theoretical model developed showed the logical possibility that an increase in the desired rate of capital accumulation allows, through modernization of the existing capital equipment, to increase the technological content of domestic production, thus increasing the income elasticity of exports and reducing the income elasticity of imports.

The historical experience of the Brazilian economy during the post-War period until 1980 illustrates the validity of the hypothesis suggested in this paper. Indeed, in this period the Brazilian economy underwent a great structural shift induced by the accumulation of capital. This structural change permitted relaxing, even if only temporarily, the external constraint to growth, enabling high rates of real output growth.

The acceleration in capital accumulation during the 1950-1980 period came mainly from autonomous investment, both by the government and from foreign direct investment. This situation changed starting in the 1980s, when the external debt crisis triggered a series of macroeconomic imbalances that undermined Brazilian economic growth. During the

phase of accelerated growth, the technological gap narrowed, but the failure to consolidate local production of technology because of subsequent external restrictions prevented the continued closing of this gap. Since the economic opening of the 1990s, the productive structure has increasingly been specialized in natural resources.

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