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Structural change and macrodynamic capabilities

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Resumo

Neste artigo estudamos alguns mecanismos que impedem uma rápida difusão de progresso tecnológico de países avançados para subdesenvolvidos. A fim de fazer este estudo, focamos sobre duas abordagens que desafiam a visão de que o hiato tecnológico entre países desenvolvidos e subdesenvolvidos está diminuindo. O primeiro é a abordagem de dinâmica de mudança estrutural, e o segundo é a abordagem evolucionária. Ambas as abordagens revelam que a eliminação de hiatos tecnológicos entre países ricos e pobres é mais complexa do que tem sido reportado pela teoria ortodoxa.

Abstract

In this paper we study some mechanisms that block a rapid diffusion of technological progress from advanced to underdeveloped countries. In order to accomplish this task we focus on two approaches that challenge the view that technological gaps between rich and poor nations are diminishing. The first is the structural economic dynamic approach and the second is the evolutionary view. Both of them reveal that the elimination of technological gaps between rich and poor nations is more complex than what has been reported by the mainstream theory of economic growth.

1_ Introduction

In this paper we intend to show that the Evolutionary approach may be adopted to endogenize technical progress in the Structural Economic Dynamic – SED hereafter – approach [Pasinetti (1981, 1993), Baranzini and Scazzieri (1990), Araujo and Teixeira (2003, 2004) and Araujo and Lima (2007)]. We also intend to show the relevance of the SED approach extended to consider endogenous technological progress to tackle the existence of technological and per capita income gaps between developed and underdeveloped countries. Contributions to the literature on technological gaps suggest that one of the stylised facts regarding relations between and among rich and poor countries is the widening gap between their per capita incomes See, for example Ocampo (2005) as well as Dutt (2002). It has been cogently argued that neoclassical theories of economic growth fail to account for widening gaps in per capita incomes: as exogenous rates of economic growth rate of technical progress determine the overall rate of growth.

Denying the importance of changes in the sectoral composition, the neo-classical model focuses on issues

that can be addressed within the limited scope of a one-sector framework, considering that the only barrier to diffusion of technology from advanced to underdeveloped countries is the cost of imitation and adaptation. Following this reasoning, in the neo-classical theory of growth there is no room for a widening gap since the exogenous growth rate of technical progress determines the overall growth rate[1]. According to Fagerberg (1994, p. 1147), in this theory

> technology is assumed to be a public good and subsequent empirical research showed that a theory based on this premise explains very little of the observed differences in growth across countries.

Denying the complexities involved in the process of innovation and its diffusion, the neo-classical model focuses on issues that can be addressed within a limited scope of a one-sector framework and considers that the only barrier to diffusion of technology from advanced to underdeveloped countries is the cost of imitation and adaptation. Since this analysis is made without considering the complexities of the innovation processes, no attention is given to the dynamic capabilities of firms facing

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[1]   Schumpeter (1934) had already emphasised that technological progress is the engine of economic growth. The neo-Schumpeterian School has been focusing on the determinants of creation and diffusion of technological progress. Bresnahan and Trajtenberg (1995, p. 83-84) claim that economists have known for a long time that technical change is the single most important force driving the secular process of growth. Yet, relatively little progress has been made in accounting for Solow's residual of aggregated production functions, largely because economic theory tends to treat all forms of technical change in the same diffuse manner.

particular environments, institutions and labour skills in advanced and underdeveloped countries. In this case the technical progress attained by the firms in the former countries is easily transferred to those in the latter[2].

This reasoning can be considered a benchmark for the revival of the neo-classical theory of growth, known as the 'New Growth Theory'. Since the evidence had shown that technology could not be treated as a public good, the mainstream economics was challenged to justify the theoretical convergence of per capita income that is hardly seen in practice if we consider developed and underdeveloped nations.

Grossman and Helpman (1991, p. 238) have built models in which a higher degree of openness allows developing countries to adopt technologies from the advanced nations at a faster rate and thus to grow, in equilibrium, more rapidly than with a lower degree of openness. According to them

> countries that trade in world markets invariably learn a great deal about innovative products and about the novel methods that are being used to produce older goods.

In the same vein Lucas (2000) relies on the mechanism of international learning for convergence: poor countries are simply to assume to learn from the experience of rich countries and to catch upto them.

According to Ocampo (2005, p. 8) this view precludes any analysis of the relationship between growth and inequality. He considers that:

> [t]he contrast between the balloon and structural dynamics views of economic growth can be understood in terms of the interpretation of one of the regularities identified in the growth literature: the tendency of per capita GDP growth to be accompanied by regular changes in the sectoral composition of output in the patterns of international specialization. According to the balloon view, these structural changes are simply a by-product of the growth in per capita GDP. In the alternative reading, success in structural change is the key to economic development.

This point is confirmed by Metcalfe *et al.* (2003, p. 40):

> While the idea of semi stationary or proportional growth may have been helpful in the early stages of growth theory, as for example, in the Von-Neumann growth model, it cannot help in the context of understanding development since it rules out, ex hypothesis, the most important of all the stylised facts, structural change.

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Bresnahan and Trajtenberg (1995, p. 83-84) claim that economists have known for a long time that technical change is the single most important force driving the secular process of growth. Yet, relatively little progress has been made in accounting for the Solow's residual of aggregated production functions, largely because economic theory tends to treat all forms of technical change in the same diffuse manner. This view is supported by Metcalfe (1988, p. 167) who could be quoted: an

> (…) economic analysis of technical change is not a straightforward matter. The familiar tools of equilibrium economics are best suited to discussing the long-run effects of new products and methods of production; they are not well suited to analysis of the disequilibrium processes by which new technologies are generated, improved and absorbed into the economic structure.

In this paper, departing from the SED and the evolutionary approaches, we intend to show that the diffusion of new technologies is harder than what has been reported by the mainstream literature. From the SED approach we can focus on changes in the sectoral composition of an economy due to the existence of particular rates of technical progress and growth rates of demand for each of the sectors. The existence of the non-homothetic tastes is shown to create some mechanisms that block a rapid diffusion of technological progress from advanced to underdeveloped countries. Besides the evolutionist approach, by focusing on the dynamic capabilities of firms, this can show us that the process of innovation, even if made through imitation, is more complex than what has been reported by the mainstream literature on technological transfers.

It is important to note that although these theories share a common scepticism towards the neo-classical growth theory, the connections between them are now well established in the literature. An attempt to built a bridge between these approaches was attempted by D'agata (2010, p. 334-335) for whom

> [T]he awareness of the literature on structural change as far as the problem of learning is concerned makes this literature very close to evolutionary theory where this problem is notoriously one of the focal point of analysis. (...) Finally, one should not forget that one of the aims of evolutionary theory is to propose an

alternative theory of growth and dynamics to neoclassical economics, and from this point of view evolutionary growth theory and the theory structural change seem to be complementary.

In the present paper we intend to explore these complementarities between the two approaches. The aim is to endogenize technological progress in the SED approach from an evolutionary viewpoint and then to perform an analysis of the difficulties that developing countries faces in incorporating indigenous technological progress by using the SED approach. In the next section we analyse the SED approach to technological gaps and in section 3 we focus on the barriers posed by the evolutionary approach. Section 4 concludes.

2_ Engel's Law as a Constraint to the Diffusion of International Technical Progress

In this section we focus on the evolving patterns of demand and productivity growth as important elements determining the capability of absorption of foreign technical progress. The central idea is that different rates of growth in demand, governed by different income elasticities, and

international evolution of tastes critically affect international learning and diffusion of technology[3]. According to Pasinetti (1981, 1993) structural change refers to variations in the sectoral composition of the economy due to the existence of particular growth rates of demand and technical progress in each sector. Pasinetti (1993, p. 39) considers that there exists a minimal set of information on the evolution of consumption patterns, which may be conveyed by the following three points:

i. as per capita income increases, a marked tendency emerges for each consumer, not proportionally increase the demand for various goods, but rather to follow, in satisfying various needs, a certain hierarchical order, by first satisfying essential needs an then gradually moving on to the satisfaction of those needs that are less and less essential.

ii. The variation in the composition of consumption may well occur independently of the increase in income and of the changes in prices, as a consequence of the appearance on the market of newly invented goods and services.

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[3] We recognise that when technological change is effectively added to the productivity process it affects the structure of the economy as will be considered below.

iii. There is no good for which the consumption of an individual can increase indefinitely. A saturation level exists for the consumption of any good and service, even if this saturation level may be reached at different speeds for different goods or at different levels of per-capita income.

The starting point of the SED approach to technological gaps is the concept of material bases. Baranzini and Scazzieri (1990) define the material bases of an economic system as the matrix of objective condition defined by:

i. the natural and environmental resources;

ii. the technological skills and capabilities, which determine the technological set-up.

They argue (Baranzini and Scazzieri, p. 258) that

> *there exists a precise relationship between the institutional set-up and the corresponding material bases: once a certain degree of sophistication in productive organization is attained, the material basis, which is expressed by means of an objective stock-flow network, takes shape according to the possibilities implied by the existing institutional set-up*

The existence of a precise relationship between the institutional set-up and the corresponding material bases is strong evidence that technological diffusion from advanced to underdeveloped countries may be constrained by the specificity of particular production processes in the latter. The theory of development applied to backward countries needs to take into account history and expectations and a set of initial conditions such as high unemployment, subsistence wage level, shortage of capital *etc*. Needless to say, choosing among alternative trajectories of development depends upon the degree of backwardness when planning for growth is initially undertaken.

Fagerberg (1994, p. 1156) concludes that country-specific factors are, through various channels, assumed to influence the process of technical change, and thus give the process of technical change a particular 'national' flavour. Where technical progress is 'localised', it will leave relatively unaffected the less-capital-intensive techniques that the underdeveloped country would choose in the light of its factor endowment. This view is confirmed by Freeman (1995, p. 19) who

> *shows that historically there have been major differences between countries in the ways in which they have organised and sustained*

the development, introduction, improvement and diffusion of new products and processes within their national economies.

In his analysis, Pasinetti (1981, 1993) goes a step further and shows that even in the case where there is not a precise relationship between the material bases and the institutional set up, the diffusion/absorption of new technologies may be damaged by the particular material bases of advanced and underdeveloped economies. The central idea is that different rates of growth of demand, governed by different income elasticities, and international evolution of tastes critically affect international learning and diffusion of technology[5]. In this context, technical change that an underdeveloped country can take advantage of is partial since there is a definite order in which the production process can be enlarged according to the increases in demand as income expands. Actually, there is an almost fixed order in which the production process can be enlarged and methods of production can be learnt[6]. In this vein, Engel's Law, which gives rises to non-homothetic tastes and particular structures of consumption and production for each country or region,

constitutes one of the mechanisms blocking prompt diffusion and absorption of international knowledge in developing countries.

It is important to mention that despite the fact that technical change plays a central role, taking place at a different pace in the various sectors, it is exogenously determined in the Pasinetti's model. Some authors such as Reati (1998) went a step further and have introduced long waves in this model, assuming that productivity growth is fundamentally driven by technological revolution, which gives rise to a complex dynamic involving a set of prices, physical quantities and employment. However, the origins of this revolution remain unexplained in this framework.

It is at this point that the evolutionary approach is best suited to provide the structural economic dynamic approach with the tools to endogenise innovation, which is the focus of the next section. In fact, if on one hand the evolutionary view can provide the explanation for technical progress and innovation, something that is missing in the structural economic dynamic approach, on the other hand, the latter may clarify the

connections between technical progress and structural change, something that is not highlighted by the former.

Metcalfe, Ramlogan and Uyarra (2003) have studied the relationship between competition for innovation and structural change. According to them,

> *The correspondence between evolution, competition and development is exact. Each is a theory of the growth of specified entities and populations of entities and since the focus is upon differences in growth rate the natural implication is that development and competition entail structural change.* (Metcalfe, Ramlogan and Uyarra, 2003).

Although providing an important link between competition and structural change, these authors do not focus on a detailed explanation of mechanisms that act as the link between competition and structural change.

This gap is filled by the structural economic dynamic approach to economic growth. According to it, technical progress raises productivity and increases per capita income but this higher purchasing power is not translated into a proportional increase of demand for different goods and services, due to Engel's Law. Hence,

changes in the composition of demand will give rise on the production side to variations in the sectoral composition of the economy, which is nothing but structural change.

In order to understand the importance of this mechanism as a barrier to the diffusion of technological progress amongst countries it is useful to consider the existence of two countries denoted by A, for advanced, and U, for underdeveloped. Assume, for the sake of convenience only, that they produce the same set of commodities with different methods of production but the same structure of costs for each single good. This corresponds to the situation in which consumer preferences are homothetic in both environments, giving rise to the same structure for economies with different levels of national income. It is assumed that all commodities can be produced in A with 1/10th of the labour they require in U. In this case the new methods of production developed in the advanced countries are directly applicable for both countries since the sectoral composition of both economies is the same. It follows that learning new techniques from abroad arises as

a straightforward source of gains from international relations in this unrealistic set up.

Although the hypothesis of homothetic tastes is useful as a first approximation, the analysis may well be enriched when it is dropped, allowing us to consider the effects of evolution of human needs and preferences on the sectoral composition. Non-homothetic tastes give rise to entirely different compositions of demand and, therefore, different structures of production and employment, according to the particular levels of real per capita income in each of the countries.

In this vein it is possible to consider the effects of Engel's law on the diffusion and absorption of technological diffusion where uneven growth is the most probable outcome. In such an environment the path of diffusion and absorption of new technologies will reflect, on the input side, the order of priorities in which production of consumption goods is organised according to the consumers' preferences. Technical change that an underdeveloped country can take advantage of is partial, since there is a definite order in which the production process can be enlarged according to the increases in demand as income expands. Actually, there is an almost fixed order in which the production process can be enlarged and methods of production can be learnt[4]. In this vein, Engel's Law, which gives rises to non-homothetic tastes and particular structures of consumption and production for each country or region, constitutes one of the mechanisms blocking prompt diffusion and absorption of international knowledge in developing countries.

Besides, technology transfer to the developing countries will not necessarily increase their growth rate, but may reduce the rate of labour absorption, having negative impacts on the employment level. The extent of this phenomenon depends on institutional characteristics of the developing countries, such as the flexibility of the labour legislation and the skills of the labour force, an issue that will be addressed in the next section. Araujo and Teixeira (2003) have shown that the employment level, EL, in country U can be measured by the following expression:

[4]   According to Pasinetti (1981, p. 75) *"although possibilities of substitution among commodities are of course relevant at any given level of real income, there exists a hierarchy of needs. More precisely, there exists a very definite order of priority in consumers' wants, and therefore among groups of goods and services, which manifests itself as real income increase".*

$$EL(t) = \sum_{i=1}^{n-1} (a_{in} + \xi\, a_{i\hat{n}}) a_{ni} +$$

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

Where 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 ξ. The dynamic paths of the demand and technical coefficients are given below:

$$a_{in}(t) = a_{in}(0)e^{r_i t} \qquad (2)$$

$$a_{i\hat{n}}(t)\, a_{i\hat{n}}(0)e^{r_{\hat{i}} t} \qquad (3)$$

$$a_{ki,n}(t) = (g + r_i)\, a_{in}(t) \qquad (4)$$

$$a_{ki,\hat{n}}(t) = (g + r_{\hat{i}})\, a_{i\hat{n}}(t) \qquad (5)$$

$$a_{ni}(t) = a_{ni}(0)e^{-(\rho_i + \gamma_i \rho_{\hat{i}})t} \qquad (6)$$

$$a_{nki}(t) = a_{nki}(0)e^{-(\rho_{ki} + \gamma_{ki}\rho_{\hat{k}i})t} \qquad (7)$$

where r_i is the growth rate of internal demand for commodity i and $r_{\hat{i}}$ stands for the growth rate of foreign demand for good i. The rate of technical change for sector i is denoted by ρ_i while ρ_{ki} has the same meaning in relation to sector ki. Besides, $\rho_{\hat{i}}$ and $\rho_{\hat{k}i}$ are the rate of change of productivity in the foreign sectors $\hat{i}$ and $\hat{k}_i$, respectively. The symbols γ_i and γ_{ki} stand for the fraction of foreign technological progress that is captured through international learning, $0 \le \gamma \le 1$ and $0 \le \gamma_{ki} \le 1$.

By placing the dynamic path of coefficients, captured by expressions (2) to (7), into the expression (1), this allows us to conclude that the employment level (*EL*) may be smaller due to patterns of foreign trade and the absorption of technical progress. This result is demonstrated by Pasinetti (1981) for a closed economy and Araujo and Teixeira (2003a) have verified it to be the case for an open economic system.

The balance of payment, hereinafter BOP, constraint is another issue that may spring from particular structures of developed and underdeveloped countries that may also affect the capability of an underdeveloped country to absorb international knowledge. In order to show how these particularities may damage the growth experience it

is useful to consider the following notation. Let us consider that the profit rate in sector i is denoted by π_i, p_i is the price of commodity i and p_{ki} is the price of the capital goods in the underdeveloped country ($i = 1, 2, ...,$ n-1). Araujo and Teixeira (2003) have shown that the equation that expresses the intertemporal balance of payment constraint should be written as:

$$\sum_{t=0}^{\infty} \left[\sum_{i=1}^{n-1} (\xi\, a_{i\hat{n}} - a_{\hat{i}\hat{n}})\, (p_i - \pi_i p_{ki}) + \right.$$

$$\left. + \sum_{i=1}^{n-1} (\xi a_{ki,\hat{n}} - a_{\hat{ki},n})\, p_{ki} \right] = 0 \qquad (8)$$

If for those commodities in which the country specializes, the growth rate of demand, r_i, is lower than the growth rate of demand for those commodities that it imports, $r_{\hat{i}}$, the country will face a BOP constrained growth that springs from Engel's Law that may damage the absorption of technological progress. From this analysis it is possible to conclude that countries that produce goods with a higher income elasticity of demand can benefit from a higher growth rate of per capita income. If for those commodities in which the country specializes, the growth rate of demand is low, the country may face constrained growth that springs from Engel's Law.

In fact, recent literature tends to admit that a large portion of technical progress is specific to capital goods. If this is true, the capability of underdeveloped countries to absorb foreign technical progress is connected to the availability of capital goods to use new technologies. Balance of payment constraints may damage the capability of the developing countries to adopt technology from abroad. In general, to use advanced technologies, such countries must import that equipment that is directly or indirectly necessary for mastering the new technologies but that cannot be produced at home[5]. Importing such advanced machine may be prevented by an intertemporal balance-of-payments constraint, which is a consequence of Engel's Law. Accordingly, for most of the underdeveloped countries, only exportation of primary products, with low foreign demand elasticities, is available. Hence the balance of payment constraint on growth that springs from Engel's Law has a negative effect upon

[5]   As pointed out by Oda (1999, p. 208) *"learning new techniques without importing any capital goods is also meaningless unless all the capital goods that are directly or indirectly necessary for using the learnt techniques can be produced at home. The importation of advanced capital goods is not the origin of acquisition of new techniques, but the latter is almost inevitably accompanied by the former".*

the adoption of new technologies learnt from abroad[6].

Any analysis of the North-South linkages from which reliable policy conclusions are to be drawn should take into account not only technical progress but also the barriers to its diffusion and absorption due to the particular structure of economies with different levels of per capita income and labour skills.

3_ An Evolutionary Approach to Technological Gaps

The paradigmatic nature of technological progress has important consequences in terms of its diffusion amongst firms operating in different environments and subject to particular conditions of credit constraint, labour skills *etc.* According to Dosi (1988, p. 1127) a technological trajectory can be defined as *"the activity of technological process along the economic and technological trade-offs defined by a paradigm"*. This means that in general there is a path created by the acquisition of technological progress, which has to be followed by firms in a sector if they want to succeed.

In addition, this process is at the same time both selective and cumulative

and these characteristics give rise to an ordered path that technological progress follows in a specific sector. The neo-classical theories tend to ignore the importance of this order, considering the tasks of imitation and innovation easier than what they really are in practice. Barro and Sala-i-Martin (1999, p. 266) have reported that

> *(...) follower countries tend to catch up to the leaders because imitation and implementations of discoveries are cheaper than innovation. This mechanism tends to generate convergence even if diminishing returns to capital or to R&D do not apply.*

Note that the central point of the studies above is that imitation and adaptation of technologies is cheaper than financing R&D. But this view has been disputed by some authors such as Dosi (1988, p. 1140) who states that

> *In general, it must be noticed that the partly tacit nature of innovative knowledge and its characteristics of partial private appropriability makes imitation, as well as innovation, a creative process, which involves search, which is not wholly distinct from the search for new development, and which is economically expensive – sometimes more expensive than the original innovation.*

....
[6]   Thirlwall (1994) argues that the effective constraint to long-term steady growth of underdeveloped countries, at a high rate, is the long-run rate of growth of exports, combined with the long run elasticity of demand for imports in relation to the national income (output). His balance of payments constrained growth model and the so-called Thirlwall's Law have typically been used to analyse the determinants of growth for industrialised nations. Moreno (1999), and McCombie and Thirlwall (1994) deal with developing countries. Lopes and Cruz (2000, p. 478) pointed out that *"All these studies have been carried out under the (implicit) assumption that the real terms of trade or real exchange rate remain constant in the long run"*. Dutt (2000) relates Thirlwall's approach to a model of North-South trade to show how it may explain uneven development. The Journal of Post Keynesian Economics, v. 19, n. 3, Spring 1997, provides a *"Minisymposium on Thirlwall's Law and Economic Growth in an Open-Economy Context"*.

This view is also supported by Cohen and Levinthal (1989) for whom the assumption that knowledge is a public good is not according to the degree of complexity required to implement it automatically by firms. According to them, all firms should invest in R&D in order to take advantage of the existing level of technology.

By using the findings of an extensive survey of historical experience in industrial plants in Latin America, Katz (1984) studies some key factors affecting the acquisition of technological capabilities by industries in the less developed countries. The findings of this author show that the sequence in which different types of capabilities are acquired depends on the acquisition of technological capabilities and this can be implemented through an infant industry protection strategy. The use of import substitution strategies has been claimed by some authors as crucial for the creation of a proper environment for diffusion and absorption of technological progress. In fact some authors consider that almost all advanced countries have adopted infant industry protection in some phase of industrialization. [see Bhaduri and Nayyar (1996), Baer (1972) and Chang (2002)].

This view is strongly supported by Cimoli *et al.* (2006, p. 8) for whom

> *a fundamental element in countries that successfully caught-up with the leaders during the 19th and 20th centuries was active government support of the catch-up process, involving various forms of protection and direct and indirect subsidy. The guiding policy argument has been the need for domestic industry in the industries of the day to be judged critical in the development process for some protection from advanced firms in the leading nations.*

This view was confirmed by Cimoli *et al.* (2003) for whom the existence of gaps in learning capabilities have hindered the use of new technologies in Latin America. Due to a number of underlying weaknesses in the institutional fabric inherited by the region, its factor markets have functioned very imperfectly and have failed to deliver what was expected of them in terms of a better long-term overall performance. For Teitel (2004) skills, institutions, and policies played critical roles in the growth experience of a number of countries. The emphasis on indigenous technological development, as opposed to obtaining

technical knowledge through foreign investment, is also a springboard of his analysis. The process of economic growth is shown to be instead, a path or process, dependent, and determined by the circumstantial convergence of requisite skills, appropriate institutions and supportive public policies.

This shows that assimilation of technological paths by firms of other countries may involve higher costs. The advent of the 'New Economy', understood as the rapid advances of information and communication technology extending labour productivity, is a striking example of the particular nature of technological progress that is being generated in developed countries and which is barely adopted by underdeveloped nations. Acemoglu (2002, p. 63) points out that

> (...) *new technologies developed in the rich economies are typically 'too skill-biased' for LDC, the recent acceleration in skill bias could have negative implications for the LDCs.*

According to him the bias of the technical progress is mainly determined by the qualification of the available labour force. In this vein skilled biased technical progress was generated in

advanced countries because there was a supply of skilled workers in those countries. Of course this is not the scenario observed in underdeveloped nations, where the labour force is characterised by low qualification. One could conclude that skilled biased technical progress would produce a skilled labour force in the less developed countries (LDC's). But this is exactly the contrary path observed in advanced countries.

Another important characteristic of technological diffusion raised by Acemoglu (2002) is that a new technology is adopted only if it is more profitable than the available technologies. There are a large number of new technologies developed in the advanced countries that are not profitable to be adopted in underdeveloped countries. In the advanced countries, the most productive technology is in general the most profitable one. In the underdeveloped case the most productive technology may not be the most profitable one due to costs involved with its adoption and training the labour force to use the new technology.

In fact, a number of recent contributors have emphasised the role of skill resources. It is quite obvious that the process of technology absorption is affected by the skills of the labour force and this is a crucial constraint on the selection of the technological profile to be implemented by a developing economy. Parente (1994), studying technology adoption, learning by doing and economic growth, stresses that adoption costs may well take different forms, including institutional and legal constraints. He argues that barriers to technological progress, such as tariffs or import restrictions can explain some of the disparities of income levels across countries. As his approach is supply driven, he does not mention that some barriers are imposed by balance of payments constraints.

Gonzalo (2002) focuses on the processes of adoption and maintenance of new technologies as well as their, shall we say, consequences to the growth and development strategies. His main objective is to explain differences in the use of investment goods due to the high costs of implementation of new technologies,

given the same available technological menu. Naturally, maintenance costs affect the adoption process.

Adoption costs have been repeatedly invoked to explain technological sclerosis and higher age of capital in developing countries. Of course, an increase in the absorption costs of technological improvements generated abroad not only lowers the short run growth rate in the less advanced countries but also decreases the speed of convergence towards the advanced ones. According to Bessen (2002, p. 444),

> (...) whole new technologies may incur large adoption costs because they involve learning new skills, implementing new forms of organization, and developing complementary investments.

Surely, the technological gap increases with the size of the absorption costs.

In summary, the investment-specific nature of technological progress in the 'New Economy', added to the balance of payments constraints and to the deterioration in the terms of trade, make the diffusion and absorption of new technologies in the South a daunting task.

4_ Concluding Remarks

In this paper we have focused on some mechanisms that block rapid diffusion of technical progress from advanced to underdeveloped countries. From the structural economic dynamic and evolutionary approaches we highlight some mechanisms that prevent firms in the underdeveloped countries from catching up to the technological frontier. The structural economic dynamic approach allows us to study the issue from a sectoral level while the evolutionary approach focuses on the dynamic capabilities of firms to show the complexity of the innovation process, even if it is made through imitation.

The basic lesson to learn is that the diffusion/absorption of technological progress relies heavily on characteristics of the particular environment of the firms or sectors such as the level of per capita income, the set of institutions, the skills of the labour force etc. Unfortunately, the dominant neoclassical literature on economic growth is inadequate to deal with the issue of technological transfer, since its frameworks cannot take into account the complexities of the innovation process and particular

conditions of the economies[7]. This theory, applicable to developed nations, was based on economic background (or structure) where near full employment prevailed, as well as an adequate stock of capital and the balance of payments constraints were not too severe.

On the other hand the theory of development applied to backward countries needs to take into account a set of initial conditions such as unemployment, subsistence wage level, shortage of capital *etc*. Needless to say that choosing among alternative trajectories of development depends upon the degree of backwardness when planning for growth is initially undertaken. To close both technology and income per capita gaps may well require a temporary protection by a number of tariff and non-tariff barriers to trade and industrial policy with a variety of incentives, credit subsidies and price controls.

We show that cross-country differences in demand patterns give rise to particular structural changes and compositions. An economic system with high per capita income has a structure that is different from one with a low per capita income. But if the composition is different, then the technological

....
[7]   According to Metcalfe (1988, p. 167) *"the economic analysis of technical change is not a straightforward matter. The familiar tools of equilibrium economics are best suited to discussing the long-run effects of new products and methods of production; they are not well suited to analysis of the disequilibria processes by which new technologies are generated, improved and absorbed into the economic structure".*

progress that is useful for each of these economies is also different. Hence while technological progress increases demand, its absorption and diffusion is also affected by the composition of the economy, which is critically affected by the composition of demand in each country. If the underdeveloped country has access through exports to a market with a high per capita demand, it can benefit by creating a domestic environment favourable to the production of more sophisticated goods.

The syntheses of the analysis presented here is that the structural economic dynamic and the evolutionary approaches of the systems should be considered as the starting point for the creation of a proper environment for international learning in underdeveloped countries. We acknowledge that more than one policy strategy follows from an understanding of the obstacles to diffusion and absorption of technical progress posed by Engel's law and by the complexities of the process of innovation. A possible conclusion is that poor regions need to induce structural changes in their economies that take into account the complexities of the innovation process.

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