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National Innovation System and external constraint on growth

Sistema nacional de inovação e restrição externa ao crescimento

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RESUMO: According to the literature on export-led growth models differences in income elasticities of demand for imports and exports among countries bring about different degrees of external constraint on growth. However, there is not in this literature an explanation that uses the Evolutionary concept of National Innovation System (NIS) that shows why there are differences in income elasticities among countries. Moreover, there is not a consensus about the exogenicity of the elasticities. Some authors highlight the high level of income elasticity of demand for exports in sectors with high level of technological intensity. However these authors seem to not explain the motive for this. The aim of this paper is to theoretically show the causal relation between an economy's NIS, its income elasticities and its Current Account performance. It also aims to show the role of NIS in the exogeinicity/endogeinicity of the income elasticities. Empirical evidence and a Granger Causality Test are presented and do not reject the core argument of the paper.
KEYWORDS: Technological progress; income elasticities; economic growth.

ABSTRACT: Segundo a literatura sobre modelos de crescimento com restrição externa, as diferenças nas elasticidades-renda da demanda de importações e de exportações entre os países levam a diferentes graus de restrição externa ao crescimento dos mesmos. Contudo, não há nesta literatura uma explicação que utiliza o conceito Evolucionário de Sistema Nacional de Inovações (SI) para mostrar o motivo para as diferenças nas elasticidades-renda dos países. Ademais, não há um consenso sobre a exogeneidade destas elasticidades. Alguns autores enfatizam que a elasticidade-renda de exportações é maior nos setores com maior

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intensidade tecnológica. Porém, estes autores não explicam os motivos para isto ocorrer. Neste artigo visa-se mostrar teoricamente a relação de causalidade entre o SI de uma economia, suas elasticidades-renda e seu desempenho em transações correntes. Objetiva-se, também, mostrar o papel do SI na determinação da exogeneidade/endogeneidade das elasticidades. A evidência empírica apresentada neste estudo não rejeita seus argumentos.
PALAVRAS CHAVE: Progresso tecnológico; elasticidades-renda; crescimento econômico.
JEL Classification: E12; F43; O44.

INTRODUCTION

Prebisch's works (2000a, 2000b) and those of authors who deal with export-led growth models (ELGM), consider that differentials in growth rates between countries result from differences in their income elasticities of demand for imports and exports. Such differences in elasticities bring as a consequence different degrees of balance-of-payments constraint on growth. Authors such as Thirlwall (1979), Dixon and Thirlwall (1975), Thirlwall and Hussein (1982), McCombie and Thirlwall (1994), Moreno-Brid (2003), Barbosa Filho (2001), Cimoli et al. (2010), Gouvea and Lima (2013) formalized ELGM. According to these models, the income elasticities (IE) are exogenous and current account (CA) deficits may constraint growth in the long run. Thus, growth depends on CA performance which in turn depends on IE.

However, there isn't a consensus about the exogenicity of the IE. Krugman (1989, 1999) have criticized the literature on ELGM and argued that the IE are endogenous and change due to differences in the rate of growth of total factor productivity among countries. Fagerberg (1988) have also worked at the supply side of the economy to show that technological progress affects the IE. Authors such as Bértola et al. (2002) and Porcile et al. (2007), have argued that supply-side effects emerges from the pattern of specialization of the industrial structure insofar as the latter affects the IE. On the other hand, McCombie and Thirlwall (1994, p. 388-391) present arguments for the exogenicity of the IE.

There is no such study that uses the Evolutionary concept of National Innovation System (NIS) in order to show why there are differences in IE among countries. Moreover, the concept of NIS can be useful in explaining differences in IE between industrialized countries, since Prebisch's explanation relate to differences between agrarian and industrialized countries. According to Boianovsky and Solís (2014), in Prebisch's view just the countries from the Periphery (agrarian countries) show a balance-of-payments constraint on growth.

In this paper, the concepts created by the Evolutionary School are used to show how the relative development of NIS plays a relevant influence on the size of the IE and on their exogenicity/endogenicity aspect. If NIS changes IE, it affects the external constraint on growth. The aims of this paper are threefold. First, it brings to the literature on the ELGM the Evolutionary concept of NIS in order to demonstrate in a theoretical way the role of NIS in the existence of IE differentials among industrial countries. Second, it focuses on the concept of NIS in order to reject Krugman's critique about the ELGM. Third, it shows some empirical evidence about the causal relationship between the NIS and CA surpluses.

In the next section, the role of NIS and technological progress for the existence of income elasticity differentials among industrial countries and for improvements on the CA balances is theoretically discussed. In the third section Krugman's critique about ELGM and an argument for the rejection of such critique are presented. Some empirical evidences about the relationship between NIS and CA balances (including a Granger Causality Test) are presented in the fourth section. Last section brings the conclusions of this work.

NATIONAL INNOVATION SYSTEM AND THE CURRENT ACCOUNT BALANCE

The literature on ELGM argues that countries present a balance-of-payments equilibrium growth rate (BPEGR) in the long run. Countries with low income elasticity of demand for exports and high income elasticity of demand for imports present a tendency to show external crises due to the recurrence of its CA deficits. Thus, external crises are a way to force the rates of growth to converge to the BPEGR in the long run (McCombie and Thirlwall, 1994, p. 256-261).

On the other hand, we advocate that the relative development of a country's NIS plays a relevant influence on the size of the IE. The aim of this section is to show the causal links among the degree of relative development of a country's NIS, the size of its IE and its CA performance.

Countries as Separate Technological Systems

The concept of NIS was developed in the Evolutionary literature.[1] The NIS is a country's institutional framework that summarizes the agents involved in innovation and technical change. Firms, universities, research institutions, factor endowments, financial systems, government policies, cultural traditions, etc. are part of a country's NIS (Nelson, 1993; Freeman, 1995; Ribeiro et al., 2006). The networks of relationships among these agents are seen as crucial to technological progress (e.g., user-producer interactive learning; inter-firms relationships; links among universities, research institutions, government policies and industries; science-technology links; interaction with the market and with related firms; mutual trust and personal relationships, etc.)

Innovations and technical change have systemic and tacit aspects. Freeman (1995) emphasizes that technological change is analysed as the joint outcome of

[1] Nelson and Winter (1982) discuss the origins and basic premises of the Evolutionary approach.

innovation and learning activities within organizations, especially firms, and interactions between these and their environments. Firms are the main locus of technological accumulation and are characterized by different combinations of intrinsic capabilities, including technological know-how (Fagerberg, 1994).[2] On the other hand, environments of firms are seen as crucial for technological progress and its diffusion.

Technologies are embedded in organizations and are not easily transferable to other settings. Technological spillovers to a large extent are geographically localized (Fagerberg, 1994). Thus, the Evolutionary literature rejects the argument that technology is a public-good (e.g., Fagerberg, 1994; Dosi et al., 1994). The cumulative – or path dependent – character of technological progress is often stressed. Following Dosi (1988, p. 123), "Technology, far from being a free good, involves a fundamental learning aspect, characterized by varying degrees of *cumulativeness, opportunity and appropriability* [...] Both appropriability and cumulativeness of technical change are affected by the degrees of *tacitness* and degrees of *formal understanding* of each technology".

According to Dosi et al. (1994, p. 28), imports of technology and autonomous innovative efforts are not alternative but complementary activities. "Technologies cannot be taken off the shelf and simple put into use anywhere. Without infrastructural investment in education, training, R&D, and other scientific and technical activities, very little can be accomplished by way of acquisition of imported technologies."

Therefore, country-specific factors are assumed to influence the process of technical change. History, culture, institutions and government policies together are seen as crucial determinants of the characteristics and dynamics of each country's NIS. Thus, writers from this tradition see countries as separate technological systems, each with its own specific NIS and own specific dynamics (Lundvall, 1992; Nelson, 1993; Freeman, 1995).

Nelson (2005), Freeman (1995), Fagerberg and Godinho (2005), Dosi et al. (1994), Bernardes and Albuquerque (2003) highlight the positive effects of the NIS on an economy's productivity, competitiveness and growth. They also consider the impossibility of substituting the NIS by the importation of technology, given that technology has a tacit, path dependence, systemic and local feature. Thus, technology is not a public-good.

Therefore, in spite of the recent process of globalization, the NIS remains central in the development of technical progress and its dissemination (Freeman, 1995). These authors show that Technological progress and its diffusion in a coun-

[2] Writers from this tradition emphasize the importance of Research and Development (R&D) system as the source of innovations. They emphasize also the role of the state in coordinating and carrying through long-term policies for industry and the economy (Freeman, 1995; Bernardes and Albuquerque, 2003). The R&D activities and government policies are part of a country's NIS.

try depend on the development of that country's NIS, which in turn, affects the level of technological sophistication of the country's production.

The Causal Relationship Between NIS and the Income Elasticities

We argue that the country's NIS development influences its CA performance. As will be shown, the greater the development of NIS, the lower the income elasticity of demand for imports in relation to income elasticity of demand for exports will be, and therefore, the greater the CA surplus will be.

This relationship is not valid only for countries that are the centre of the international financial system. The net capital inflows in the country where the main international financial market is located tends to be high and persistent and brings about economic policies that are associated with the occurrence of chronic CA deficits, even when the economy is competitive. In other words, in the last few decades the capital flows in the financial account of the countries' balance of payments have become increasingly larger than the flows into the current account (Plihon, 1995; Ffrench-Davis, 2003) and, on the other hand, any increase in the current account deficit must be matched by a surplus on the financial and capital accounts (adjusting for changes in reserves). Thus, countries with a relative developed NIS, which includes a developed financial system, benefit from the international capital flows insofar as they are considered as low risk countries for investment. They are competitive in the international trade markets due to the relative development in their NIS and they show sophisticated financial instruments and financial arrangements due to the high level of development of their financial systems. They show also convertible currencies because of the high level of development of their financial systems and NIS. As a consequence, there is a large capital inflow in their financial accounts and they show persistently financial accounts surpluses and, therefore, current account deficits, although they are competitive economies. This seems to be the case of the United States and the United Kingdom during the last few decades.

Fagerberg (1988) have worked at the supply-side of the economy to show that the technological progress affects the IE. Authors from the literature on ELGM (Porcile et al., 2007; Araujo and Lima, 2007; Gouvea and Lima, 2013) have argued that supply-side effects emerge from the pattern of specialization of the industrial structure insofar as the latter affects the IE. Ferrari et al. (2013, p. 66) assume that income elasticity of demand for exports is higher in sectors with high level of technological intensity than in sectors with low level of technological intensity. According to McCombie and Thirlwall (1994, p. 390-391) "[…] the supply characteristics of goods (such as their sophistication, quality, etc.) determine relative income elasticities". However, these authors seem to do not explain the channels through which this process happens. In order to analyse the relationship between NIS and the CA performance, the channels that link technical progress and the IE will be explained.

We begin with the relationship between NIS and the income elasticity of demand for exports. We argue that in international trade, the greater the level of technological sophistication of products (LTSP), the closer the structures of their markets resemble oligopoly, the more dynamic are their markets and the less they are subject to protectionist measures.

The positive correlation between the LTSP and the degree of oligopoly, and between the LTSP and the level of dynamism of its markets is due to the fact that a product that is in the technology frontier, or close to it, cannot be produced in countries which do not possess a developed NIS. Production cannot just simply be transferred to other countries, given that few economies possess a NIS that is developed enough to enable them to manufacture such products. That means: i) no heavy competition for these products in world markets and tacit or explicit agreements concerning price fixing for the goods in the international market is made possible. This situation supports an increase in the income elasticity of demand for the country's exports; ii) the demand for such products can only be satisfied by means of imports from the few countries where the NIS is able to produce it, thus guaranteeing a world-wide market with increasing (dynamic) demand for this type of technologically sophisticated product. The higher the dynamism of the country's exports markets, the higher the income elasticity of demand for this country's exports tends to be.

The inverse correlation between the LTSP and the degree of protectionism in its markets abroad is due to the fact that a product made by low level of technological content can be produced by many countries, even if the production costs are higher than the world average. Domestic production is made viable by erecting barriers to importation of this type of product. However, if the technological content of the product is of a high level, it cannot immediately be produced even though barriers have been established if the country's NIS is not developed enough to make it possible. In such cases, the domestic demand for the product can only be satisfied by imports and this would imply a low level of protectionism (in the domestic markets of a wide range of countries) and a high level of the income elasticity of demand for exports high technology products.

Concerning the diversification of the country's industrial structure, the more developed its NIS, the greater is the possibility of reaching the technological frontline in various areas of production. Therefore, the greater the degree of diversification in the industrial structure tends to be. Consequently, there is greater diversification in the range of its export goods, which favours growth in the value of exports, due to two factors, namely, i) the export opportunities and the domination of new markets will be greater to the extent that there is greater diversification in the range of export goods; ii) the stability of growth in the value of exports will be greater the more diversified exports are because the greater the chance that a drop in price and/or demand for exports be offset by an increase in price and/or demand of another product in the range of exports.

Therefore, the four items examined – level of oligopoly, market dynamism, level of protectionism and diversification of the industrial structure – suggest that the more developed a country's NIS, the greater its income elasticity of demand for exports.

The relationship between the level of a country's NIS development and its income elasticity of demand for imports is also associated with these four items. Countries with a low level of NIS development are not capable of producing goods with high technology content and need to import such goods from high priced markets where there is oligopoly. In addition to this, the more dynamic a market for a particular good, the greater will be the demand in this market, thus favouring an increase in prices and making its imports more expensive – the positive correlation between LTSP and the degree of market dynamism has already been explained. Also, the lower the import barriers, the greater the value of imports. As already argued, there is an inverse correlation between the degree of a product's technological sophistication and the level of protectionism in its markets abroad. Finally, the less developed the country's NIS, the less diversified its industrial structure will be. Therefore, the more diversified its range of imports, the greater the proportion of internal demand that will be satisfied by means of imports. All these factors lead to growth in the income elasticity of demand for imports.

Therefore, in a country where the NIS is relatively less developed, the income elasticity of demand for exports tends to be lower than the income elasticity of demand for imports, leading to external structural vulnerability, as postulated initially by Prebisch (2000a, 2000b). It may be concluded that the level of development of the country's NIS affects the size of its IE and it is positively correlated with the performance of the trade balance and the CA balance.

THE NIS AND THE DEBATE ON THE EXOGENICITY/ ENDOGENICITY OF THE INCOME ELASTICITIES

Krugman (1999) criticized the literature on ELGM and considered a supply-side explanation of the IE. He argued that "differential growth rates affect trade flows in such a way as to create apparent differences in income elasticities [...] I am simply going to dismiss a priori the argument that income elasticities determine economic growth, rather than the other way around" (Krugman, 1999, p. 47).

Krugman presents an increasing returns model of international trade based on monopolistic competition. Labor is the only factor of production and there is not difference in relative factor endowments among countries or in factor intensities among goods. There are two countries and each can produce and consume any of an infinite number of product varieties. The price of representative goods is equalized between countries and the number of product varieties produced in a country is proportional to its labor force. Trade arises because of increasing returns and will result from the desire of consumers in each country to diversify their purchases. The country that presents the higher rate of labor force growth will grows faster and will produce a greater number of product varieties than the other country. Exports will grow faster in the country which labor force grows faster, therefore giving the faster growing country an apparently higher income elasticity of demand for its exports.

Krugman's argument shows the following mechanism: if the labor force grows, then productivity grows, output and income grow and the size in the supply of product variety grows. Since consumers desire to diversify their purchases, demand grows without changes in prices. Thus the faster growing country exports more and increases its share on world expenditure, i.e., increases its income elasticity of demand for exports. Krugman (1999) considered a non-realistic model to make his point about the supply-side explanation of the IE. As this author recognized himself, "No effort will be made at realism" (Krugman, 1999, p. 50). However, adopting the Evolutionary approach one can explains changes in the IE.

As was argued above, the more developed the country's NIS, the greater its IE of demand for exports in relation to its IE of demand for imports will be. So, the relative development of a country's NIS leads to productivity and economic growth and to changes in its IE. This is a supply-side explanation of the IE and of the growth process. However, there is not a mechanism that could account for a causal relation running from growth to IE as Krugman argued. Both growth and IE are a consequence of the country's NIS relative development. I.e., the IE is dependent on the country's NIS relative development.

The export markets of technologically sophisticated goods are characterized by low level of protectionism, high degree of oligopoly and increasing demand. Thus, these export markets are characterized by high level of prices if compared to the level of prices in the perfect competition marked. Moreover, the diversification in the country's range of the export goods favours export opportunities and the domination of new markets. These characteristics affect the income elasticity of demand for exports and are present because technology is not a public good. On the other hand, countries which NIS present low level in its relative development need to reduce its barriers for import sophisticated goods with high prices level from world markets. Besides this, these countries show a less diversified industrial structure and thus show a more diversified range of imports, leading to a great proportion of internal demand that is satisfied by means of imports. These characteristics affect the income elasticity of demand for imports and are present because technology is not a public good.

Therefore the technological progress is the engine of both growth of productivity and output and affects the size of the country's IE insofar as other countries cannot reproduce themselves the NIS development of the former country. However, if on the one hand the non-public good aspect of technology is central to explain why the income elasticity of demand for exports is higher than the income elasticity of demand for imports due to the relative development of the country's NIS, on the other hand this same factor is a reason for the predominance of a picture where there are no changes on countries' IE for a long time.

If technology is not a public good, and if the development of a country's NIS and the technological progress rest on systemic and tacit aspects that are hard to change, the ranking of the degree of development of the countries' NIS tends not to change, leading to the stability of its IE. The path dependence and tacit aspects of technology explain why the catch up is rarely observed among countries and why the countries that are either on the technology frontier or farm from it remain for a long time in this position and, therefore their IE for export tend to remain for a long time either higher or lower in relation to their IE of demand for import. I.e., as technology is not a public good, a country's relative technological progress leads to changes in its IE, but at the same time a country's relative technological progress is hard to happen because technology is not a public good and, therefore, the countries' IE show great stability.

According to the ELGM, the rate of growth of domestic income consistent with balance-of-payments equilibrium (i.e., the balance-of-payments equilibrium growth rate), Y_B, is $_{€.Z}/\pi$, where $_Z$ is the rate of change of world income, $_€$ is the income elasticity of demand for exports and π is the income elasticity of demand for imports. Thus, if the IE shows great stability the estimates of Y_B make sense and the proposition from the ELGM that IE of demand for imports and exports determine growth in the long run is valid, i.e., growth is demand determined. In other words, the countries' IE do not change frequently due to the non-public good aspect of technology and this picture is consistent with models (ELGM) that assume that IE are exogenous.

Moreover, there are in the literature on ELGM some explanations for the exogenicity of the IE. As McCombie and Thirwall (1994, p. 389) pointed out, "countries' income elasticities are largely determined by natural resource endowments and the characteristics of goods produced which are the product of history and independent of the growth of output". Moreover, they argue that although productivity growth may cause economic growth, elements as induced investment, embodied technical progress, learning by doing, scale economies, etc., are associated with a mechanism that could account for a causal relation running form exports and output growth to productivity growth.

Thus, if the exogenicity character in the IE is predominant, growth may be demand determined. The IE may determine growth by imposing a balance-of-payments constraint on demand in a context where factor supplies are endogenous to demand. Although technological progress is a determinant of growth, there are other sources of growth. Demand may be constrained by balance-of-payment or may be lacking due to uncertainty about the future (Keynesian Liquidity Preference Theory).

In the Keynesian approach growth is demand determined, even in the long run. However, as Keynes argued, the Classical theory is a particular case of the general theory. This imply that in the Keynesian view the rate of growth of total factor productivity and the supply side of the economy also plays a role in the long run growth. Thus, a picture where technological progress affects productivity, the IE and lung run growth do not deny the Keynesian view. As McCombie and Thirlwall (1994, p. 390-391) stressed, "However, this is not to say that supply-side factors do not matter in the growth process. Income elasticities determine the balance-of payments constrained growth rate, but the supply characteristics of goods (such as their sophistication, quality, etc.) determine relative income elasticities. In this important respect, there can be a marrying of the demand and supply-side explanations of the comparative growth performance of nations".

EMPIRICAL EVIDENCE

The level of development of a country's NIS can be measured on the basis of that country's *per capita* production of patents compared to the *per capita* production in the world as a whole. According to Bernardes and Albuquerque (2003, p. 873) and Albuquerque (1999), patents are not an infallible means of measuring the level of technological progress but, nevertheless, it is the method used in the literature and is useful in achieving this objective. Using data relating to science and technology indicators, Albuquerque (1999) concluded that the countries which have a developed NIS are: Germany, France, Italy, Japan, the United States, the United Kingdom, Denmark, Belgium, the Netherlands, Ireland, Austria, Switzerland, Canada, New Zealand, Australia and Israel. Countries which are at the stage of catching up are: South Korea, Taiwan and Singapore.

Therefore, in this article Albuquerque's (1999) classification was used to collect data on the international trade of two groups of countries: countries with a developed NIS (DIS) and those with an undeveloped NIS (UDIS). The following countries were selected to represent the DIS group because they compose the G7 group, i.e., they are considered the most developed countries in the world: Germany, France, Italy, Japan and Canada.[3] For the UDIS 16 countries which data was available were chosen: Argentina, Bolivia, Brazil, Colombia, Chile, Ecuador, Mexico, Peru, Uruguay, Venezuela, Malaysia, Thailand, India, Indonesia, Philippines and South Africa.

Table 1 shows the CA balance for the DIS and UDIS groups. For the period 1960-2010 when data was available, the DIS (UDIS) group had an average CA surplus (deficit) of US$ 79.5 billion (US$ 12.8 billion). Thus, the countries with a developed NIS are those with better performance of its CA balances.

Table 1: Total and Average Current Account Balance, 1960–2010 (US$ billion)

	Sum of CA balances in the period: 1960-2010	Average in the Period: 1960-2010	Standard Deviation
DIS	4,057	79.55	105.05
UDIS	-654.6	-12.83	33.45

Source: Author's elaboration using data from World Development Indicators database, 2012. DIS = countries with a developed NIS – G7 countries excluding USA and UK were taken as proxy; UDIS = countries with an undeveloped NIS: Brazil, Argentina, Bolivia, Colombia, Chile, Ecuador, Mexico, Peru, Uruguay, Venezuela, Malaysia, Thailand, India, Indonesia, Philippines and South Africa.

[3] The exclusion of this group of two countries that are important in the world scenario, the Unites States and the United Kingdom, was justified above.

Table 2 shows the average balance of the total trade balance in goods with high technological intensity (HT), manufactured goods (MG) and primary goods (PG) for the DIS and UDIS groups between 1980 and 2010. In the case of the UDIS group, the average trade balance and the average HT and MG balance was in deficit, while the average PG trade balance was in surplus. In the DIS group, exactly the opposite situation was found.

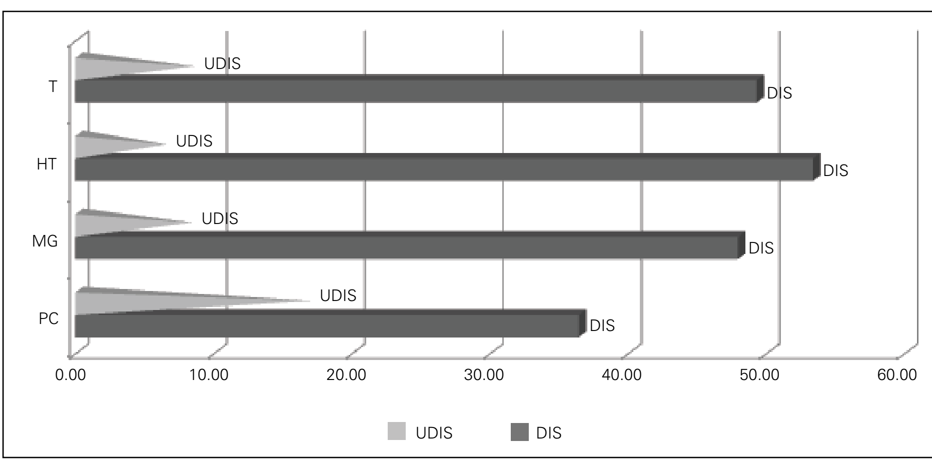
Table 2: Total Trade Balance in Goods with high technological intensity, Manufactured Goods and Primary Goods, 1980-2010(US$ billions)

Period	UDIS				DIS			
1980-2010	TTB	HT	MG	PG	TTB	HT	MG	PG
Average	-2.5	-46.2	-13.4	10.9	29.94	52.5	76.6	-46.3

Source: Author's elaboration using data from United Nations Statistics Division, World Trade Organization, 2012. DIS = see Table 1; UDIS = see Table 1. TTB = total trade balance; HT = goods with high technological intensity trade balance; MG = manufactured goods trade balance; PG = primary goods trade balance.

Figure 1 shows the percentage share of the world exports of goods with HT and of MG and PG, for the period 1980-2010. In all the categories described here, the share in world exports from countries in the DIS group is always larger than the share from countries in the UDIS group. Even more, this gap is much larger for MG and goods with HT, as compared to PG.

Figure 1: Exports share in world exports, by type of goods-1980-2010-(%)



Source: Author's elaboration. Data from United Nations Statistics Division, World Trade Organization, 2012. DIS = countries with a developed NIS – G7 countries were taken as proxy; UDIS = see Table 1. PC = primary commodities; MG = manufactures goods; HT = goods with high technological intensity; T = total exports of goods.

Table 3 presents the average trade balance in PG, labor-intensive and natural-resource-intensive goods, as well as goods with high, medium and low technological level between 1980 and 2010.[4] The average trade balance for the UDIS group was in deficit for high, medium and low technology goods and in surplus for PG and labour-intensive and natural-resource-intensive goods, while the result was exactly the opposite in the case of the DIS group.

Table 3: Trade balance in primary commodities, labor-intensive and natural-resource-intensive goods, and goods with high, medium and low technological intensity (US$ billions)

Period	UDIS					DIS				
1980-2010	PC	LNRI	HT	MT	LT	PC	LNRI	HT	MT	LT
Average	82.9	26.7	-46.2	-53.4	-10.3	-104.4	-139.4	31.8	179	27.3

Source: Author's elaboration using data from United Nations Statistics Division, World Trade Organization, 2012. DIS = countries with a developed NIS – G7 countries were taken as proxy; UDIS = see Table 1. PC = primary commodities; LNRI = labor- and natural-resource-intensive goods; HT, MT and LT are, respectively, goods with high, medium and low technological intensity.

Moreover, the UDIS group shows a low share of technology-intensive goods in the total exports, which is quite lower than the share for countries in the DIS group, characterized by larger export shares of goods with higher technological intensity (Table 4). The largest share in total exports from the UDIS group is PG (41.31% of total exports). In the DIS group, exports of goods with high and medium technological intensity and of PG represent around 30%, 37% and 14%, respectively.

Table 4: Export Composition by Factor Intensity-1980-2010-(%)

Period	UDIS						DIS					
1980-2004	PC	LNRI	HT	MT	LT	Total	PC	LNRI	HT	MT	LT	Total
Average	41,3	15,2	21,6	15,5	6.2	100.0	14.5	9.6	30.4	37.1	8.3	100.0

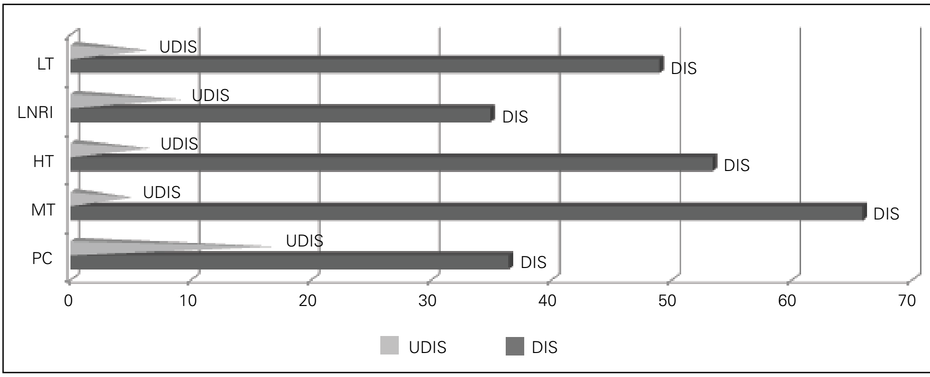
Source: Author's elaboration using data from United Nations Statistics Division, World Trade Organization, 2012.

DIS = countries with a developed NIS – G7 countries were taken as proxy; UDIS = see Table 1. PC = primary *commodities*; LNRI = labor and natural-resource-intensive goods; HT, MT and LT are, respectively, goods with high, medium and low technological intensity.

Figure 2 complements the argument by showing strict dominance of countries from the DIS group in world exports of goods with HT, as compared to the UDIS group. Such difference is smaller in the case of PG and labor-intensive and natural-resource-intensive goods, where the group UDIS is more competitive.

[4] This classification was made by United Nations Conference on Trade and Development (UNCTAD, 2002).

Figure 2: Share of exports in world exports according to the degree of factor intensity-1980-2010(%)



Source: Author's elaboration. Data from United Nations Statistics Division, World Trade Organization, 2012.
DIS = countries with a developed NIS – G7 countries were taken as proxy; UDIS = see Table 1.
PC = primary commodities; LNRI = labor - and natural-resource-intensive goods; HT, MT and LT are, respectively, goods with high, medium and low technological intensity

The argument that technological innovation plays an important role in trade balance and in CA balance is corroborated by the correlation coefficient between the share of each of the 23 countries of both UDIS and DIS groups (including USA and UK) in the world production of per capita patents and the share of each country in world exports of goods with HT (table 5). These coefficients are high and positive, showing an average of 0.95 for all the periods analysed, and suggesting a high correlation between the level of development of the NIS in a country and its performance in exports of high technology goods.

Table 5: Correlation Coefficient between the share of each country in world production of *per capita* patents and the share of each country in world exports of high technology goods–sample of 23 countries

Period	1980	1985	1990	1995	2010	1980-2010	1990-2010
Correlation coefficient	0.95	0.96	0.96	0.95	0.93	0.94	0.93

Source: Author's elaboration. The 23 countries are: Germany, France, Italy, Japan, Canada, USA, UK, Brazil, Argentina, Bolivia, Colombia, Chile, Ecuador, Mexico, Peru, Uruguay, Venezuela, Malaysia, Thailand, India, Indonesia, Philippines and South Africa.

Table 6 shows the coefficients of correlation between the CA balance and the share in the world *per capita* production of patents in the 21 countries which make up the DIS and UDIS groups. The correlations are high and positive: 0.70 and 0.71 for the periods 1980-2010 and 1990-2010 respectively and confirm the importance of NIS development for the performance of these countries' CA transactions.

Table 6: Correlation Coefficient between Current Account balance and the share of 21 countries in the *per capita* world production of patents

Period	1970-2010	1980-2010	1990-2010
Correlation Coefficient	0.69	0.70	0.71

Source: Author's elaboration. The 21 countries are: Germany, France, Italy, Japan, Canada, Brazil, Argentina, Bolivia, Colombia, Chile, Ecuador, Mexico, Peru, Uruguay, Venezuela, Malaysia, Thailand, India, Indonesia, Philippines and South Africa.

The empirical evidence presented above suggests a correlation between the development of the NIS and the CA performance of a country. To investigate whether causal relationships exist between these variables the temporal precedence test will be applied in the sense of Granger (1969) for 21 countries through the analysis of an unbalanced panel – USA and UK were excluding from our sample of 23 countries for the reasons previously indicated. It is expected that the share of the country in the world *per capita* production of patents (PAT) Granger causes its current account balance (CA).

In the context of panel data there does not yet exist a methodology generally adopted to test the causality between variables, although some procedures appear in the literature. In this work the procedure of Carroll and Weil (1994) and Judson and Owen (1999) has been adopted, that make use of the AH estimator (Anderson and Hsiao, 1981) starting from panel data. It is necessary to estimate two distinct dynamic relations between PAT and CA:

$$CA_t = \alpha + \beta\ CA_{t-1} + \gamma_1 PAT_{t-1} + u_t \qquad (1)$$

$$PAT_t = \alpha + \beta\ PAT_{t-1} + \gamma_1 CA_{t-}1 + u_t \qquad (2)$$

Initially, the existence of a long-term relationship between CA and PAT through unit root tests and of cointegration for panels is checked. Stationarity tests consider the possibility of structural breaks in the series. The test proposed by Andrews and Zivot (1992) was adopted.[5] If the unit root hypothesis is not rejected, the hypothesis of structural break is tested. The identification of the structural break is done where the statistical t test presents a maximum value. Should the null hypothesis of structural break be rejected, the methodology proposed by Maddala and Wu (1999) will be applied, for unbalanced panels, that permits estimates and inferences to be made on unit roots in all the countries. The approach of the cointegration method with structural break is an extension of the unit root test with structural break developed above. Following Andrews and Zivot (1992), the model considers only one endogenous break in the cointegration relationships.

Following Gregory and Hansen (1996), evidence of structural break and the co-integration relationships is provided by three models: level shift (C), level shift with trend (C/T) and the regime shift model (C/S). In all the models structural

[5] For more details see Andrews and Zivot (1992) and Vogelsang (1997).

change is tested by the presence of a dummy variable. We estimate the three models for the set of panel countries on those dates where the structural break was shown to be significant. After the models were estimated, the Augmented Dickey-Fuller Unit Root Test is applied (ADF) on the residuals of the equations, using the critical values tabulated by Gregory and Hansen (1996). There is a cointegration relationship between the series if the residuals of the estimated equations are stationary.

The causal relationship between the variables will be checked by the separate estimation of equations (1) and (2) by means of the methodology proposed by Anderson and Hsiao (1981). Thus, applying the method of instrumental variables on the first difference, proposed by the authors, we rewrite, for example, equation (1) as follows:

$$CA_t - CA_{t-1} = \beta_1 (CA_{t-1} - CA_{t-2}) + \delta_1 (PAT_{t-1} - PAT_{t-2}) + (u_t - u_{t-1}) \qquad (3)$$

Observe that, in (1.1), the disturbance ($u_t - u_{t-1}$) is now correlated with the independent variable ($CA_{t-1} - CA_{t-2}$). Anderson and Hsiao (1981) recommend as instrument ($CA_{t-2} - CA_{t-3}$) or (CA_{t-2}). Granger's causality, in the sense that PAT causes CA, is demonstrated if the null hypothesis, $\delta_1 = 0$, is rejected. Finally, for the purpose of analyzing the robustness of the results obtained by the application of the dynamic estimators of Anderson and Hsiao (1981), we present the results of the LSDVC estimator proposed by Bruno (2005), known as corrected fixed effects models.

Tests and Results

The results of the unit root tests with structural break of Andrews and Zivot (1992) for 21 countries during 1970-2010 are presented in Table 7. The unit root null hypothesis for the CA series in 21 of the countries of the panel cannot be rejected. For the PAT series, most of the countries possess unit root, with the exception of Bolivia, Colombia, Ecuador, Peru, South Africa and Uruguay.

Table 7: Tests for Unit Roots, 1970-2010

Countries	CA Séries		PAT Séries	
	Date of the Break	t statistics - I(1)	Date of the Break	t statistics - I(1)
Argentina	1998	-2,738	1986	-3,335
Bolivia	1999	-3,412	1977	-7,149***
Brazil	1989	-3,212	1989	-2,984
Chile	2004	-3,505	2004	-3,834
Colombia	1999	-3,144	1977	-6,890***

Ecuador	1995	-4,346	1984	-6,283***
India	1994	-3,008	2005	-0,684
Indonesia	1996	-4,367	1977	-4,358
Malaysia	2002	-4,358	1998	-3,678
Mexico	1996	-3,831	1993	-3,366
Peru	2005**	-2,214	1981	-6,278***
Philippines	2002	-3,061	1976	-3,495
South Africa	1995	-3,861	1990	-5,341**
Thailand	1987	-5,506	1992	-4,097
Uruguay	1994	-4,870	1991	-5,142**
Venezuela, RB	1995	-3,786	1996	-3,904
Canada	1977	-1,376	1980	-3,278
France	2000*	-3,226	1982	-3,843
Germany	1999	-2,857	1996	-3.312
Italy	1998	-3,102	2005	-4,778
Japan	1987	-4,727	1980	-3,428

Source: Author's elaboration.
Model with Constant and time trend. * Significant at 1% level. Critical values are given in Andrews and Zivot (1992). ** H_0 should not be rejected, i.e., $\theta = 0$, at 5% level of significance, according to F statistic.

For the countries where the unit root null hypothesis in the CA and PAT series was rejected we applied the methodology of Vogelsang (1997) that permits inferences to be made on structural breaks. The null hypothesis of absence of structural change was rejected in favour of the option of a broken trend for these countries in both the series, at the level of 5% of significance. For the countries in which the unit root hypothesis was not rejected we tested the significance of the structural break. In accordance with Table 7, the null hypothesis of structural break to the level of significance of 5% is rejected for most of the countries researched in both the series, CA and PAT, with the exception of Peru and France in the case of the first series. The results of these tests conjointly with the results of the unit root tests of Maddala and Wu (1999), applicable in panel for the set of countries (Table 8), indicate that the CA and PAT series are integrated of order one, that is, I(1).

Table 8: Results from Maddala and Wu (1999) Test

Variables	Test	Lags Values	Statistic Value	P-value	Critical Values (t)	P-value
			with Time Trend		with Constant and Time Trend	
CA	MW	2	75.8584	0.0036	77.9526	0.0023
D(CA)	MW	2	781.8881	0.0000	671.1758	0.0000
PAT	MW	2	68,9202	0.000	99,1878	0.000
D(PAT)	MW	2	-1366,2838	0,0000	1214,9170	0,0000

Source: Author's elaboration.
MW = Maddala and Wu. D = first difference of the variable. Chi-squared statistic: Ho = existence of unit root in all countries.

As regards cointegration, all the estimations of the cointegration model of Gregory and Hansen (1996) were carried out with the first difference of the CA and PAT series and with the structural date break endogenously determined. The null hypothesis was rejected to the level of 1% of statistical significance, in all the models (table 9).[6] It is concluded that the series are cointegrated.

Table 9: Cointegration Test

Date of the Break	Models		
	C	C/T	C/S
	ADF of the Residuals		
2000	-3.44*	-3.34*	-3.18*
2005	-3.41*	-3.37*	-3.25*
2000/05	-3.35*	-3.31*	-3.16*

Source: Author's elaboration.
Note: * Significant at 1% level. Critical values are given in Gregory and Hansen (1996).
C = model *level shift*; C/T = model *level shift with trend*; C/S = model regime *shift*.

The causal relationships between PAT and CA were tested starting from the estimation of equations (1) and (2) by applying the AH estimators (Anderson and Hsiao, 1981). Table 10 shows the results of the estimations, including those obtained by corrected fixed effects (LSDVC) to analyze the robustness of the dynamic model. The sample used involves data from 1970 to 2010. Due to the loss of degrees of freedom due to the small size of the temporal sample, equations (1) and (2) were estimated with only two lags. In addition, the introduction of many

[6] We also carried out the Westerlund Test (2007) for the panel set. From one Westerlund statistic z: Ho = not cointegration, it was possible to reject Ho, to the level of 5% of probability for the CA and PAT series.

lags, although it diminishes the serial autocorrelation, can generate a colinearity problem among the explanatory variables.

We find that PAT causes CA, seeing that in equation (1), where ΔCA is the dependent variable, the first lag of ΔPAT is significant. The results obtained by AH for equation (2), where ΔPAT is the dependent variable, show that ΔCA is not significant, and the value of the estimated coefficient is almost null.

Table 10 – Granger Causality for Panel Data

Dependent Variable	D.CA		D.PAT	
Technique Independents Variables	Corrected Fixed Effects	Anderson Hsiao	Corrected Fixed Effects	Anderson Hsiao
L_1D. CA	1.24 (0.00) ***	1.14 (0.539)	-8.12e-14 (0.933)	-1.86e-12 (0.351)
L_2D. CA	(dropped)	(dropped)	-3.14e-14 (0.976)	-1.91e-12 (0.317)
L_1D. PAT	3.06e+09 (0.047) **	388 (0.029) **	0.52 (0.000) ***	0.86 (0.111) *
L_2D.PAT	-3.24e+09 (0.040)**	-187 (0.384)	(dropped)	(dropped)
Observations	641	641	641	641

Source: Author's elaboration.
P-values are in brackets. D.VAR = VAR(t)-VAR(t-1), L_1D.VAR = VAR(t-1)-VAR(t-2), L_2D.VAR = VAR(t-2)-VAR(t-3).
*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

To test the robustness of the results obtained by the application of the AH dynamic estimator, we utilized the LSDVC dynamic estimator. The results of the latter were found to be consistent with the results of the AH model, as there is no substantial change in parameter magnitude or in its statistical significance (Table 10).

All these results (Tables 1 to 10 and Figures 1 and 2) endorse the argument that the relative level of development of a country's NIS is an important determinant of its income elasticities and therefore of its CA performance. Countries with more (less) developed NIS have a higher (lower) level of CA surpluses. Thus, economies with a developed NIS tend to have a lower level of external constraint on growth. In countries with a less developed NIS there is a higher level of external constraint on growth.

CONCLUSIONS

Authors from ECLAC and those that deal with ELGM converge to the same explanation regarding the differences in growth rates among countries. These differences would derive from different levels of external constraint on growth. The external constraint on growth, in turn, would depend on the country's IE of demand for imports and exports that would be exogenous.

Why are there IE differentials among industrial countries? There is not in the literature an explanation that uses the Evolutionary concept of NIS to answer this question. In order to fill this gap, this paper built theoretical causal links between the development of a NIS and changes in IE of an economy. It also uses the NIS concept and the Evolutionary literature in order to explain why IE shows great stability over time and therefore the estimates of the balance-of-payments equilibrium growth rate make sense. I.e., the proposition from the ELGM that IE determine growth in the long run is valid. Thus, the NIS concept and the Evolutionary literature can be used in order to give a response to Krugman's critique (Krugman, 1999). Finally, the theoretical arguments were supported empirically through the construction of several indicators and Granger Causality Test. We found that countries where the NIS is more developed dominate world trade and present structurally positive external balances. The opposite is the case for countries where the NIS is less developed.

The empirical evidence we presented support the argument that the relative development of the NIS in a country is relevant to explain the intensity of its external constraint on growth. Thus, it reaffirms the importance of stimulating the development of the NIS in developing economies as a way to consistently reduce the gap in growth rates between countries.

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