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STRUCTURAL HETEROGENEITY, AND ENDOGENEITY OF ELASTICITES ON THE BALANCE-OF-PAYMENTS CONSTRAINED GROWTH MODEL[*]

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SUMÁRIO

RESUMO

O objetivo deste trabalho é demonstrar que, especialmente nos países em desenvolvimento, mudanças na taxa de câmbio real afetam estruturas de produção e a elasticidade-renda da demanda por importações e exportações, – e, consequentemente, as restrições ao crescimento da balança de pagamentos na forma da Lei de Thirlwall. Se esta última é reduzida, então tais países estão aptos e alcançar uma taxa de crescimento maior no longo prazo. Desta forma, seguindo Dosi, Pavitt e Soete (1990), apontamos como uma desvalorização da taxa de câmbio real afeta a heterogeneidade produtiva de uma economia, pela redução de seus salários reais. Além do mais, demonstramos que as elasticidades são endógenas, com base no argumento que uma taxa de câmbio subvalorizada incentiva pesquisa e a inovação. Isto é devido ao seu impacto positivo nas condições de auto-financianmento e acesso ao crédito, tornando possível modernizar e diversificar a estrutura de produção. No longo prazo, isto implica uma expansão da capacidade exportadora e uma redução da dependência das importações. Ademais, de acordo com Kaldor e Mirrlees (1962), apresentamos um modelo que formaliza a endogeneidade das elasticidades, tornando-as dependentes da idade média do estoque de capital da economia. Por fim, demonstramos como a abordagem sugerida neste trabalho é uma melhora na análise SED *(Structural Economic Dynamics)*, indicando como variações nas taxas de câmbio real alteram a composição setorial da economia. Nas considerações finais, apresentamos uma série de argumentos que apóiam a hipótese de que elasticidades são endógenas à taxa de câmbio real.

Palavras-chave: *Restrições na Balança de Pagamentos, Taxa de Câmbio Real, Heterogeneidade Estrutural*

ABSTRACT

The aim of this paper is to demonstrate that, especially in developing countries, changes in the real exchange rate affect both the structure of production and the income elasticities of the demand for imports and exports – and, as a result, the balance-of-payments constraint to growth in the fashion of Thirlwall's Law. If the latter is weakened, then these countries are able to reach a higher long-term growth rate. Thus, following Dosi, Pavitt e Soete (1990), we show how a devaluation of the real exchange rate affects an economy's productive heterogeneity, by reducing its real wages. In addition, we demonstrate that the elasticities are endogenous, based on the argument that maintaining an undervalued exchange rate encourages research and innovation. This is due to its positive impact on self-financing conditions and on the access to credit, making it possible to modernise and diversify the structure of production. In the long-term, this implies an expansion of the export capacity and a reduction of the dependence on imports. Furthermore, based on Kaldor and Mirrlees (1962), we present a model that formalises the endogeneity of the elasticities by making them dependent on the average age of the capital stock of the economy. Lastly, we show how the approach suggested in this article is an improvement on the Structural Economic Dynamics (SED) approach, by demonstrating how variations in the real exchange rate alter the sectoral composition of the economy. In the final considerations, we present a series of arguments supporting the hypothesis that elasticities are endogenous to the real exchange rate.

Key words: Balance-of-Payments Constraints, Real Exchange Rate, Structural Heterogeneity

JEL: E10, O11, O31

1. INTRODUCTION

The relationship between the exchange rate and economic growth is an intriguing aspect, in both developed and developing countries. Specifically, the essential question is to find out what is the impact of the real exchange rate on growth, especially in the long-term, since the effects of its variations on aggregate demand, after the rate has adjusted to the new level, are not clear. There are two main approaches to the issue. On the one hand, there is the mainstream literature based on growth accounting sources, according to which the long-term impact of the real exchange rate on growth basically depends on how it affects Total Factor Productivity. On the other hand, there is the Keynesian-Structuralist approach, which shows that the exchange rate policy is an important tool capable of affecting both long- and short-term output and employment. From this point of view, the exchange rate level may have a permanent effect on long-term growth, because the income elasticity of imports and exports reacts to the level of the real exchange rate, and/or because it influences the growth of labour productivity and capital accumulation in the fashion of Thirlwall's (1979) approach (Barbosa-Filho, 2001).

These theoretical insights provide the basis for our paper. Its aim is to analyse the relationship between the exchange rate, structural heterogeneity and the income elasticities of demand for exports and for imports in developing economies. The basic hypothesis is that maintaining an undervalued real exchange rate leads to the diversification of both investment and output, mainly in the sectors which compete in the international market. Such greater diversification has the effect of weakening the restrictions resulting from the necessity of maintaining the balance-of-payments equilibrium. Thus, the exchange rate policy can influence growth not only by increasing competitiveness, but also by providing the necessary incentives for greater technological development. This means that, in addition to affecting aggregate demand, this policy also influences long-term supply, especially regarding exports. This is reflected in the income elasticities of demand for imports and exports, and justifies the argument that they are endogenous to the level of the real exchange rate.

We thus set out the theoretical arguments that support that elasticities are endogenous. Using structuralist arguments, we show how changes in the real exchange rate have an effect on the structure of production. More specifically, following Dosi, Pavitt and Soete (1990) it is shown how a devaluation of the real exchange rate affects an economy's structural heterogeneity by reducing real wages. This is particularly important in developing economies, because they have got a structure of production that is both specialised and heterogeneous, which can hinder accumulation. In other words, these economies largely specialise in the production of primary goods for export, while their consumption requirements in terms of durable and investment goods are provided by imports. Since, as a general rule, the income elasticity of exports for primary goods is low, while the income elasticity of imports for manufactured goods is high, it follows that the necessity of maintaining the balance-of-payments equilibrium places a greater restraint to growth.

In addition, it is assumed that the income elasticity of demand for exports and for imports is endogenous to the level of the real exchange rate. Keeping an undervalued real exchange rate provides an incentive for research and innovation, via effects on the conditions of self-financing and on the access to credit. This leads to the modernisation and diversification of the production capacity, which,

in turn, allows for both a long-term increase of the export capacity and a reduction of the import dependence. Endogeneity is thus demonstrated by the theoretical argument that these elasticities depend, amongst other factors, on the technological development and on the range of goods produced, while these last two variables are affected by variations in the real exchange rate. Endogeneity is also supported by the argument set forth by Kaldor and Mirrlees (1962), regarding the endogenous nature of the elasticities of imports and exports. According to them, the endogeneity increases insofar as the elasticities become dependent on the average age of the economy's capital stock. In this case, the model holds that innovation is introduced as a passive element in relation to capital investment. Thus, the technology gap determines the difference between the income elasticities of exports and imports. This gap, in its turn, depends on the ratio of the useful working life of the capital equipment in the domestic economy in relation to the foreign economies. This working life is inversely dependent on profitability, which is affected by variations in the real exchange rate.

Furthermore, we show how this is an improvement on the Structural Economic Dynamics (SED) approach, since it explains how variations in real exchange rate change the sectoral composition of the economy. According to SED, a country's per capita rate of growth is directly related to the growth rate of its exports, and inversely related to the sectoral income elasticities of imports. The latter are weighted by coefficients that indicate the relative share of the different sectors in the imports and exports. It is therefore argued that maintaining a moderately undervalued real exchange rate may lead to a structural change in the economy, in the sense that it may increase the participation of "advanced" sectors in the range of exports.

The paper is divided into four sections. In Section 2 we analyse the relationship between the real exchange rate and structural heterogeneity. In Section 3, we deal with the relationship between the exchange rate and the balance-of-payments constraint and with the endogeneity of elasticities. Section 4 examines the link between the approach used in this article and the Multisectoral Thirlwall's law. Section 5 sets out the conclusions.

2. THE EXCHANGE RATE AND STRUCTURAL HETEROGENEITY

Dosi, Pavitt and Soete (1990) show how a devaluation of the real exchange rate affects an economy's structural heterogeneity by reducing real wages[1]. However, the analysis presented here introduces some improvements to their work, by holding that the income elasticities of demand for imports and exports are endogenous to the real exchange rate. This makes it possible to extend the previous analysis, considering that variations in the balance-of-payments constraint are not only the result of structural changes arising from variations in wages. They are also due, amongst others, to the effects that variations of the real exchange rate have on the pattern of specialisation (via wage modifications), on the investment of the companies in research and innovation and on the conditions for financing these investments (self-financing and the access to credit)[2]. Thus, it will be demonstrated

[1] Porcile & Holland (2005) use this same structure, adding Schumpeterian contributions for analysing the relationship between the technology gap, specialisation and heterogeneity.

[2] The arguments to support this hypothesis will be presented in the next section.

that the structural change resulting from maintaining an undervalued real exchange rate creates a specialised manufacturing structure that improves the conditions of foreign equilibrium.

In order to do so, we initially suppose that there are two countries and two groups of commodities: the first type of commodity is traded with reference to its production cost (Ricardian Commodities), and the second kind, Innovative Commodities, is produced and exported by countries that develop innovative products. We shall first analyse only the Ricardian Commodities.

To simplify the analysis, let us suppose that labour is the only production cost. If the labour input coefficients are defined as $a_1, a_2, ..., a_n$ for Country A and $a_1^*, a_2^*, ..., a_n^*$ for Country B, and the commodities are indexed in the conventional manner – so that the relative labour requirements are ranked in decreasing order of the home country's comparative advantages –, we have the following discrete representation:

$$a_1^*/a_1 > .... > a_i^*/a_i > ... > a_n^*/a_n$$

Calling s each commodity, the function can be defined along the conventional continuum, $[0, 1]$:

$$D(s) = \frac{a^*(s)}{a(s)} \qquad \text{with } D'(s) < 0 \tag{1}$$

where $D(s)$ represents Country A's productivity compared to Country B, so that the greater $D(s)$ is, all things being equal , the greater will be the comparative advantage of A.

The goods s can be arranged in decreasing order of country A's comparative advantage, so that the good numbered zero ($s = 0$) represents the one for which Country A's comparative advantage is maximised. This sequence produces a curve D_S that slopes downwards at the same rate as the increase in the value of s, as shown in Figure 1. Moreover, the slope of this curve depends on the velocity with which Country A's comparative advantage decreases as it diversifies its output towards a greater number of goods s.

The international specialisation for each commodity in A or B will depend on the relative labour costs:

$$a(s).w \gtrless a^*(s).w^* \tag{2}$$

That is:

$$\omega \gtrless D(s) \tag{3}$$

with;

$$\omega = \frac{w}{w^*} \tag{4}$$

where w and w^* are the wage rates in countries A and B, respectively. The commodity $\bar{s}$, which separates each country's production, is given by:

$$\bar{s} = D^{-1}(\omega) \tag{5}$$

with $D^{-1}(\omega)$ being the inverse function of D. The specialisation process is shown in Figure 1 below. So, for a given wage ratio (w/w^*) equal to ω_0, Country A specialises in the set of commodities from 0 to $\bar{s}$, and Country B in the commodities from $\bar{s}$ to 1.

FIGURE 1
Specialisation along a "Ricardian Commodities" Continuum

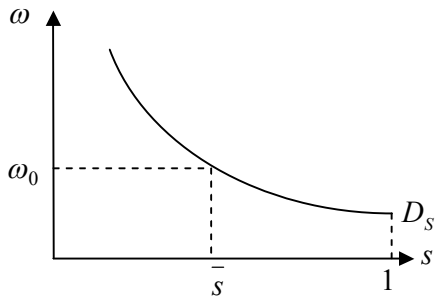
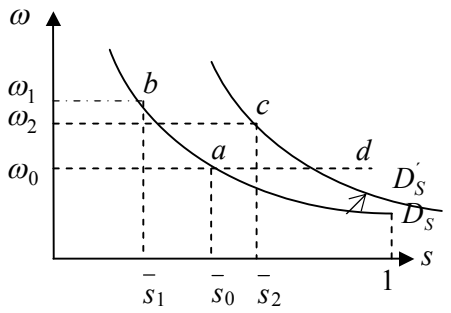


Figure 2 shows the effects of variations in wages and domestic productivity. It can be seen that an increase in domestic wages relative to foreign competitors (an increase of Country A's wages relative to Country B's) will reduce the set of commodities that can be competitively produced in this country, and vice versa (movement from point a to point b). If it is assumed that relative productivity depends on the technology gap between the countries, so that when this gap decreases the county's productivity increases, then curve D_S shifts upwards and to the right (D_S to $D_S^{'}$), and this country is now able to produce a greater range of goods with a higher relative wage (point c)[3].

[3] A productivity increase in Country A allows for the competitive production of a wider range of goods. However, given the positive effect on labour demand caused by the increased output, this kind of change in the pattern of specialisation is accompanied by an increase in relative wages. This may not be true if Country A has an abundant supply of labour, since it is possible for the level of employment to increase without a corresponding increase in wages (Point d).

FIGURE 2

Effect of Variations of Wages and Domestic Productivity



At this point, two comments should be made. First of all, real wage variations determine changes in the pattern of specialisation. And, in the second place, changes in productivity alter the level of competitiveness. As we argue later on, both variables are affected by variations in the real exchange rate.

To continue with our analysis, we suppose that, under normal circumstances, the rate of growth of a modern economic system is not limited by the labour supply, but rather by the requirement to balance the foreign accounts. It is thus possible to establish the link between the prevailing international specialisation and the Keynesian determination of the level of economic activity. Let us start with the demand function. Or, specifically, with the portion that concerns imports, because in the two-country model this is what counts in determining the balance of trade constraint of each economy. Thus:

$$Y^*.\int_0^{\bar{s}} \phi^*(s).dz = Y\int_{\bar{s}}^1 \phi(s).dz \qquad (6)$$

where the demand functions $\phi()$ and $\phi()$ are taken to be different for each country, due to the different price and income elasticities of each commodity, s. Country A's income multiplied by its propensity to import should be equal to that of country B.

$$\frac{Y}{Y^*} = \frac{\psi^*(s,\omega)}{\psi(s,\omega)} \qquad \textbf{(7)}$$

where $\psi()$ and $\psi^*()$ agree with the integral of equation (6). Since labour is the only input, the income of each economy is given by:

$$Y = w.N \qquad (8)$$

$$Y^* = w^*.N^* \qquad (9)$$

with $N \leq L$ and $N^* \leq L^*$, where N and N^* are the employment levels, less than or equal to the labour supply levels L and L^*, respectively.

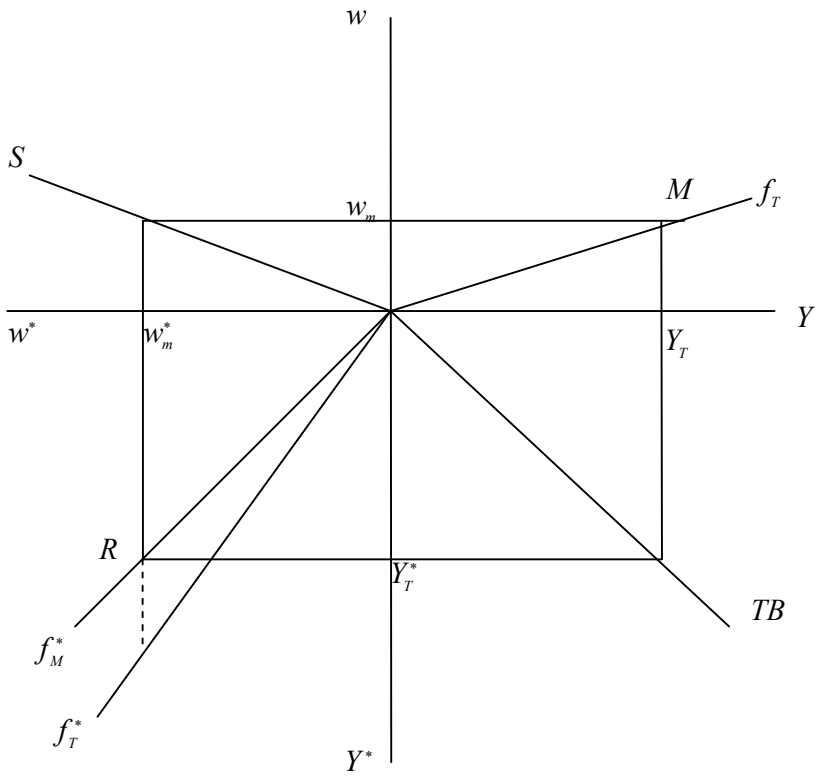
The system formed by the four homogenous equations (2), (7), (8) and (9) defines four of the seven unknown variables (Y, Y^*, N, N^*, w, w^* and the border commodity which specifies the pattern of specialisation $\bar{s}$). The system therefore defines all the limits for every price and income adjustment, determined according to: a) the technological conditions; b) the composition of the consumption basket; and c) the interdependence constraint, due to the balance of trade (Dosi, Pavitt and Soete, 1990).

Figure 3 illustrates this situation. The line S, along the upper left quadrant, is the locus of the relationship between the wages which ensure a certain level of specialisation ($\bar{s}$). The line TB represents the locus of the equilibrium points for the balance of trade at this level of specialisation. In addition, it is important to note that, since only labour costs are taken into account, the angle between any line f and the axis w measures employment in Country A, and the line between f^* and the axis w^* measures employment in country B.

To illustrate this, let us take two wage levels, w_m and w_m^*, and assume that the first is the minimum socially acceptable wage in Country A, and is equal to the average productivity in that economy. Specialisation $\overline{s_0}$ is defined by w_m / w_m^*. Furthermore, let us suppose that there is full employment in A, defined by the line f_T (point M). Therefore, the equilibrium income for Country A is Y_T, the maximum income level, while for Country B this is given by point Y_T^*. Note that this point may correspond to an income level lower than that of full employment. Let us assume that line f_T^* defines the full employment point in country B. As shown in Figure 3, this cannot be reached, given the balance of trade constraint (line TB). Thus, at point R, country B experiences significant unemployment.

FIGURE 3

Specialisation, Balance of Trade Constraints and Growth



We will now analyse the effects of another combination of wage rates for the two countries (let us say, $w > w_m$ and $w^* < w_m^*$), maintaining the level of technology and of demand. This means, in terms of Figure 3, that line S will rotate in a clockwise direction (from S_1 to S_2), increasing the number of commodities produced by B. Line TB rotates in the same direction (from TB_1 to TB_2), given that the propensity to import increased in A and decreased in B. This situation is shown in figure 4.

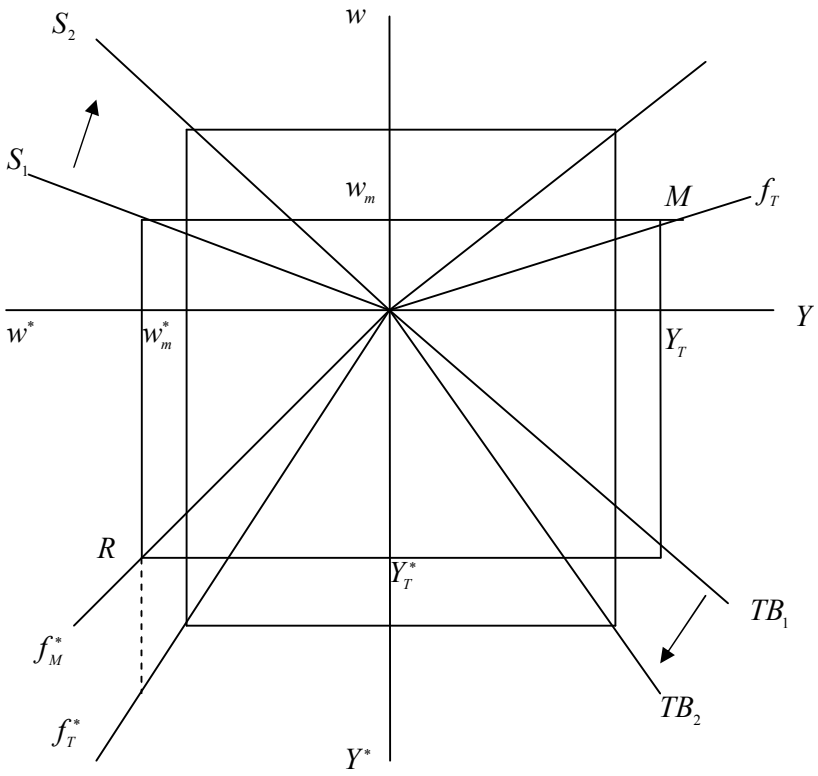
As can be seen, the wage per worker and the average labour productivity in A are now higher, but, since its import requirements have increased, this country will suffer a greater constraint as a result of the necessity of balancing the foreign accounts. On the other hand, it should also be noted that any changes whatsoever in the income-intensity of commodities, which are the result of variations in the price and income elasticities, will cause the balance of trade equilibrium constraints to become weaker or stronger for each pattern of trade. It will work in favour of the country which produces commodities with higher income-intensity, for any given specialisation.

The main point of this paper is to identify the exact mechanism which makes the curves S and TB shift to positions beyond those shown by Dosi, Pavitt e Soete (1990). It should be noted that the analysis these authors set forth allows for variations in the wage ratio (which may occur due to

variations in the exchange rate), but considers the technological situation as given. Moreover, variations in the elasticities are not fully explained. However, the mechanism proposed in this paper considers that variations in the real exchange rate, insofar as they alter the technological situation, and, hence, productivity, are capable of shifting the curve TB, notwithstanding the maintenance of the wage ratio. This means that, in terms of Figure 2, the shift from point a to point d is not explained by an exogenous productivity shock, but rather by the technological advances brought about by a devaluation of the exchange rate. As the level of technological development rises, thus causing a corresponding improvement in the level of technology embodied in the products, domestically manufactured goods become increasingly attractive and better able to satisfy domestic and foreign demand. In other words, the income elasticities change and, consequently, so does the balance-of-payments constraint to growth. We have thus identified the mechanism which explains the endogeneity of elasticities.

FIGURE 4

Specialisation, Balance-of-Payments Constraints and Growth under new ω

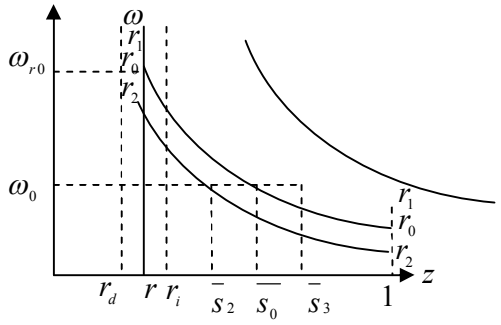


Before going deeper into this topic (Section 3), the role of innovative commodities will be included in our analysis. We take as our hypothesis the assumption that, irrespective of relative costs, these commodities can only be produced by Country A, for the simple reason that it is the only one that knows how to produce them, since it is the leader in innovation. The "commodity continuum" can therefore be reorganised according to the interval (o,l), as shown in Figure 5. Innovative

commodities are represented by the interval o and r, and Ricardian commodities by the interval r and l. The process of innovation in Country A changes the line $r_0 r_0$ to $r_1 r_1$, and increases its level of specialisation at a given wage rate, or increases the wage for a given specialisation.

It must be emphasised that the introduction of innovative commodities imposes certain restrictions to the changes in specialisation that variations in real wages can bring about. If we analyse the situation in Country B, it is easy to see that any growth in ω (given a reduction in wages) greater than ω_{r0} will have absolutely no effect at all on the specialisation in this country, but will only worsen its terms of trade. Furthermore, let us suppose that product innovation increases the output of commodities of this system (l shifts to the right in Figure 5), while, at the same time, it moves the dividing line that separates Innovative from Ricardian commodities from r to r_1. Alternatively, let us suppose that, for example, the whole process of imitation shifts the border commodity from r to r_d. Thus, if we take into account the fact that the proportionality is distributed along line $r_0 r_0$, it can be easily seen that every occurrence of product imitation will always improve Country B's pattern of specialisation and its balance-of-payment constraints. In the case of product innovation, the opposite applies. That is to say, every innovation process that increases labour productivity in Country A increases the wage and income gaps between the countries, while every occurrence of technological imitation and/or technology transference to Country B reduces these gaps. This means that every innovation process brings about divergence, and every imitation process leads to convergence between these two countries.

FIGURE 5
Specialisation in Innovative and Ricardian Commodities



However, what needs to be considered here is that the decisions companies make about spending on technology are functions of the real exchange rate. So, even though devaluation has limited effects on wage competitiveness, it must be highlighted that the number of commodities produced by Country B (which is not the leader in innovation) tends to increase, due to the effects of the devaluation on profit rates and, consequently, on investment in technology (whether it be imitative or innovative). In other words, even at point ω_{r0} a devaluation of the real exchange rate can affect the pattern of specialisation.

The last point to be made is that if the hypothesis that wages are the only production cost is modified, allowing for costs associated with capital goods which are not internally produced, then variations in the real wages will have a reduced effect on the pattern of specialisation and on the balance of trade equilibrium constraint. In the most extreme case, where all the capital goods are produced abroad and the capital/output relationship is high, then an exchange rate devaluation (wage reduction) may have the effect of reducing the number of commodities that can be efficiently produced, as well as of tightening the balance-of-payments constraint. This occurs because, although the price of capital inputs in real terms is now higher, the terms of trade have worsened.

Although this hypothesis may be correct, it is considered improbable, because, first of all, a large share of the capital inputs is internally produced. And, in the second place, in such a situation the effect of a devaluation on company profits is not taken into account, which could more than compensate for any increase in the price of inputs. Furthermore, we should take great care when assessing the hypothesis that countries which are not leaders in innovation should opt for technology imitation/transference as their strategy for growth (see Figure 5), since this policy has obvious limitations. Traditionally, in Neo-Schumpeterian theory, the essence of the catching-up process is that the wider the technological gap between leader and follower countries, the greater will be the follower countries' potential for making technological progress – as long as they have got the necessary "social capability" to take part in the process of the international dissemination of the advanced technologies developed by the leading countries (Abramovitz, 1986). However, technological backwardness is not a sufficient condition for the catching-up process to take place. A backward country requires an appropriate set of socioeconomic attributes that will allow it to make use of the "advantages of backwardness". Amongst other factors, these characteristics consist of a country's scientific and educational infrastructure, its level of spending on R&D and the qualifications possessed by its labour force. These are the attributes which constitute the National Innovation System (NIS) (Freeman, 1995; Nelson, 1993), and the more a country's NIS presents characteristics similar to those of "mature countries", the greater will be its chances of catching up with them (Albuquerque, 1999).

According to Albuquerque (1996, p. 228), the NIS concept refers to "an institutional structure which drives technological development (…) creating a **national innovation system**, enabling the flow of scientific and technological information and knowledge required for the innovation process to take place" (P. 228). The point here is the tacit and local nature of technology implicit in this concept; specifically, the idea that the NIS needs to be created, and cannot be simply imported. On the one hand, this means that the globalisation process does not homogenise technical development and, on the other hand, that the local and institutional nature of technology implies that every economy is capable of developing its own NIS, thus creating the preconditions for carrying out innovative activities. According to Freeman (2004), despite the fact that the process of market integration and globalisation continues to grow stronger, the NIS remains of fundamental importance in the development and diffusion of technological progress, because countries with more developed NISs will have better chances of carrying out innovative activities, which will lead to greater competitiveness. In relation to the previous discussion, this means that there are at least two limitations to the argument that maintaining an overvalued real exchange rate facilitates the acquisition of low-cost technology. The first is that it fails to take into account its effect on decisions made by companies about their expenditure on innovation (which depends on profits). The second point is that, to the extent that

innovation is of a tacit and local nature, the acquisition of foreign technology does not in itself guarantee that technological backwardness will be overcome. That is to say, "technical progress" must, at least in part, be established locally, and not simply imported. If not, many of the spillovers inherent to the innovation process will be lost.

3. THE REAL EXCHANGE RATE AND THE BALANCE-OF-PAYMENTS CONSTRAINTS: THE ENDOGENEITY OF ELASTICITIES

In the models of growth that include balance-of-payments constraints, first developed by Thirwall (1979), the long-term equilibrium growth rate depends on the ratio between the income elasticities of demand for exports and for imports, multiplied by the growth rate in the rest of the world. In these models, which usually assume Purchasing Power Parity (PPP), variations in the real exchange rate are considered to be irrelevant to long-term growth. However, the fact that these models accept PPP means that they ignore some of the important effects that the real exchange rate has on growth. Indeed, it is necessary to take into account that the exchange rate policy can be administered so as to alter functional income distribution, and thus change both the country's international competitiveness and the decisions of the companies regarding their expenditure plans, such as those which affect investing in research and innovation. This, in turn, brings about structural changes in the economy (changes in elasticities), highlighting the important role of the exchange rate to long-term growth. In other words, non-price competitiveness is also affected by variations in the exchange rate policy. This means that there is a link between the Post-Keynesian and Neo-Kaleckian works on growth, since variations in the exchange policy are important elements in the premises of both theoretical traditions. Specifically, the Neo-Kaleckian idea that the exchange rate can affect long-term growth, via changes in the functional income distribution, joins the Post-Keynesian propositions based on the problem of elasticities. The point is that now the elasticities become endogenous to both variations in the real exchange rate and technological change. They are, moreover dependent on these same two elements. In order to clarify this argument, we present the following points:

a) First of all, it is accepted that the income elasticity of demand for exports is a direct function of, amongst other factors, the range of products that a country produces and the level of technology incorporated in these products. As previously noted, variations in the real exchange rate alter real wages, leading to the diversification or specialisation of output. This occurs because when there is, for example, an increase in real wages, the sectors which are already at a competitive disadvantage in the international market, due to the low technological level of their products, lose space or cease to exist. The economy is thus forced to specialise in the sectors with natural competitive advantages. In the case of developing countries, this means specialisation in primary goods. It so happens that the income elasticity of demand for such products is low, which confirms that the specialisation in these sectors causes greater constraints to growth. On the other hand, a reduction in real wages (devaluation) leads to the diversification of output and, in the long-term, this means greater export capacity and less dependence on imports.

Maintaining an undervalued real exchange rate also means that it is possible to provide incentives for technological development. More specifically, by increasing the profits of companies and their self-financing capacity, exchange rate devaluation affects the availability of funds that companies have at their disposal for investment in research and innovation projects. In other words, it is argued that raising the real exchange rate leads to a (temporary) redistribution of income favouring wages (in detriment of profits), which means a reduction of the self-financing capacity of firms. This is then reflected in a reduction of the funds for acquiring new technology and lower access to financing, due to information asymmetries in financial markets that give rise to credit rationing. Thus, even though there is the possibility of obtaining cheap (foreign) technology, it is likely that various manufacturing sectors would still be incapable of investing in the modernisation of their production capacity, given the scarcity of resources and the existence of credit rationing. Therefore, it is by maintaining an undervalued real exchange rate that it can be expected of firms to undertake innovative activities that result in greater structural diversification (e.g., a greater variety of products) and structural homogenisation[4], given that, in this scenario, technical progress would be incorporated by sectors not linked to the foreign market. Since returns on innovative activities are greater for the most backward sectors, it is to be expected that such intersectoral discontinuities would be rapidly overcome.

In addition to this, it should be noted that the increase in structural heterogeneity, when favouring the *tradables* sectors as a result of maintaining an undervalued real exchange rate, makes it easier to accept the Kaldorian implications of "Verdoorn's Law". According to this law, there is a positive relationship between growth in industrial output and the rate of growth of industrial productivity – the causal connection defines that any increase in the former leads to the growth of the latter. Briefly explaining, this takes place because as production increases over time, it is accompanied by important changes in the structure of production and in the composition of demand. Both have got beneficial effects for industry, since these modifications lead to the utilisation of new production processes or involve the creation of new products. Moreover, new entrepreneurial units come into being, or existing ones are expanded, enabling the use of more modern equipment that are possibly better suited to larger production units. This means, therefore, that there is a new direct relationship between the growth of output and an increase of productivity.

The main point of this approach is that when output grows due to a rise in demand, the productivity of the affected sectors also increases. In macroeconomic terms, this means that there are dynamic economies of scale. It is worth noting that these economies of scale are associated to technological change. Thus, they are not reversible, since they result from learning-by-doing and from the growing division of labour associated to the growth of the market. The maintenance of an undervalued real exchange rate allows a greater growth of output and productivity by stimulating

[4] As noted in the works of Latin-American structuralist authors, regarding the issue of structural homogeneity, the problem concerns the fact that, although certain countries have economies with a dynamic centre, it is limited to a relatively modern primary exporting sector linked to a small number of industrial and service sectors. There is a declining occupational structure, marked by high unemployment, that creates a structure of production which is both specialised and heterogeneous. In other words, structural heterogeneity refers to uneven levels of technology and productivity within the structure of production. These are brought about, to a large extent, by the system's lack of dynamism, which, in turn, is caused by the low rate of capital accumulation, the use of inadequate technology and by the disparities in workforce training. The point that needs to be highlighted here is that the majority of these elements, especially technology and innovation, are affected by the exchange rate.

foreign demand. That is to say, we return to the idea of cumulative causality resulting from the mutual feedback between growth and increasing returns, also associated to the greater technological development brought about by the expansion of output. Thus, maintaining an undervalued exchange rate leads to the growth of industrial sectors, which prompts an increase of output and contributes to the acceleration of the rate of technological change in the economy as a whole, while also increasing its competitiveness in foreign markets[5]. Furthermore, the increase in structural heterogeneity in a "dual" economy, to use Lewis's term, makes it possible to raise labour productivity by reallocating resources from the backward non-tradable sectors to the advanced tradable ones.

To summarise, therefore, it is argued that maintaining an undervalued real exchange rate leads to greater structural heterogeneity, greater technological development, greater capacity for financing investment and an increase in overall labour productivity. All of this leads, in the long-term, to a greater income elasticity of demand for exports.

A similar argument can be made for the case of the income elasticity of demand for imports, with the idea that this is a function of the number of goods manufactured in a country and the level of technology embodied in them. Therefore, insofar as the devaluation of the exchange rate increases structural heterogeneity and the technological content embodied in the goods, it reduces the need for foreign goods, and hence there is a decrease in the income elasticity of demand for imports.

b) In the second place, it is argued that structural change may actually be caused by capital accumulation, which leads to a reduction of the technology gap, since new technologies are, as a rule, embodied in new machines and equipment. In its turn, capital accumulation is critically dependent on macroeconomic policy, especially the adoption of an exchange rate policy which prioritises the maintenance of national industrial output.

In order to demonstrate this argument, we shall present a model which, according to Kaldor and Mirrlees (1962), endogenises the income elasticities of demand for exports and for imports, by making them dependent on the average age of the capital stock of the economy[6]. Thus, it can be assumed that the more modern or the newer are the capital equipment, the greater will be the technological content of the production, and, consequently, the higher will be the income elasticity of exports and the lower will be the income elasticity of imports. In other words, any increase of capital accumulation that impacts the structure of production will lead, via modernisation of the industrial infrastructure, to a rise of the technological content of exports and, therefore, to an increase of the income elasticity of exports and of the growth rate compatible with balance-of-payments equilibrium.

Formally, it is assumed that the ratio between the elasticities is associated to the technology gap and inversely related to the ratio of the useful working life of the capital equipment in the domestic economy in relation to foreign countries:

[5] See Dixon and Thirlwall (1975).

[6] It is assumed that capital accumulation does not affect "Thirwall's Law", given that the income elasticity of exports (ε) and imports (π) depends on the structure of production, which is held to be independent of the rate of capital accumulation. The point here is that these elasticities become dependent on capital accumulation, which, in its turn, is dependent on the exchange rate policy.

$$\frac{\varepsilon_t}{\pi_t} = f_1 \cdot \left[\frac{T_t}{T_t^*} \right], \qquad f_1' < 0 \tag{10}$$

where T_t is the useful working life of the domestic capital equipment and T_t^* represents the same for the foreign capital equipment. The relation between the two variables is a measure of the technology gap. Therefore, the structure of production in both domestic and foreign economies will depend on the average age of the capital stock in each economy. If $T_t > T_t^*$, that is, if the time span required for the current stock of domestic capital equipment to be replaced is greater than that of the world economy, then the pace of replacement of domestic capital equipment is lower than the rate abroad. Thus, technological development progresses more rapidly in the rest of the world, widening the technology gap between the economies.

Based on this, let us suppose that the income elasticities of demand for exports and for imports stand in inverse relation to each other, and that this ratio is T_t / T_t^*. Let us also suppose that there is a drop in the income elasticity of exports (ε_t) relatively to the income elasticity of imports (π_t). In this case, we may assume that this fall indicates that the rate of substitution of capital equipment in the domestic economy has slowed down in comparison to the foreign economy, that is, the ratio T_t / T_t^* has increased. Therefore, if $T_t > T_t^*$, then, $\varepsilon < \pi$. The opposite argument also applies here.

Then, in contrast to the Kaldor-Mirrlees (1962) model, it is held that:

$$T = f_2 \cdot \left(\frac{w}{q} \right) \qquad f_2' > 0 \tag{11}$$

where w is the growth rate of real wages and q is the growth rate of labour productivity.

In the original Kaldor-Mirrlees (1962) model, the useful working life of capital equipment is assumed to be an endogenous variable that is negatively correlated with wages ($f_2' < 0$). It is argued that when the growth rate of wages is higher than the productivity growth rate, businessmen seek to speed up the pace at which capital equipment is modernised, in order to protect themselves from the fall in profits. In other words, when wages rise, T falls, leading businessmen to replace existing machines with the latest, most productive models.

However, by contending that T is an endogenous variable that is positively correlated with wages ($f_2' > 0$), the argument put forward in (11) differs from the original model. It is proposed that the pace of modernisation of capital equipment in developing countries basically depends on profitability – i.e., investment in new equipment is dependent on profits, so that the pace of modernisation is faster when profits are higher. Moreover, it is taken into account that in credit-based systems, the rate of accumulation depends on the "financial accelerator", whereby an increase in cash

flow (profits) gives rise to an increase in investment by making access to credit easier[7]. Therefore, in terms of equation (11), an increase in the growth rate of real wages increases the useful working life of capital equipment (reduces the pace of modernisation) by lowering the rate of growth of profitability.

This argument can be used to rewrite the technology gap concept by means of the following approximation:

$$\frac{T_t}{T_t^*} = f_3.\left(\frac{w_t/q_t}{w_t^*/q_t^*}\right), \qquad f_3' < 0 \tag{12}$$

Given this hypothesis, the difference in the technology gap between the two periods will reveal the relationship between the domestic unit production costs (taking only labour inputs into account) vis-à-vis external unit production costs.

Therefore, it is known that a devaluation of the real exchange rate causes real wages to fall, which, in terms of equation (12), means a reduction of their rate of growth and, hence, of the technology gap. As demonstrated below, a deceleration of the growth rate of real wages means an increase in the growth rate of profitability. This intensifies capital accumulation and leads to the modernisation of the manufacturing structure, as a result of the incorporation of newer or more modern capital equipment. In other words, this means greater income elasticity of exports and lower income elasticity of imports.

Let us define profitability as (R):

$$R = f_4.\left(\frac{W}{Q}\right), \qquad f_4' < 0 \tag{13}$$

which may be written as a rate of variation:

$$r = f_5.\left(\frac{w}{q}\right), \qquad f_5' < 0 \tag{14}$$

and, taking equations (12) and (14) into account, we have:

[7] The argument is that when profitability rises above certain levels, companies are able to gain access to "new credit markets" – e.g., international markets – or it may even be the case that, above a certain amount of credit, they manage to access other financing mechanisms, such as pension funds. This interpretation is associated with the idea put forward by Zysman (1983) that financial structures can be divided into capital market-based systems and credit-based banking systems, the latter being found in developing countries. This means that the capital market is weak and companies therefore heavily depend on credit in order to obtain resources for investment. This situation may also be analysed according to a modified version of what is known as the "financial accelerator", a concept developed by Hyman Minsky, who based his idea on Kalecki's theory of financial risk. According to Minsky, the higher is a company's cash flow, the less it depends on external credit sources and, therefore, the lower is the risk for borrowers and lenders. Since both of these risks affect the price of the supply and demand for capital equipment, it follows that the higher is the cash flow, the stronger will be the relationship between the demand and supply price and, therefore, the greater will be the investment in fixed capital. This modified version may also thus be stated: as company profits rise, the risk for the lender is reduced and, consequently, access to credit becomes easier.

$$\frac{T_t}{T_t^*} = f_6.\left(\frac{r_t}{r_t^*}\right) \qquad f_6' > 0 \tag{15}$$

or, in terms of profitability:

$$\frac{T_t}{T_t^*} = f_7.\left(\frac{R_t}{R_t^*}\right) \qquad f_7' > 0 \tag{16}$$

Equation (16) shows that the ratio of the useful working life of domestic capital equipment as compared to foreign equipment depends on the relationship between the domestic and foreign profit rates. If the unit (output) costs of production grow more rapidly in the domestic economy than abroad, then domestic capitalists – facing a fall in profits – will be forced to slacken the rate of investment in the modernisation of capital equipment.

If we replace equation (10) with equation (16), we have:

$$\frac{\varepsilon_t}{\pi_t} = f_8.\left[\frac{R_t}{R_t^*}\right] \qquad f_8' > 0 \tag{17}$$

Equation (17) shows that the higher is the domestic rate of profit vis-à-vis its foreign counterpart, the faster will be the rate of modernisation of the domestic capital stock vis-à-vis the foreign stock. This makes the growth rate of domestic output be higher than that of the rest of the world. When the domestic rate of profit is higher, entrepreneurs tend to invest more in the modernisation of the capital stock. The model thus assumes induced innovation to be a dependent variable in relation to capital investment. Therefore, the technology gap determines the difference between the income elasticities of exports and imports, while the latter depends on the ratio of the useful working life of capital equipment in the domestic economy in relation to the foreign economies. This useful working life is inversely related to profitability, which, in its turn, is affected by variations of the real exchange rate. Hence, it is shown that the income elasticities of demand for exports and for imports are endogenous to the real exchange rate. Consequently, the growth rate of domestic income compatible with balance-of-payments equilibrium will also be a function of the real rate of exchange.

Thus, in line with the literature on models of balance-of-payments constrained growth, and based on the arguments herein presented, we have:

$$X_t = \left(P_{dt} / E_t.P_{ft}\right)^{\eta}.Y_E^{\varepsilon} \qquad \text{(Demand Function for Exports)} \tag{18}$$

$$M_t = (P_{ft}.E_t / P_{dt})^{\psi}.Y_t^{\pi} \qquad \text{(Demand Function for Imports)} \tag{19}$$

where P_{dt} is the domestic price, X_t is exports, P_{ft} is the external price, E_t is the nominal exchange rate, M_t is imports, Y_t is internal income, $\psi\ (<0)$ is the price elasticity of imports, π is the income

elasticity of imports, $\eta \ (<0)$ is the price elasticity of exports, ε is the income elasticity of exports and Y_E is the foreign income.

The difference now is that we assume that the income elasticity of demand for exports and for imports is a function endogenous to the level of the real exchange rate, i.e:

$$\varepsilon_0 = f(\bar{s}_{(\theta_0)}, a_{(\theta_0)}, I^k_{(\theta_0)}) \qquad \text{with } \frac{\partial \varepsilon}{\partial \bar{s}}.\frac{\partial \bar{s}}{\partial \theta} > 0 \ ; \ \frac{\partial \varepsilon}{\partial a}.\frac{\partial a}{\partial \theta} > 0 ; \ \frac{\partial \varepsilon}{\partial I^k}.\frac{\partial I^k}{\partial \theta} > 0 \tag{20}$$

$$\pi_0 = f(\bar{s}_{(\theta_0)}, a_{(\theta_0)}, I^k_{(\theta_0)}) \qquad \text{with } \frac{\partial \pi}{\partial \bar{s}}.\frac{\partial \bar{s}}{\partial \theta} < 0 \ ; \ \frac{\partial \pi}{\partial a}.\frac{\partial a}{\partial \theta} < 0 ; \ \frac{\partial \pi}{\partial I^k}.\frac{\partial I^k}{\partial \theta} < 0 \tag{21}$$

where $\bar{s}_{(\theta_0)}$ is the range of goods that a country produces, $a_{(\theta_0)}$ is the technical coefficient (innovative activities), I^k is the technical change (innovation is introduced as a passive element in relation to capital investment) and θ is the level of the real exchange rate. It can be seen that if, for example, the level of the exchange rate θ_1 is higher than θ_0, i.e., it is undervalued, then the following relationship for the elasticities associated with this rate is valid: $\varepsilon_1 > \varepsilon_0$ and $\pi_0 > \pi_1$.

Thus, it is possible to rewrite the aforementioned Thirwall's Law for balance-of-payments constrained growth as follows:

$$y_t = \frac{\varepsilon(\theta)}{\pi(\theta)}.y_E. \tag{22}$$

where y_t is the growth rate of domestic income and y_E is the growth rate of foreign income.

That is to say, the growth rate compatible with balance-of-payments equilibrium is equal to the result of multiplying the ratio between the income elasticity of demand for exports to the income elasticity of demand for imports (both of which are dependent on the real exchange rate) by the growth rate of the income of the rest of the world. This result demonstrates that the balance-of-payments equilibrium growth rate now also depends on the level of the real exchange rate.

If we differentiate equation (22) in relation to the real exchange rate, we have:

$$\frac{\partial y_t}{\partial \theta} = \left\{ \frac{\left[\pi(\theta).\overbrace{\frac{\partial \varepsilon(\theta)}{\partial \theta}}^{+} - \varepsilon(\theta).\overbrace{\frac{\partial \pi(\theta)}{\partial \theta}}^{-} \right]}{[\pi(\theta)]^2}.y_2 \right\} > 0 \tag{23}$$

4. THE REAL EXCHANGE RATE AND MULTI-SECTORAL THIRLWALL´S LAW

The previous sections showed how variations in the real exchange rate affect structural heterogeneity and the balance-of-payments constraint, and, as result, long-term economic growth[8]. So far, it should be pointed out that there is a link between this approach and the Structural Economic Dynamics (SED) approach. According to the latter, changes in the structure of production alter the rate of growth, since a specific growth rate is associated with each manufacturing sector (the result of their different income elasticities). This means that there is a rate of economic growth which corresponds to each specific structure of production, so that it is the sectoral differences between countries which explain the differences in their growth rates.

The work of Araújo e Lima (2007) formalises this idea by deriving a balance-of-payments equilibrium growth rate analogous to Thirlwall's (1979) within a Passinettian multi-sectoral macrodynamic analysis. The result, termed the Multisectoral Thirwall's Law, states that a country's per capita income growth rate is directly proportional to its export growth rate (that is, sectoral income elasticities multiplied by the growth rate of exports in the international economy) and inversely proportional to the sectoral income elasticities of imports. Sectoral income elasticities are weighted according to coefficients that measure the relative share of the different sectors in the range of imports and exports. Therefore, the fundamental contribution of this model is to provide an understanding of how it is that, despite the absence of international economic growth, individual economies can grow at higher rates without suffering the effects of balance-of-payments constraints, as a result of changes in the country's patterns of trade (which is reflected in the coefficients of the relative share of each sector in the imports and exports). In other words, one of the principal implications of the Multi-Sectoral Thirlwall's Law is that shifts in the composition of demand or in the structure of production that are not reflected in changes in income elasticities, but rather in changes in the share each sector represents in aggregate imports and exports, are also important for growth.

We also need to study how variations in the real exchange rate alter the relative share of different sectors in total imports and exports. It was previously argued that maintaining an undervalued exchange rate has important effects on structural heterogeneity – a moderate devaluation of the exchange rate may lead to structural changes in the economy by increasing (decreasing) the relative participation of the "advanced sectors" in the range of exports (imports). That is to say, even if variations of the real exchange rate have no effect at all on elasticities, there is another transmission mechanism, namely, the change in the sectoral composition of exports and imports. This demonstrates how maintaining an undervalued real exchange rate may have positive effects on reducing the balance-of-payments constraints and on economic growth.

In order to explain this point, equation (24) presents a reduced version of the Multisectoral Thirwall's Law:

[8] See also Porcile, Dutra & Meirelles (2007) and Porcile & Cimoli (2007).

$$y_t = \frac{\sum_{i=1}^{n} \rho_i \varepsilon_i}{\sum_{i=1}^{n} \gamma_i \pi_i} . y_E \qquad 24)$$

where y_t is the domestic income growth rate; y_E is the foreign income growth rate; ε_i is the income elasticity of exports produced by sector i; π_i is the income elasticity of imports from sector i, and ρ_i and γ_i represent the weight of sector i in total exports and imports, respectively.

Let us now suppose that there is a hypothetical economy with only two sectors – a backward and primary one (Sector 1) and an advanced and industrial one (Sector 2). Sector 1 is characterised by a low income elasticity of demand for exports and a high income elasticity of demand for imports, the inverse being true for Sector 2. In addition to this, it is assumed that, initially, these sectors have got an equal share in the total production of exports and imports (situation A), that is, $\rho_1 = \rho_2$ and $\gamma_1 = \gamma_2$. Therefore, we have:

(Situation A)

$$y_t(A) = \frac{\sum(\rho_{1(A)}.\varepsilon_1 + \rho_{2(A)}.\varepsilon_2)}{\sum(\gamma_{1(A)}.\pi_1 + \gamma_{2(A)}.\pi_2)} . y_E \qquad (25)$$

where $\rho_1 = \rho_2$, $\varepsilon_1 < \varepsilon_2$, $\gamma_1 = \gamma_2$ and $\pi_1 > \pi_2$.

We then demonstrate what happens to the domestic income growth rate when there is a devaluation of the real exchange rate (Situation B). As we have seen, a devaluation of the real exchange rate affects specialised output by increasing structural heterogeneity precisely in the the most technologically advanced sectors . Thus, it is argued that a devaluation of the real exchange rate alters the availability of funds for carrying out investment projects related to research and innovation, by increasing the profits of the companies and their self-financing capacity. It also changes the relative price of inputs, especially wages, and this causes important structural modifications in the economy via its effect on costs and competitiveness. These structural changes can be represented in a simplified manner by an increase in the number of economic sectors and/or the production of a greater variety of goods

If we maintain the hypothesis of a two-sector economy, we may assume that this structural change would be represented by the production of a greater variety of goods. It is to be expected that the greater part of this "new" production (different types of goods) would come from the advanced industrial sector, given that its output is more technologically advanced, subject to increasing returns to scale and is more likely to take advantage of economies of scope[9]. Moreover, competitiveness in

[9] Economies of scope refer to the production of more than one good. This occurs when the overall production cost of the goods is less than the sum of the costs of the separate production of each good.

this sector has got a greater influence on comparative advantages, via the differentiation of output. It is therefore to be expected that output differentiation and the search for innovation would be an intrinsic strategy of the companies in this sector.

We thus demonstrate how a devaluation of the real exchange rate modifies the level of technology embodied both in existing manufacturing output and in new types of goods, by stimulating technological development and altering the relative share of the industrial sector in the range of total imports and exports. Since this sector has got a lower income elasticity of demand for imports, and the income elasticity of demand for exports is higher, in terms of equation 26 an increase in the growth rate of this sector leads to an increase in the balance-of-payments equilibrium growth rate. Therefore, if the elasticities and the foreign income growth rate are maintained constant, it can be shown that a devaluation of the real exchange rate will cause an increase in the long-term growth rate via changes in sectoral composition – i.e., now $\rho_1 < \rho_2$:

(Situation B)

$$y_t(B) = \frac{\sum(\rho_{1(B)}.\varepsilon_1 + \rho_{2(B)}.\varepsilon_2)}{\sum(\gamma_{1(B)}.\pi_1 + \gamma_{2(B)}.\pi_2)}.y_E \tag{26}$$

where $\rho_1 < \rho_2$, $\gamma_1 < \gamma_2$, $\varepsilon_1 < \varepsilon_2$ and $\pi_1 > \pi_2$. Comparing equations (25) and (26), we have $y_t(B) > y_t(A)$.

This result makes it possible to extend and improve the theoretical findings of the Structural Economic Dynamics (SED) approach, for it shows that variations in macroeconomic policy (exchange rate policy) can alter a country's patterns of trade. This is reflected in the coefficients that measure the relative share of the different sectors of the economy in the range of imports and exports. Thus, according to this interpretation, it is possible to argue that the structure of production (which determines the sectoral composition of the exports and imports) is not the only important factor determining long-term growth rates. The way macroeconomic policies (especially exchange rate policies) are managed is also of fundamental importance, since it is capable of altering the structure of production. In other words, the novel feature presented here is that, contrary to the SED approach, which does not explain how structural change takes place, we now have at our disposal a link that shows how it comes about as a result of exchange rate policy management.

5. CONCLUSIONS

One of the conclusions of the balance-of-payments constrained growth model is that variations in the real exchange rate have no long-term effect. This occurs because, on the one hand, they do not affect the main determinants of growth (i.e., income elasticities), and, on the other hand, because the empirical evidence tends to show, under the scope of this kind of model, that the effects of such variations are minimal. However, this conclusion arises from the fact that the majority of these studies

ignore the effects that variations in the real exchange rate have on the structure of production. It may be forthrightly asserted that these studies ignore the effects of the real exchange rate on the structure of production, on technological development, on productivity and on the income elasticities of demand for imports and exports.

This article has presented the arguments that demonstrate how variations in the real exchange rate have important consequences for long-term growth. Indeed, it has been shown that such variations change production costs by affecting real wages, which creates incentives that are capable of altering an economy's structure of production. This sort of structural change is also caused by the effects variations in the real exchange rate have on both the terms of financing (self-financing and access to credit) and on the companies' expenditure plans, especially regarding research and innovation. It has also been argued that the effects of exchange rate variations on the demand for industrial products significantly impact overall labour productivity. Therefore, based on these arguments, we hold that income elasticities are endogenous to the real exchange rate. We thus establish a link between, on the one hand, Post-Keynesian theory based on balance-of-payments constrained growth models, and, on the other, Neo-Kaleckian works on growth based on changes in the functional distribution of income. Moreover, the arguments set forth in this article allow for theoretical advances in relation to the conclusions of the Structural Economic Dynamics approach.

The main conclusion of this article is that income elasticities should be considered endogenous, and, therefore, the impact of the level of the exchange rate on growth, especially in the long-term, is not limited to the effects its variations have on aggregate demand.

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