# Cumulative Causation in a Structural Economic Dynamic Approach to Economic Growth and Uneven Development*

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**Abstract:** The Structural Economic Dynamic approach is distinguished by its simultaneous approach to demand and supply sides of economic growth. However, the idea that growth itself can transform an economy, which became known in the literature as cumulative causation, cannot be properly studied by this framework because technological progress is treated in the same exogenous manner as in the traditional Neoclassical model. Besides, it is the only source of economy growth with no role played by demand as the engine of economic growth but only in the sectoral composition of the economy. Here we introduce Verdoon's Law in the Pasinetti's model of structural change thus making it able to study cumulative causation and thus rendering structural changes endogenous in this model.

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**Keywords:** Cumulative causation, structural change, Verdoon's law.

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## 1. Introduction

Although cumulative causation and structural change are alien concepts to the mainstream economics they are central tenets of post-Keynesian growth theory and play an important role in explaining the contemporaneous process of economic development. A number of economists consider that there is a correspondence between the quest for economic growth and the challenge of performing the proper structural changes, by fostering the growth of sectors that produce goods with high elasticity of demand [see Ocampo (2005), Cornwall and Cornwall (2002) and Fagerberger (2000)]. It is also acknowledged that economic growth has strong historical dependence linkages in which laggard countries face struggles to catch up to the technological frontier and to shrink the income gap with the advanced ones. [see Fagerberger (1994)].

The concept of cumulative causation was systematically developed by Kaldor[1] (1966, 1972) and has been addressed by a number of authors such as Skott (1988), Thirlwall and McCombie (1994), and Setterfield (1997) to describe one of the logical effects of what became known in the literature as the Verdoon's Law. According to Kaldor, the disparities in the growth rates of advanced countries may be explained to a large extent by the effect of increasing returns to scale in industry, together with its fast

[1] In May 1983, the *Journal of Post Keynesian Economics* published a Symposium on Kaldor's growth law. According to Hall and Whybrow (2008, p.354) the notion of cumulative causation was firstly discussed by Veblen in his inquiry into the dynamic interplay of the material and immaterial in economic and social processes, and thus serves as the foundation for his efforts to develop an evolutionary theory for Economic Science. The roots of this idea may be found in the writings of Adam Smith for whom the division of labour is limited by the extent of the market. Young (1928) is also referred as pioneer in this tradition pointing out that many of the economies of scale results from greater differentiation, the emergence of new processes, etc.

growth. According to this theory productivity is strongly determined by the growth rate of output, a view that reverses the direction of causality assumed by the Neoclassical model and gives demand a central role in the process of economic growth. In this vein, manufacturing plays a special role in terms of backward and forward linkages, and economies of scale explain why a faster growth of output lead to faster growth of productivity, thus making economic growth demand induced rather than resource constrained.

Intrinsically related to this process is structural change, which was formally studied among others by Pasinetti (1983, 1991) in his Structural Economic Dynamic – SED hereafter – approach. According to Pasinetti, structural change refers to variations in the sectoral structure of the economy due to the existence of particular rates of technological progress and demand for each final consumption good. His emphasis on demand composition brings out an important qualitative improvement in relation to the aggregated models that cannot possibly take into account the composition of consumption demand since any increase in per capita income is transformed into a higher level of consumption of the same kind[2]. The importance of the structural change in the study of economic development cannot be minimized and some authors such as Ocampo considers that (2005, p. 8) "success in structural change is the key to economic development." Fagerberger (2000) goes a step further considering that structural changes play a very important role for overall productivity growth.

Although the Pasinettian approach has some advantages over the aggregated Neoclassical model in his framework technological change is treated essentially in the

[2] It is implicit in these models a well-known and strict definition of balanced growth: growth of a non-inflationary, full-capacity utilisation with all sectors growing at the same rate [Solow (1956)].

same manner as in the mainstream view, with the exception that for each sector is assigned an exogenous rate of technological progress. Some attempts of giving a better treatment of technological progress in the Pasinettian framework were provided by a number of authors.

Reati (1998) for instance has introduced long wages in this model to explain technological revolutions and have obtained a more complex dynamics for prices, output and employment level. Araujo and Teixeira (2010) have introduce investment specific technological progress in the this framework along with the traditional Harrod neutral technological progress and have conclude that the embodied technological progress has important effects not only on the structure of the economy but also on the composition of employment, challenging the view that it does not produce structural unemployment. Araujo and Teixeira (2011) also have tried to endogenize technological progress in the Pasinetti's framework by considering an evolutionary view of dynamic capabilities as fundamental driving forces of technological changes. In the same vein, D'Agata (2010) adopts evolutionary theory to endogenize technological progress and consumption dynamic with bounded rational firms and consumers in the Pasinetti's framework.

Despite the fact that these approaches are useful to endogenize technological progress they are not able to deal with cumulative causation since they have built no links between productivity growth and output growth as emphasized by Roberts and Setterfield (2007). According to them there is a conception of endogenous technological growth associated with Post-Keynesian growth theory – specifically, the Kaldorian tradition – according to which the rate of technological progress is sensitive to the rate of growth of output, so that "growth depends on growth" or, adding a temporal dimension to the relationship, growth at any point in time depends on its own past history in a self-reinforcing schema of cumulative causation. By ignoring cumulative causation, Pasinetti's model overlooks some important dimensions of economic growth mainly related to its determinants. Besides, one of the main messages of his model in relation to the Neoclassical one is that economic growth is a multidimensional process that cannot be studied by simplistic models that ignores the complexity of this phenomenon. In this vein, one of the aims of this paper is to introduce in the Pasinettian analysis this deeper notion of technological progress, thus by making it consistent with the deeper conception of endogenous growth identified by Roberts and Setterfield.

Besides, although cumulative causation and structural change are acknowledged as playing key roles in the process of economic growth there is no formal model for the best of our knowledge that bring together the contributions of Kaldor and Pasinetti on these matters[3]. This is surprising since the rationale for cumulative causation entails structural change once the reallocation of resources from low productivity activities to that ones with increasing returns of scale play a central role in the generation of economic growth. And one of the engines of structural change, namely technological progress, is widely known to be affected by demand considerations in the post-Keynesian tradition as emphasized by the Kaldorian view.

Cornwall and Cornwall (2002) for instance developed a model of demand and supply analysis of productivity growth in which they show that the growth experience of 16 OECD economies after 1973 and the US in the nineties may be explained in terms of the change of demand factors and change of structure, concluding that the prime benefit of a strong aggregate demand is its effects on investment and technological

[3] Of course we are not referring here to the models related to the Cambridge Equation that became generally known in the literature as the Kaldor-Pasinetti model. Setterfield (2002) develops a model of cumulative causation, structural change and evolutionary hysteresis but not following the Pasinettian analysis.

change. According to them “[w]hile the type and pace of technological progress cannot be predicted, we are confident in predicting that strong demand will increase the rates of innovation and of diffusion of available technologies, and in doing so will increase productivity growth.” [Cornwall and Cornwall (2002, p. 204)].

Although their model emphasizes the main channels of interdependence between growth of demand, technological progress and structural change, it is not formally built, and for this reason it is not able to determine either the type or the pace of technological progress. By introducing cumulative causation in the Pasinetti’s framework allows us to treat these issues in a formal framework in which the pace of technological progress can be determined. Another advantage of this approach is that one of the most important outcomes of the process of economic growth, namely structural change, is also tackled formally. Then it is possible to demonstrate formally that disequilibria is the most probable outcome of economic growth and cumulative causation, a result that has been called to attention by a number of economists. [Young (1928), Kaldor (1978), Boyer and Petit (1991)].

It is worth to mention that this line of research has already been pursued by Kaleckians, who introduced Verdoorn’s Law into their framework [see Lavoie (1992)]. In fact the cross-fertilization between Post-Keynesian strands has been pursued by a number of authors and rendered interesting outcomes such as the multi-sectoral version of the Thirlwall’s law [see Araujo and Lima (2007)]. In fact, Pasinetti (2005, p. 839-40) has already pointed to the need of establishing connections among these different branches in the Keynesian tradition in order to build a successful alternative paradigm to mainstream economics[4].

In his search for consistency within Kaldorian growth theory, Blecker (1992) argues that balance-of-payments-constrained growth theory, based on Thirlwall's Law, can be made consistent with cumulative causation *via* the operation of Verdoorn's Law as long as relative purchasing power parity – RPPP hereafter – is assumed *not* to hold. But RPPP *is* traditionally assumed to hold in the derivation of Thirlwall's Law, the advocates of which make much of the lack of influence of relative prices on long run growth outcomes. But it is also shown here that in a structural economic dynamic setup, a reconciliation between the cumulative causation and the balance of payment constrained views may be obtained even if the RPPP holds.

This paper is structured as follows: In the next section we present what we consider to be a Pasinettian version of a cumulative causation in his structural change model. In section 3, we endogenize technological progress in the Pasinetti's model by introducing sectoral versions of the Verdoon's law. Section 4 applies the results obtained in the previous section to study uneven development. Section 5 summarizes the results.

## 2. Pasinetti's Model

Pasinetti's model is distinguished by its simultaneous focus on economic growth from both supply and demand sides thus rendering the model capable of performing an analysis of structural change. In this model, exogenous technological progress increases

[4] He points out a lack of theoretical cohesion amongst models in this tradition to explain why the Keynesian School has somewhat failed as a successful alternative paradigm to mainstream economics.

real per capita income through lower prices. The higher per capita income is translated into higher consumption of final goods but this increase of consumption is not evenly spread across all consumption goods. Those with a higher elasticity of demand receive higher shares of consumer expenditures and this process gives rise to structural changes[5]. It is important to note that in this model the only role played by demand is to determine an unevenly expenditure of an increasing per capita income. This view contrasts with other models in the Post-Keynesian tradition in which the demand plays an important role not only in the short run but also on the long run determination of equilibrium growth rate[6] [see Setterfield (2002)].

It is possible to roughly summarize the working of the Pasinetti's model through the following scheme. First exogenous technological progress hits sector *i* inducing smaller price of the consumption good due to its effect on the labour coefficient increasing productivity. The smaller price does not mean that consumers will spend higher fractions of their per capita income in this consumption good. The gain in real per capita income can be transferred for other consumption goods, mainly those with higher elasticity income of demand. The outcome of this process is structural change.

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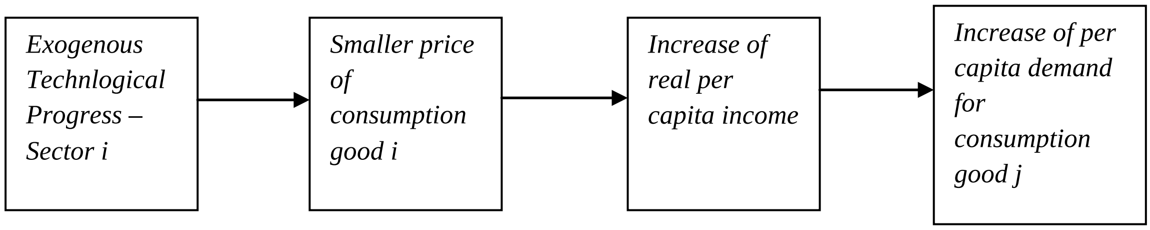
[5] Of course there is some reciprocity, that is, the technological absorption is determined by the structure of the economy but when technological change is effectively added to the productivity process it affects the structure of the economy as will be shown in the next sections.

[6] The so-called Economics of Demand-Led Growth comprises a number of models from different traditions in the Post-Keynesian school such as the Kaleckian and the Kaldorian models of economic growth [Setterfield (2002)].

**Structural Change in the Pasinetti's Model**




From this scheme it is possible to conclude that structural changes in the Pasinetti's model are not endogenous since they are powered by exogenous technological progress; while the forces that cause structural change are exogenous the ones that driven it, namely sectoral demand, are endogenous but also affected by exogenous technical coefficients.

In order to develop our extension of the Pasinetti's model to cumulative causation let us consider an open version of this model following Araujo and Teixeira (2003). To establish the basic notation, it is useful to choose one of the countries, let us say *U*, to express physical flows. Consider that $X_i$ denotes the domestic physical quantity produced of consumption good *i* and $X_n$ represents the quantity of labour in all internal production activities; per capita demand of consumption goods is represented by a set of consumption coefficients: both $a_{in}$ and $a_{i\hat{n}}$ stand for the demand coefficients of final commodity *i*. The former refers to domestic and the latter to foreign demand. In the same vein, $a_{ki,n}$ and $a_{ki,\hat{n}}$ stand for the investment coefficients of capital goods *ki*. The production coefficients of consumption and capital goods are respectively $a_{ni}$ and $a_{nki}$. The family sector in country *A* is denoted by $\hat{n}$ and the size of population in both countries is related by the coefficient of proportionality $\xi$. The physical system may be written as follows:

$$\begin{cases} X_i - (a_{in} + \xi \ a_{i\hat{n}})X_n = 0 \\ X_{ki} - (a_{ki,n} + \xi \ a_{ki,\hat{n}})X_n = 0 \\ X_n - \sum_{i=1}^{n-1} a_{ni} X_i - \sum_{i=1}^{n-1} a_{nki} X_{ki} = 0 \end{cases} \tag{1}$$

A sufficient condition to ensure non-trivial solutions[7] of the system for physical quantities in country *U* is:

$$\sum_{i=1}^{n-1} (a_{in} + \xi \ a_{i\hat{n}}) a_{ni} + \sum_{i=1}^{n-1} (a_{ki,n} + \xi \ a_{ki,\hat{n}}) a_{nki} = 1 \tag{2}$$

This is also a condition for full employment of the labour force. The solution of the system for physical quantities may be expressed as:

$$\begin{cases} X_i = (a_{in} + \xi \ a_{i\hat{n}})X_n \\ X_{ki} = (a_{ki,n} + \xi \ a_{ki,\hat{n}})X_n \end{cases} \tag{3}$$

The set of solution for prices may be expressed as:

$$\begin{cases} p_i = (a_{ni} + \pi_i a_{nki})w \\ p_{ki} = a_{nki} w \end{cases} \tag{3}’$$

Where $p_i$ is the price of commodity *i* country *U* ($i$ = 1,2,...,$n$-1), *w* is the wage rate (uniform), and $\pi_i$ is the rates of profit. Let us assume that the dynamic path of the per capita demand coefficient for commodity *i*:

$$a_{in}(t) = a_{in}(0) e^{r_i t} \tag{4}$$

[7] As pointed out by Pasinetti (1981, p. 33), fulfilment of (2) is a sufficient condition for the system for physical quantities to have non-trivial solutions. However, non-fulfilment does not imply any meaningful solution. The particular form of the coefficient matrix (all its entries are zeros, except those in the last row, those in the last column, and along with the main diagonal) means that the solution of the system can be derived directly, without substitution, from the first 2*n*–1 equations. Therefore, relative quantities are determined independently of condition (2).

$$a_{i\hat{n}}(t) = a_{i\hat{n}}(0)e^{r_i t} \qquad (5)$$

The term $r_i$ determines the growth rate of demand for commodity $i$. According to Pasinetti (1981) this rate is endogenously determined by technical conditions, which may be expressed by:

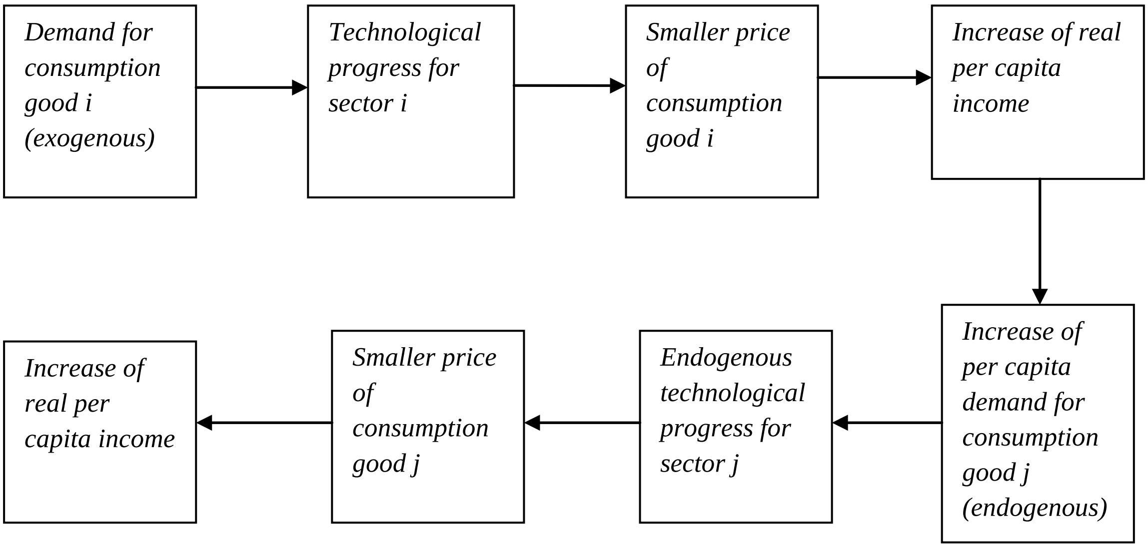
$$r_i(t) = f_i\{a_{n1},..., a_{n,n-1}, a_{nk_1},..., a_{nk_{n-1}}; \frac{d}{dt}[a_{n1},..., a_{n,n-1}, a_{nk_1},..., a_{n,k_{n-1}}]\} \qquad (6)$$

By considering that effective demand condition is fulfilled in the first time, Pasinetti shows that in general it will not necessarily be fulfilled later on, related to the existence of particular growth rates of demand and productivity in each of the model's sectors, that is:

$$\sum_{i=1}^{n-1}(a_{in} + \xi \ a_{i\hat{n}})a_{ni} + \sum_{i=1}^{n-1}(a_{ki,n} + \xi \ a_{ki,\hat{n}})a_{nki} < 1 \qquad (7)$$

In the Pasinettian analysis, the natural growth rate in each sector is given by $\rho_i + g$. Note that the natural rate is exogenously given in the Pasinetti's model. In the alternative reading presented in this article we assume that technological progress is endogenous rather than exogenous and is induced by the exogenous demand for consumption good *i*. Following Kaldor we assume that autonomous demand play an important role in the long run, so the demand for consumption good *i* is assumed to be exogenous due to foreign demand. But once demand takes places technological progress in sector *i* occurs leading to smaller price of this consumption good. The smaller price means an increase in real per capita income which may be translated into higher consumption for consumption good *j*. The increase of demand for consumption good *j* induces endogenous technological progress in this sector and in this vein the process tends to be self-sustained, presenting cumulative causation.

**Cumulative Causation and Structural Change in the Pasinetti's Model**




According to this scheme, structural changes are triggered by exogenous demand that induce technological progress through increasing returns of scale and learning-by-doing. The consequent increase in per capita income due to the raise in productivity will turn into an increase into per capita demand that may also induce more technological progress. In this vein in some moment of this virtuous cycle, structural changes are made endogenous and are due to endogenous changes in the per capita demand. This fact has strong implications in terms of theory and practice of economic development. First, it shows that the role played by demand in the process of economic growth cannot be limited to drive structural changes, but demand is also one of the engines of economic growth via its effect on stimulating the creation and diffusion of technological progress. Second, it stresses that the triggering point of this virtuous cycle is external demand, but once it is under way, indigenous demand may expand and may also be an important component to spur growth. In this vein a vigorous strategy of export led growth may play an important role to start the virtuous cycle motioned by cumulative causation.

Suppose, for instance, a structural change in the economy due to a change in the composition of foreign demand. The growth rate of output of some sectors will fall, while the growth rate in other sectors will rise. Thus, according to the Verdoon's Law, the rate of productivity growth will fall for sectors where growth has fallen and will rise for sectors where the growth rate went up. The cumulative causation – positive, say – will be greater for those sectors affected positively by the change in demand – ceteris paribus. Or, ceteris paribus, the share of sectors in the national income will be greater when more change in the composition of demand affect positively – negatively – sectors with higher – lower – Verdoorn coefficient – i.e., as a variation in growth rate of the product results in variation in the rate of productivity growth. This will lead to more structural changes but now they will be endogenous.

An interesting implication of this analysis is that cumulative causation created by Verdoorn's Law could be connected with the phenomenon of Schumpeterian creative destruction. According to Setterfield (2002, p. 227) "[a] process may be defined as evolutionary if it is characterized by endogenously generated structural change involving novelty". But this is exactly the kind of structural changes that were depicted in the above paragraph. According to this process, a sectoral working of cumulative causation created by Verdoorn's Law may trigger an evolutionary process in which some sectors may get very large in terms of its employment share. In the next section we approach this model formally by introducing cumulative causation in the Pasinetti's model of structural change.

## 3. An Extended Model to Accommodate Cumulative Causation

In the Pasinetti's model technological progress is exogenous and is particular to each sector. The production coefficients of consumption $a_{ni}$ convey the effect of technological progress in the sector of final goods. Defining productivity in each sector, $q_i(t)$ as the inverse of labour coefficient, we have the following identity:

$$\frac{\dot{q}_i}{q_i} \equiv \rho_i \equiv \frac{\dot{a}_{ni}(t)}{a_{ni}(\mathrm{t})} \tag{8}$$

where the rate of technical change for sector *i* is denoted by $\rho_i$. Besides let us consider, following Kaldor, Thirlwall and McCombie (1994) and Setterfield (1997, p. 367), that the productivity varies according to a Verdoorn law. The novelty here is that we assume a Verdoorn law particular to each sector:

$$\frac{\dot{q}_i}{q_i} = \gamma_i + \alpha_i \frac{\dot{X}_i}{X_i} \tag{9}$$

Where $\alpha_i$ is the Verdoorn coefficient. It captures the extent to which output growth generates subsequent productivity growth via dynamic increasing returns. But from expression (3) the production of sector *i* is given by the internal and foreign demand for this consumption good. Let us assume following Araujo and Lima (2007) that foreign demand is given by the foreign demand coefficient:

$$a_{i\hat{n}} = \begin{cases} \left(\dfrac{p_i}{ep_{\hat{i}}}\right)^{\eta_i} y_A^{\beta_i}\ X_{\hat{n}}^{1-\beta_i} & \text{if } p_i < ep_{\hat{i}} \\ 0 & \text{if } p_i \geq ep_{\hat{i}} \end{cases} \tag{10}$$

Where $p_i$ and $p_{\hat{i}}$ stand for price of the i-th consumption good in countries *U* and *A*, respectively, *e* stands for the nominal exchange rate and $y_A$ is the per capita income of country $A$. $\eta_i$ is the price elasticity of demand for export of commodity $i$, with $\eta_i < 0$, while $\beta_i$ is the income elasticity of demand for exports, with $\beta_i > 0$ . This specification follows Setterfield (1997). According to him, Kaldor treats exports as the key source of autonomous demand. The importance of export growth is also emphasized by Cornwall and Cornwall (2002, p. 206). According to them its importance to productivity growth is twofold: first, it allows the larger scale production methods to improve productivity and, second, it encourages the adoption of the best available technologies spurring productivity. The growth rate of the foreign demand is then given by:

$$\frac{\dot{a}_{i\hat{n}}}{a_{i\hat{n}}} = \begin{cases} \eta_i\left(\sigma_i^U - \sigma_i^A - \varepsilon\right) + \beta_i \sigma_y^A + (1-\beta_i)\hat{g} & \text{if } p_i < e p_{\hat{i}} \\ 0 & \text{if } p_i \geq e p_{\hat{i}} \end{cases} \tag{11}$$

The internal demand is assumed to grow exponentially according to expression (4). The available labour force grows at rate $g$. By adopting the following convention: $\frac{\dot{p}_i}{p_i} = \sigma_i^U$ , $\frac{\dot{p}_{\hat{i}}}{p_{\hat{i}}} = \sigma_i^A$ , $\frac{\dot{e}}{e} = \varepsilon$ $\frac{\dot{y}_A}{y_A} = \sigma_y^A$ , $\frac{\dot{X}_{\hat{n}}}{X_{\hat{n}}} = \hat{g}$ and $\frac{\dot{y}_U}{y_U} = \sigma_y^U$ we can write the growth rate of demand for the *i*-the consumption good as:

$$\frac{\dot{X}_i}{X_i} = \begin{cases} \theta\, r_i + (1-\theta)\left[\eta_i(\sigma_i^U - \sigma_i^A - \varepsilon) + \beta_i \sigma_y^A + (\beta_i - 1)\hat{g}\right] + g & \text{if } p_i < e p_{\hat{i}} \\ r_i + g & \text{if } p_i \geq e p_{\hat{i}} \end{cases} \tag{12}$$

Then expression (12) gives us the growth rate of the demand for the *i*-th final consumption good. If we assume Relative Purchase Power Parity[8] – RPPP hereafter – $\sigma_i^U - \sigma_i^A - \varepsilon = 0$ so the above expression reduces to:

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[8]According to the RPPP hypothesis the exchange rate between two currencies will move in line with relative price levels in the two economies. RPPP is supported by a number of empirical studies. [Alonso and Garcimartin (1998-99)].

$$\frac{\dot{X}_i}{X_i} = \begin{cases} \theta r_i + (1-\theta)\left[\beta_i \sigma_y^A + (\beta_i - 1)\hat{g}\right] + g & \text{if } p_i < e p_{\hat{i}} \\ r_i + g & \text{if } p_i \geq e p_{\hat{i}} \end{cases} \tag{13}$$

By replacing this result into expression (9) one obtains:

$$\rho_i \equiv \frac{\dot{q}_i}{q_i} = \begin{cases} \gamma_i + \alpha_i \left\{\theta r_i + (1-\theta)\left[\beta_i \sigma_y^A + (\beta_i - 1)\hat{g}\right] + g\right\} & \text{if } p_i < e p_{\hat{i}} \\ \gamma_i + \alpha_i (r_i + g) & \text{if } p_i \geq e p_{\hat{i}} \end{cases} \tag{14}$$

Hence the technological progress growth rate is now obtained as a function of parameters of demand. From expression (14) it is possible to conclude that technological progress in *i*-th sector is a function of the growth rate of internal demand and of the elasticity of foreign demand if the country has comparative advantage in producing and exporting good *i*. Otherwise, technological progress will be only a function of the growth rate of internal demand. This result shows that success in international competition for consumer markets may be decisive for a country to catch-up to the technological frontier by enjoying higher rates of technological progress. It is also important to emphasize the self-reinforcing nature of expression (14). If a country has comparative advantage in producing and exporting good *i* then chances exist that it will face a higher rate of technological progress than the same sector in the other country, and this will guarantee the leadership of this country in terms of comparative advantage.

From expression (14) it is also possible to conclude that the essence of the Pasinettian analysis remains but now technological progress is endogenous and there is cumulative causation. This result confirms what was reported by Cornwall and Cornwall (2002, p. 204) "[w]hile the type and pace of technological change cannot be predicted, we are confident in predicting that strong demand will increase the rates of innovation and of diffusion of available technologies, and in doing so will increase productivity growth.” In order to provide a complete characterization of the effects of the endogenous technological progress on structural changes focus on its effects of the labour shares amongst the various sectors. From the definition of technical coefficient for *i*-th sector it is possible to obtain the following relation:

$$\frac{\dot{a}_{ni}(t)}{a_{ni}(\mathrm{t})} = \frac{\dot{x}_{ni}}{x_{ni}} - \frac{\dot{X}_i}{X_i} = -\rho_i \tag{15}$$

By substituting expressions (13) and (14) into the above expression and after some algebraic manipulation it is possible to conclude that the growth rate of the labour force employed in *i*-th sector is given by the following expression:

$$\frac{\dot{x}_{ni}}{x_{ni}} = \frac{\dot{X}_i}{X_i} - \rho_i = \begin{cases} -\gamma_i + (1-\alpha_i)\left\{\theta r_i + (1-\theta)\left[\beta_i \sigma_y^A + (\beta_i - 1)\hat{g}\right] + g\right\} & \text{if} \quad p_i < e p_{\hat{i}} \\ -\gamma_i + (1-\alpha_i)(r_i + g) & \text{if} \quad p_i \geq e p_{\hat{i}} \end{cases} \tag{16}$$

Expression (18) shows that the absorption of labour in the *i*-th sector is an endogenous variable that is strongly affected not only by technological progress but also by demand considerations expressed by the growth rate of demand and elasticities of demand and by the Verdoorn coefficient. In the original Pasinetti’s model while the demand coefficients are endogenously driven by the rate of change of demand, technical coefficients are exogenously determined by the rate of technological progress. Then it is possible to say that the structural changes in the original Pasinetti’s model are not endogenous but exogenous. Here by endogenizing the rate of technological progress we are able to make the structural changes completely endogenous. This view stresses the importance of the demand, particularly the foreign demand which is one the only exogenous variables of our extension of the Pasinetti’s model.

The importance of the manufacturing sector in the present model can be grasped by considering that in general tradable goods are manufactured ones. In this case, the external demand exerted on these goods may induce technological progress in the maufacturing sectors yielding smaller prices for internal consumption. Thirlwall (1983, p. 347) has emphasized "that a fast rate of growth of exports and output will tend to set up a cumulative process, or virtuous circle of growth, through the link between output growth and productivity growth."

In order to fully characterize the working of the process of cumulative causation in Pasinetti's model consider that the smaller prices of manufacturing due to technological progress does not mean a higher share of per capita income spent in such goods since other goods with higher income elasticity of demand may benefit from the real per capita income increase that accrue from smaller prices of manufactures. In this vein, it is generated higher demand for goods in other sectors than manufactures, which may give rise to higher levels of technological progress. This rationale confirms the Kaldorian view expressed in one of his laws of growth that faster growth in manufacturing also generates faster growth in productivity outside manufacturing. In this vein the manufacturing sector becomes the flywheel of the economic growth.

## 4. Implications of the Cumulative Causation to a structural dynamics approach to North-South models.

One of the advantages of endogenizing technological progress from the Verdoorn's Law in the Pasinetti's model is that a number of issues that arises in relation to an open economy may be approached formally and from the viewpoint of cumulative causation. One of these issues is related to the reconciliation between the cumulative causation and the balance of payment constrained approaches to economic growth. Although some authors such as Setterfield and Cornwall (2002), and Setterfield (2002) have already built models that bring these contributions together, according to Blecker (2010, p. 7), the key assumption in Thirlwall's Law, namely the irrelevance of relative price effects in the long run, rules out cumulative causation.

Here it is possible to show that even assuming RPPP in the long run cumulative causation still plays an important role in economic growth and both endogenous technological progress according to the sectoral Verdorn's Law and Thirlwall's law determine simultaneously the growth rate of an open economy. In this vein the model can give us back some insight on the process of uneven development that is difficult to grasp in one or two sector North-South models. Araujo and Lima (2007) have derived a multi-sector version of the Thirlwall's law (1979) in which not only elasticities but also structural changes captured by changes in the coefficients may impact the growth rate.

$$\sigma_y^U = \frac{\sum_{i=1}^{n-1} \xi \beta_i a_{i\hat{n}} a_{ni}}{\sum_{i=1}^{n-1} \phi_i a_{i\hat{n}} a_{ni}} \sigma_y^A \qquad (17)$$

According to this expression higher growth rates are associated with lower sectoral income elasticities of demand for imports, given by $\phi_i$, and higher sectoral income elasticities of demand for exports, given by $\beta_i$. It should be noticed, however, that these sectoral income elasticities of exports and imports are weighted by coefficients that measure the share of each sector in the total volumes of exports and imports. As it turns out, even in case these sectoral elasticities remain constant, a change in the overall growth rate can be brought about by structural change coming from the evolution of tastes and preferences according to Engel's Law.

According to expression (17) the growth performance relies heavily upon on the ability to export, which is evidence that any growth strategy that focuses exclusively on internal markets would fail. What matters for the determination of the growth rates are not only the elasticities but also the weigh that these goods have in the economy. Besides, an outward oriented view would create demand for goods with a high income elasticity of demand, which would produce structural changes in the economy that would give a higher share to these more sophisticated goods.

In the original version of the disaggregated Law derived by Araujo and Lima the technological progress was exogenous so the dynamical paths of technical coefficients in expression were exogenous given. Now from expression (14) it is possible to observe that the dynamical path of technical coefficients will be also affected by the elasticities of demand mirroring the fact that technological progress is affected by the evolution of demand. Another important contribution from this analysis to tackle uneven development may be obtained by considering the endogenized technological progress in the structural economic dynamic model may be obtained from expression (14). Let us add superscripts to this equation to emphasize the relationship between the rate of technological progress in a particular region and the rate of growth of demand and the elasticity of demand for the good produced by that region:

$$\rho_i^U = \begin{cases} \gamma_i^U + \alpha_i^U \left\{ \theta_i^U r_i^U + (1-\theta_i^U)\left[\beta_i \sigma_y^A + (\beta_i - 1)\hat{g}\right] + g \right\} & \text{if } p_i < ep_{\hat{i}} \\ \gamma_i^U + \alpha_i^U (r_i^U + g) & \text{if } p_i \geq ep_{\hat{i}} \end{cases} \qquad (14)'$$

Expression (14)' shows us that the higher the growth rate of demand the higher the rate of technological progress and accordingly the higher the elasticity income of demand the higher of technological progress. Here we can feel the flavour of cumulative causation by observing that the changes in relative cost competitiveness due to endogenous technological progress is the explaining force behind export success.

This model also serves to illustrate another point raised by Blecker (2010, p. 2): "In terms of policy, perhaps the most radical implication of some export-led cumulative causation models is that a stimulus to domestic demand can potentially spark a virtuous circle of export-led growth, because of the positive response of technology and productivity to faster domestic expansion." From expression (14)' it is possible to conclude that if a country does not have comparative advantage in terms of producing good *i* then the technological progress in the *i*-th sector will be given by: $\rho_i^U = \gamma_i^U + \alpha_i^U (r_i^U + g)$ while the technological progress in the i-th sector of country *A* will be give by: $\rho_i^A = \gamma_i^A + \alpha_i^A \alpha_i^A \{\theta_i^A r_i^A + (1-\theta_i^A)[\beta_i \sigma_y^U + (\beta_i - 1)g] + \hat{g}\}$. The only chance the country *U* has to obtain comparative advantage is to make $\rho_i^U > \rho_i^A$ by increasing its internal demand, which corresponds to an increase in $r_i^U$ through some kind of policy as pointed out by Blecker. In order to verify this result note that from expression (3)' the price of good *i* is determined by technical coefficients whose dynamic path depend on the technological progress given by expression (14)'.

But once a country has comparative advantage in a specific sector then according to the cumulative causation view it is more plausible that it will keep that position, according to the view established here. Besides, another important result showed here is that even if we assume RPPP in the long run, changes in relative prices will play an important role in the long run explaining relative cost competitiveness due to endogenous technological progress, which is the explaining force behind export success. In this vein, cumulative causation still plays an important role even in the context of a balance of payment constrained growth.

## 5. Concluding Remarks

In the present paper, by embedding cumulative causation in the Pasinettian analysis through Kaldor-Verdoorn sectoral laws, technological progress was endogenized, and the role played by demand was evinced not only in the structural changes but also on determination of the pace of technological progress. In this vein a multi-sector model of cumulative causation was built and its implications over the process of economic development were studied. By following this approach the main channels of interactions between demand, technological progress and structural change were taken into account. Besides, it was possible to extend the SED approach by including cumulative causation as one of the mechanisms that explain the ever-widening per capita and technological gaps amongst rich and poor nations. The essence of the argument is that once a region gains a growth advantage it will tend to sustain that advantage through the process of increasing returns that growth itself induces – the Verdoorn effect. Besides, according to the view presented here it was possible to combine Thirlwall's Law and Verdoorn's Law *without* dropping the RPPP assumption, which is another evidence that there are benefits from combining insights from the various strands of Post-Keynesian growth theory.

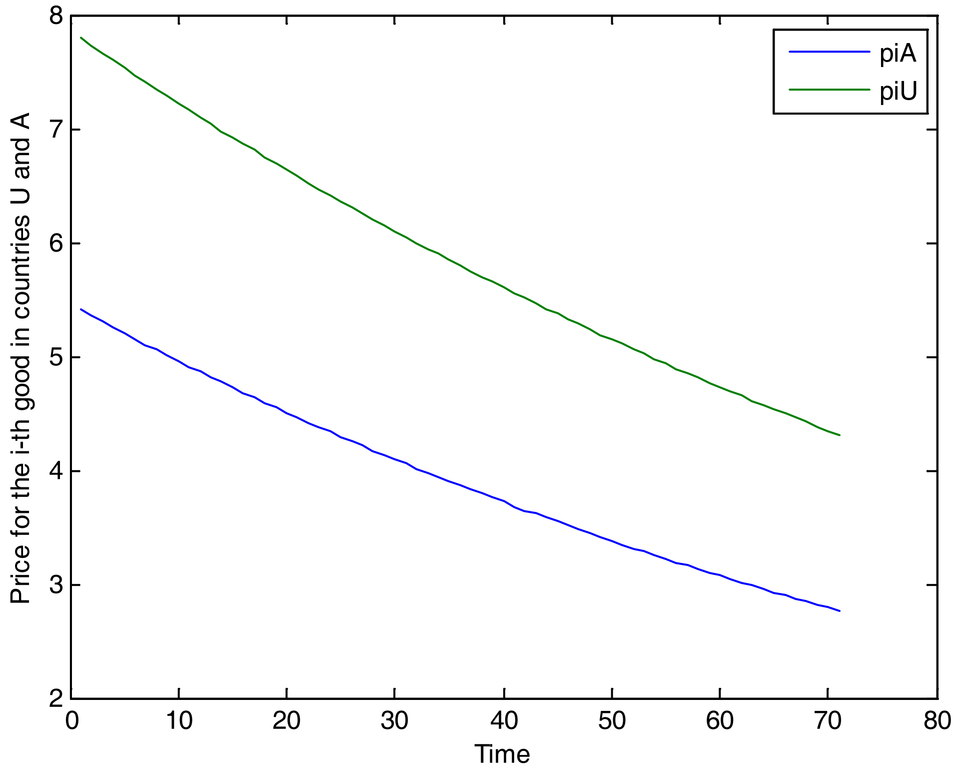
Following a SED approach embedded with cumulative causation it was emphasised that gains from international diffusion of technical progress are conditioned to the inherent patterns of human needs and preferences since they give rise to different compositions of consumer demand, patterns of technological progress and therefore different structures of production and employment in each country. That is, the diffusion and absorption of technical progress are subject to different economic structures particular to developed and underdeveloped economies. A region that produces a final good with high elasticity of demand will have high technological progress and thus grow faster than a region that produces a final good with small elasticity of demand.

**Appendix – Numerical Simulations**

The simulations for the price of a specific consumption good – let us say *i*-th good – were based on estimates for export and import income elasticity obtained from Golvea and Lima (2011) according to $\beta_i = 1.640$ and $\phi_i = 1.294$. In order to provide generality for the simulations most of the parameters of the model such as the sectoral growth rate of demand, and the initial value for labour coefficients were left to be chosen by the computer as random variables. As the idea was to focus on preferences, captured by the growth rate of demand and elasticities of demand, and on technology, expressed by the Verdoorn's coefficients, these parameters were left to vary randomly through the simulations. The values of some parameters that were not the most relevant for the simulations were chosen according to: $w^A = w^U = 10$ , $\sigma_y^A = \sigma_y^U = 0.02$ and $e = 1$.

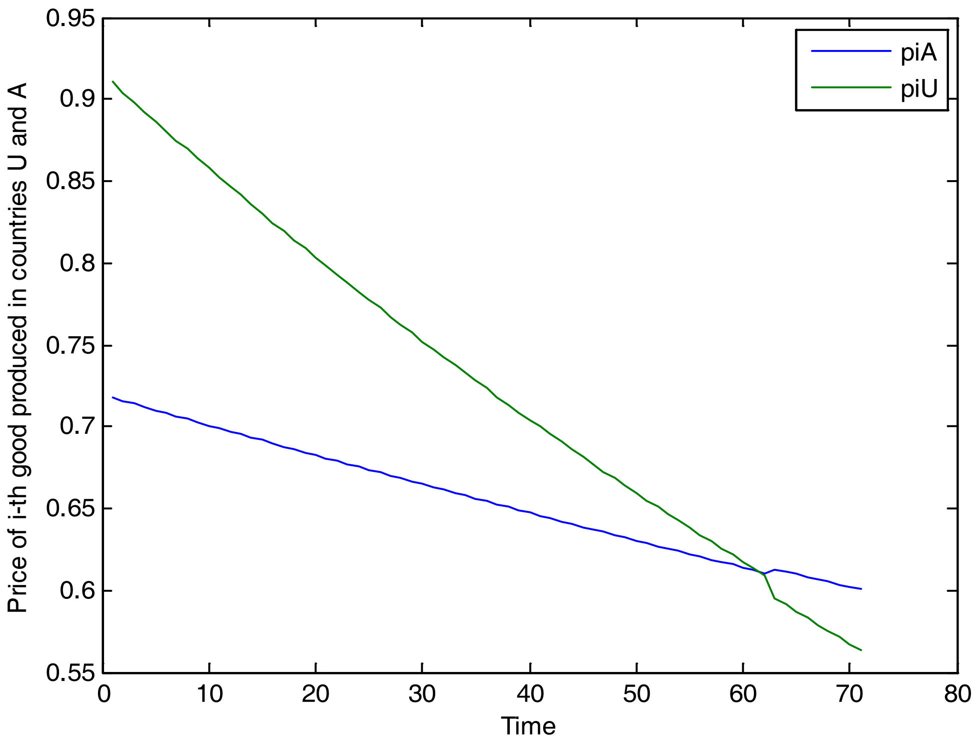
The algorithm adopted was based on expression (14)'. The idea is to compare the evolution of prices of the same consumption good – let us say *i*-th consumption good – in countries *A* and *U* taking into account that these prices will be ultimately determined by technological progress in the long run. But as shown by expression (14)' technological progress will be determined by demand considerations that will take into account comparative advantage that is strong influenced by price competitiveness. Most of the simulation results show shows that when when a country has comparative advantage in general it will keep it through the mechanism of cumulative causation – simulation 1. But in a few cases, such as in simulation 2, the *U* country was able to revert the comparative advantage of the *A* country due to higher values of Verdoorn's parameters.

**Simulation 1**: In the first simulation, the values of parameters were chosen according to: $r_i^U = 0.0041$, $r_i^A = 0.0045$, $\hat{g} = g = 0.0231$, $\theta_i^U = 0.9183$, $\theta_i^A = 0.8209$, $\gamma_i^U = 0.9516$, $\gamma_i^A = 0.8295$, $\alpha_i^U = 0.6027$, $\alpha_i^A = 0.2357$, $a_{ni}^A(0) = 0.5406$ and $a_{ni}^U(0) = 0.7794$. By considering that $w$ = 10 in both countries $p_i^U(0) = 7.794$ and $p_i^A(0) = 5.406$. And the technological progress reckoned according to expression (14)' for countries A and U is given by: $\rho_i^U = 0.0096$ and $\rho_i^A = 0.0085$.




This simulation essentially shows that when when a country has comparative advantage in general it will keep it through the mechanism of cumulative causation.

**Simulation 2**: In this case, the values of parameters were chosen according to: $r_i^U = 0.0035$, $r_i^A = 0.0077$, $\hat{g} = g = 0.0968$, $\theta_i^U = 0.5641, \theta_i^A = 0.3251, \gamma_i^A = 0.2214, \gamma_i^U = 0.5871, \alpha_i^U = 0.7050, \alpha_i^A = 0.3167$, $a_{ni}^A(0) = 0.0718$ and $a_{ni}^U(0) = 0.0910$. By considering that $w$ = 10 in both countries $p_i^A(0) = 0.718$ and $p_i^U(0) = 0.910$. And the technological progress reckoned according to expression (14)' for countries *A* and *U* is given by: $\rho_i^U = 0.0066$ and $\rho_i^A = 0.0026$. Due to this fact at time 61, price in *U* becomes smaller than price in A and then the new rates of technological progress are reckoned by the algorithm, which yields: $\rho_i^U = 0.0069$ and $\rho_i^A = 0.0025$.




Note that in this case, the key variable that makes the coutry gain competitiveness is $\gamma_i^A << \gamma_i^U$ and $\alpha_i^A << \alpha_i^U$. Note that the magnitudes of these coefficients are enough to compensate the smaller growth rate of demand in *U*-country.

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