Balance-of-payments-constrained growth in a multisectoral framework: a panel data investigation

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Balance-of-Payments-Constrained Growth in a Multisectoral Framework: a panel data investigation [†]

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ABSTRACT: This paper contributes to the literature on balance-of-payments-constrained growth by providing an innovative empirical evaluation of a disaggregated version of the so-called Thirlwall's Law derived from a Pasinettian multisectoral framework. After estimating sectoral elasticities of exports and imports for a considerable panel dataset of 90 countries over the period 1965-1999, we have performed two empirical exercises. First, we grouped countries together by income level and evaluated a multisectoral balance-of-payments-constrained growth model by analyzing prediction errors and mean absolute deviations. Second, we carried out a regression validity test on the results. Our main findings give support to the validity of the multisectoral version of Thirlwall's Law, providing therefore further understanding of the structural determinants of the uneven international development and guidance for the design of growth-enhancing national structural policies.

JEL Classification Codes: E10, F43, O19

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1 Introduction

Growth models emphasizing the constraint placed on a country's growth rate by the need to satisfy balance-of-payments equilibrium in the long run have become a forceful approach to the study of long-run growth in a Keynesian demand-oriented context. The resulting theory of "Balance-of-Payments-Constrained (BOPC) growth" focuses on the relative income (or growth rate) adjustments required to balance trade at given real exchange rates. Basically, the theory of BOPC growth postulates that the balance of payments position of a country is the main constraint on its growth rate, since it imposes a limit on demand to which supply can (usually) adapt. As a result, observed differences in growth performance between countries are associated with the relative strength of their balance of payments position. According to Thirlwall (1979), if we assume that real exchange rates are constant (or vary quite negligibly) and that trade must be balanced in the long run, there is a very close correspondence between the growth rate of output and the ratio of the income elasticity of demand for a country's exports to the income elasticity of the country's imports times the rate of world income growth. This result became known in the literature as "Thirlwall's Law", hereafter TL. Since then, the BOPC growth framework has been considerably expanded on both theoretical and empirical directions.

On the theoretical front, for instance, Thirlwall and Hussain (1982) soon extended the model to allow for imbalanced trade with capital flows in the long run. However, the inclusion of capital flows in this model did not treat in an appropriate way the dynamics of accumulated external debt and the corresponding interest payments. Later on, McCombie and Thirwall (1997), Moreno-Brid (1998-99) and Barbosa-Filho (2001) incorporated restrictions in the models to ensure that the economy's long-run growth is consistent with a sustainable path of foreign indebtedness. Intuitively, an implied relevant conclusion of these extensions was that capital flows cannot allow an individual country to increase its growth rate above that given by TL by very much or for very long.

Introducing the idea that structural change may affect the income elasticities of imports and/or exports configures another branch of recent theoretical contributions to BOPC approach (Thirlwall, 1997; Setterfield, 1997; McCombie and Roberts, 2002; Palley, 2002). As differences in the income elasticities of demand for exports and imports are attributed to non-price characteristics of goods, the BOPC approach recognizes the importance of supply factors and, therefore, the structure of production in the determination of long-run growth rates. As pointed out by Carvalho and Lima (2008), income elasticities associated with trade balance have a Janus-like nature: while on the one hand, they are determinants of aggregate demand, on the other hand, they are also a reflection of a variety of supply factors that influence the structural competitiveness of the economy in world markets.

Araujo and Lima (2007), meanwhile, developed a BOPC model for a multisectoral economy in which demand varies over time at particular rates in each one of the sectors. The resulting "Multisectoral Thirlwall's Law", as they dubbed it, and hereafter MSTL, asserts that a country's growth rate of per capita income is directly proportional to the growth rate of its exports, with such proportionality being inversely (directly) related to sectoral income elasticities of demand for imports (exports). These elasticities are weighted by coefficients that measure the share of each sector in total exports and imports, respectively. Therefore, a major implication of the MSTL is that changes in the composition of demand or in the structure of production, which are not reflected in changes in income elasticities but come through changes in the share of each sector in aggregate exports or imports, also do matter for economic growth. Given the income elasticities of exports and imports, TL implies that a country's growth rate will rise only when the growth rate of world income increases, whereas the MSTL implies that a country can still raise its growth rate even when such a raise in growth of world income does not occur, provided it is able to change the sectoral composition of exports/imports accordingly (Araujo and Lima, 2007, p. 767).[1] As will be explored in the empirical part of this paper, one advantage of this multisectoral approach is that it allows for the identification of key strategic sectors of the economy as far as the prospects for growth (with balance-of-payments equilibrium) are concerned.

On the empirical front, there have been several tests of the BOPC growth approach using different econometric methodologies. For instance, Alonso and Garcimartín (1998–99), Andersen (1993), Christopoulos and Tsionas (2003), McCombie (1997), and Thirlwall (1979) have all found supporting evidence for samples of developed countries, while Bairam and Dempester (1991), Perraton (2003), and Thirlwall and Hussain (1982) all did the same for samples of developing countries. More recently, Gouvea and Lima (2010) found supporting

[1] Razmi (2010) derives a BOPC growth model as a special case of a three good framework that incorporates exportables, importables and non-tradables. The conditions under which the idea of an external constraint as reflected in foreign income growth is logically robust are the focus of his contribution.

evidence for the TL for a sample of four Latin America countries and four Asian countries. In a nutshell, we could say that the BOPC growth approach seems to perform well for a diverse group of countries and different time periods. However, given the purpose of this paper, it is important to highlight two aspects of the broad empirical literature on BOPC growth. First, time series studies (of individual or groups of countries) have dominated the more recent empirical literature probably due to the cointegration revolution in time series econometrics. Second, though Gouvea and Lima (2010) is the first paper to perform an empirical exercise based on the MSTL (having found solid supporting evidence for it), it does so in a time series framework for four Latin America countries and four Asian countries. Meanwhile, this paper intends to contribute to the BOPC empirical literature by innovatively investigating the validity of the MSTL for a panel data set of 90 countries over the period 1965-1999. The main value added of our contribution to the existing literature therefore lies in the use of disaggregated trade data in conjunction with modern panel data econometric techniques to obtain empirical estimates on the balance-of-payments constraints to long-run economic growth for an unprecedently large sample of countries. In fact, among further advantages, panel data techniques permit controlling for other non-observable invariant variables which can heterogeneously affect sectoral export and import demand functions.

The remainder of this paper is organized in the following way. The next section provides a brief presentation of the MSTL, while Section 3 describes our database and presents the techniques used to obtain the econometric results to be discussed in Section 4. The paper then closes with concluding remarks in the final section.

2 Multisectoral Thirlwall's Law: a brief presentation

Araujo and Lima (2007) developed a BOPC model for a multisectoral economy in which demand varies over time at particular rates in each one of the sectors of two countries.[2] Let A denote the advanced country and U the underdeveloped country. Both countries are assumed to produce n-1 consumption goods. The physical and monetary flows of commodities in country U can be summarized by three conditions, along with the solution for the system of physical and monetary quantities: the full employment condition, full expenditure of national income and trade balance equilibrium. The full employment condition can be stated as:

[2] Given its nature, this section draws extensively on Araujo and Lima (2007).

$$\sum_{i=1}^{n-1}(a_{in}+\zeta a_{\hat{i}n})a_{ni}=1 \tag{1}$$

where a_{in} and $a_{\hat{i}n}$ are the per capita demand coefficients of final commodity i, with i=1, 2, ...n-1. The former refers to domestic demand and the latter refers to foreign demand. Meanwhile, a_{ni} are the production coefficients of consumption goods, which represent quantities of labor employed in each sector. The household sector in country A is denoted by $\hat{n}$ and the population sizes in both countries are related to each other by the coefficient of proportionality ζ . The condition for full expenditure of national income can be expressed as:

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

where $a_{i\hat{n}}$ is the per capita import demand coefficient for commodity i produced in country A.

The trade balance equilibrium is given by:

$$\sum_{i=1}^{n-1}(\zeta a_{\hat{i}n}-a_{i\hat{n}})a_{ni}=0 \tag{3}$$

An important property of the model, as pointed out by Araujo and Lima (2007), is that the trade balance equilibrium can be written not in terms of prices, as is usual, but in terms of labor coefficients: coefficients a_{ni} weight both the export and import demand coefficients for commodities i.

The solution of the system for physical quantities can be stated as:

$$X_i=(a_{in}+\zeta a_{\hat{i}n})X_n, \qquad i=1,2,\cdots,n-1 \tag{4}$$

where X_i is the amount of production of commodity i and X_n is the population of country U. Thus, the physical quantity of each tradable commodity that is produced in country U will be determined by the sum of foreign and domestic demands. With p_i being the price of commodity i in country U, and w_u the (uniform) wage rate, the set of solutions for prices are:

$$p_i=a_{ni}w_u \qquad i=1,2,\cdots,n-1 \tag{5}$$

Equation (5) implies that relative quantities of embodied labor continue to regulate relative commodity prices within the boundaries of each country. It is reasonable to assume that if $p_{\hat{i}} \le p_i$, which means that country U does not have a comparative advantage in producing good i, then the foreign demand for commodity i is equal to zero. If $p_{\hat{i}} > p_i$, it is assumed that foreign demand for commodity i is given by a standard export function. These conditions can be expressed as follows:

$$x_{i\hat{n}} = \begin{cases} 0 & \text{if} \quad p_{\hat{i}} < p_i \\ \left(\dfrac{p_i}{p_{\hat{i}}}\right)^{\eta_i} Y_A^{\beta_i} & \text{if} \quad p_{\hat{i}} \geq p_i \end{cases} \tag{6}$$

where $x_{i\hat{n}}$ is foreign demand for commodity i, η_i is the price elasticity of demand for export of commodity i ($\eta_i < 0$), while β_i is the income elasticity of demand for exports and Y_A is the national income of country A. The per capita coefficient for foreign demand of commodity i, expressed in (7), can be obtained by dividing both sides of equation (6) by $X_{\hat{n}}$, where we denote per capita income of country A by y_A:

$$a_{i\hat{n}} = \begin{cases} 0 & \text{if} \quad p_{\hat{i}} < p_i \\ \left(\dfrac{p_i}{p_{\hat{i}}}\right)^{\eta_i} y_A^{\beta_i} \mathrm{X}_{\hat{n}}^{\beta_i - 1} & \text{if} \quad p_{\hat{i}} \geq p_i \end{cases} \tag{7}$$

By the same reasoning for exports, if $p_i > p_{\hat{i}}$, we assume a standard import demand function and if country A has no comparative advantage in producing good i, the per capita import demand for commodity i in country U is equal to zero. Likewise, the per capita import coefficient for commodity i can be stated as:

$$a_{\hat{i}n} = \begin{cases} 0 & \text{if} \quad p_i < p_{\hat{i}} \\ \left(\dfrac{p_{\hat{i}}}{p_i}\right)^{\psi_i} Y_U^{\varphi_i} \mathrm{X}_n^{\varphi_i - 1} & \text{if} \quad p_i \geq p_{\hat{i}} \end{cases} \tag{8}$$

where ψ_i is the price elasticity of demand for imports of commodity i ($\psi_i < 0$), φ_i is the income elasticity of demand for imports and Y_U is the real income of country U. Taking natural logarithms on both sides of equation (7) in the case of $p_{\hat{i}} > p_i$, and differentiating with respect to time, we obtain the growth rate of per capita export demand for commodity i:

$$\frac{\dot{a}_{i\hat{n}}}{a_{i\hat{n}}} = \begin{cases} 0 & \text{if } p_{\hat{i}} < p_i \\ \eta_i\left(\sigma_i^U - \sigma_i^A\right) + \beta_i \sigma_y^A + \left(\beta_i - 1\right)\hat{g} & \text{if } p_{\hat{i}} \geq p_i \end{cases} \tag{9}$$

In equation (9) the following convention was adopted: $\frac{\dot{p}_{\hat{i}}}{p_i} = \sigma_i^U$, $\frac{\dot{p}_i}{p_{\hat{i}}} = \sigma_i^A$, $\frac{\dot{y}_A}{y_A} = \sigma_y^A$ and $\frac{\dot{X}_{\hat{n}}}{X_{\hat{n}}} = \hat{g}$. By adopting the same procedure with respect to equation (8) where $p_i > p_{\hat{i}}$ and by adopting the convention that $\frac{\dot{y}_U}{y_U} = \sigma_y^U$ and $\frac{\dot{X}_n}{X_n} = g$, we obtain its dynamic version:

$$\frac{\dot{a}_{\hat{i}n}}{a_{\hat{i}n}} = \begin{cases} 0 & \text{if } p_i < p_{\hat{i}} \\ \psi_i \left(\sigma_i^A - \sigma_i^U\right) + \varphi_i \sigma_y^U + \left(\varphi_i - 1\right) g & \text{if } p_i \geq p_{\hat{i}} \end{cases} \tag{10}$$

Let us assume that the rate of change of price of commodity i is equal in both countries, that is $\sigma_i^U = \sigma_i^A$, and that $g = \hat{g} = 0$, which means that the population in both countries remains constant. In this case, equations (9) and (10) can be respectively simplified to:

$$\frac{\dot{a}_{i\hat{n}}}{a_{i\hat{n}}} = \beta_i \sigma_y^A \tag{11}$$

$$\frac{\dot{a}_{\hat{i}n}}{a_{\hat{i}n}} = \varphi_i \sigma_y^U \tag{12}$$

Only one of the two above equations is valid. In order for the equilibrium in the balance of payment to be maintained, it is necessary that the rate of change of equation (3) be equal to zero. Formally:

$$\sum_{i=1}^{n-1} (\zeta \dot{a}_{i\hat{n}} - \dot{a}_{\hat{i}n}) a_{ni} + \sum_{i=1}^{n-1} (\zeta a_{i\hat{n}} - a_{\hat{i}n}) \dot{a}_{ni} = 0 \tag{13}$$

Considering the case in which there is no technical progress, that is $\dot{a}_{ni}(t) = 0$, equation (13) becomes:

$$\sum_{i=1}^{n-1} (\zeta \dot{a}_{i\hat{n}} - \dot{a}_{\hat{i}n}) a_{ni} = 0 \tag{14}$$

By substituting equations (11) and (12) into equation (14) we obtain, after some algebraic manipulation:

$$\sigma_y^U = \frac{\sum_{i=1}^{n-1} \xi \beta_i a_{i\hat{n}} a_{ni}}{\sum_{i=1}^{n-1} \varphi_i a_{i\hat{n}} a_{ni}} \sigma_y^A \tag{15}$$

Equation (15) shows the relationship between the growth rate of per capita income in countries U and A. Let us define Δ as:

$$\Delta = \frac{\sum_{i=1}^{n-1} \xi \beta_i a_{i\hat{n}} a_{ni}}{\sum_{i=1}^{n-1} \varphi_i a_{i\hat{n}} a_{ni}} \tag{16}$$

A situation of uneven development will follow in the case of $\Delta < 1$, which implies that per capita income of the advanced country grows at a higher rate than the per capita income of the underdeveloped country. It can be shown that $\Delta < 1$ if and only if:

$$\sum_{i=1}^{n-1} (\varphi_i a_{i\hat{n}} - \zeta \beta_i a_{i\hat{n}}) a_{ni} > 0 \tag{17}$$

This inequality holds if the share of consumer expenditures in A for U goods is smaller than the share of consumer expenditures in U for A goods, a phenomenon that could be explained by the so-called Engel's Law.

By summing over equation (11) and after some algebraic manipulation, we obtain:

$$\sigma_y^A = \frac{\sum_{i=1}^{n-1} \frac{\dot{a}_{i\hat{n}}}{a_{i\hat{n}}}}{\sum_{i=1}^{n-1} \beta_i} \tag{18}$$

Substituting equation (18) in equation (15), we obtain:

$$\sigma_y^U = \frac{\sum_{i=1}^{n-1} \xi \beta_i a_{i\hat{n}} a_{ni}}{\left(\sum_{i=1}^{n-1} \varphi_i a_{i\hat{n}} a_{ni}\right)\left(\sum_{i=1}^{n-1} \beta_i\right)} \sum_{i=1}^{n-1} \frac{\dot{a}_{i\hat{n}}}{a_{i\hat{n}}} \tag{19}$$

Equation (19) can be seen as a multisectoral version of what Thirlwall (1979) called the "balance-of-payments equilibrium growth rate", which led Araujo and Lima (2007) to call it the "Multisectoral Thirlwall's Law". Equation (19) asserts that a country's growth rate of per capita income in country U is directly proportional to the growth rate of its exports, with such proportionality being inversely (directly) related to sectoral income elasticities of demand for imports (exports). These elasticities, in turn, are weighted by coefficients that measure the share of each sector in total exports and imports, respectively. Therefore, a major implication of the MSTL is that changes in the composition of demand or in the structure of production, which are not reflected in changes in income elasticities but come through changes in the share of each sector in aggregate exports or imports, also matter for growth. Given the income elasticites of exports and imports, TL implies that a country's growth rate will rise only when the growth rate of world income increases, whereas the MSTL implies that a country can still raise its growth rate even when such a raise in growth of world income does not occur, provided it is able to change the sectoral composition of exports and/or imports accordingly.

3 Data and Methodology

3.1 Data description

Given that the ambition of this paper is to provide a broad empirical evaluation of the MSTL, the choice of the dataset took into account the meeting of technical requirements regarding sample size, homogeneity of data series, and the number of parameters to be estimated. Trade data come from *World Trade Flows: 1962-2000* (WTF), which is a database based on the United Nations Commodity Trade Statistics Database (COMTRADE). Instead of extracting trade data directly from COMTRADE, using the WTF database has some advantages. First, it allows us to increase our sample size as trade data organized by the 4-digit Standard International Trade Classification (SITC), Revision 2 are available over the period 1962-2000; meanwhile, in COMTRADE that organization is available only after 1984. Second, once "corrections and addictions are made to the COMTRADE data for trade flows to and from United States, exports from Hong Kong and China, and imports into many other countries" using WTF database improves the data quality (Feenstra et al., 2005, p. 1). Third, Hidalgo et al. (2007) have already made available a correspondence table between 4-digit SITC revision 2 and Leemer's Classification.[3] Table 1 presents the 10 aggregates formed by Leemer (1984) from the 61 2-digit SITC commodity classes. Besides these 10 aggregates, we created the aggregate *Others* to include not classified information.[4]

The other variables used in the estimations are individual gross domestic products (GDP) and per capita GDP growth rates, world gross domestic product (GDPW) and individual real exchange rates (RER). To have as large a sample size as possible, real exchange rates are

[3] The correspondence table is available at www.chidalgo.com/productspace.

[4] Based on the level of aggregation being considered and the presence of low valued transactions not captured in the original database, Feenstra et al. (2005) made some adjustments in the data by creating artificial categories to include this information. For details, see the fourth section of Feenstra et al. (2005).

defined as the product between the average official exchange rate (national currency/U.S. dollar) and the ratio of the implicit U.S. GDP deflator to the countries's GDP deflator. All these variables come from the World Development Indicators (WDI).

Table 1 - Leemer's Classification

SITC	Description	SITC	Description
	Petroleum (PETRO)	41	Animal oils, fats
33	Petroleum, petroleum products	42	Fixed vegetable oils
	Raw Materials (MAT)		**Labor Intensive (LAB)**
27	Crude fertilizers, crude materials	66	Nonmetallic mineral manufactures
28	Metaliferous ores, metal scrap	82	Furniture
32	Coal, coke, briquettes	83	Travel goods, handbags, etc.
34	Gas, natural and manufactured	84	Clothing
35	Electrical energy	85	Footwear
68	Nonferrous metals	89	Miscellaneous manufactured articles, n.e.s.
	Forest Products (FOR)	91	Postal pack, not classified accordingly to kind
24	Wood, lumber, cork	93	Special transactions, not classified accordingly to kind
25	Pulp, waste paper	96	Coin nongold, noncurrent
63	Wood, cork manufactures		
64	Paper, paperboard		
	Tropical Agriculture (TROP)		**Capital Intensive (CAP)**
5	Fruit, vegetables	61	Leather, dressed firkins
6	Sugar, sugar preparations, honey	62	Rubber manufactures, n.e.s.
7	Coffee, tea, cocoa, spices, etc.	65	Textile yarn, fabrics, etc.
11	Beverages	67	Iron and steel
23	Crude rubber	69	Manufactures of metal
	Animal Products (ANL)	81	Sanitary, fixtures, fittings
0	Live animals		**Machinery (MACH)**
1	Meat, meat preparations	71	Machinery, other than electrical
2	Dairy products, eggs	72	Electrical machinery
3	Fish, fish preparations	73	Transport equipment
21	Hides, skins, firkins, undressed	86	Professional goods, instruments, watches
29	Crude animal, vegetable minerals	95	Firearms, ammunition
43	Animal, vegetable oils, processed		**Chemicals (CHEM)**
94	Animal, n.e.s.	51	Chemical elements, compounds
	Cereals, etc. (CER)	52	Mineral tar and crude chemicals from coal, petroleum, natural gas
4	Cereals, cereal preparations		
8	Feeding stuff of animals	53	Dyeing, tanning, coloring materials
9	Miscellaneous food preparations	54	Medicinal, pharmaceutical products
12	Tobacco, tobacco manufactures	55	Essential oils, perfume materials
22	Oil seeds, oil nuts, oil kernels	56	Fertilizers, manufactures
26	Textile fibers	57	Explosives, pyrotechnic
		58	Plastic materials, cellulose, etc.
		59	Chemical material, n.e.s.

n.e.s.: *not elsewhere specified*
Source: Leemer (1984, p. 62)

After merging information from WTF and WDI databases, we got a sample of 90 countries over the period 1965-1999. Moreover, as the panel data estimators discussed in the next section have their asymptotic results derived for $N \to \infty$ and T fixed, the estimations were carried out using 5-year averages to minimize non-stationarity problems.

3.2 Estimation Techniques

The basic panel data model, also known as a linear unobserved effects model, can be specified as follows:

$$y_{it} = x_{it}\beta + c_i + u_{it} \tag{20}$$

where x_{it} is the vector of observable explanatory variables and the error term consists of an idiosyncratic disturbance with conventional properties, u_{it}, and an unobservable individual specific time-invariant effect, c_i, while, i e t are cross-section and time indices, respectively.

Estimating a panel data model using a pooled ordinary least squares (POLS) estimator is consistent and efficient only under the assumption that the model does not have an individual effect. If the model is generated by a data process like the one described by equation (20), endogeneity problems due to the individual specific effect may be avoided by fixed effects (FE) or random effects (RE) estimators.

An FE estimator should be used to estimate the model given by equation (20) when individual effect and observable explanatory variables are correlated, i.e. $E(c_i \mid x_{it}) \neq 0$. In this case, there are two ways to eliminate the endogeneity problem and to obtain a consistent estimator: first differences or time demeaning. The former method consists in running an OLS regression in the variables in first difference. The latter method, also called within or fixed effect transformation, involves running an OLS regression once the time demeaning has been carry out. Another way to circumvent the endogeneity problem due to individual effect is using the least squares dummy variables (LSDV) which consist in estimating equation (20) by OLS including a dummy variable for each cross-section unit.

Assuming that individual effects and observable explanatory variables are not correlated, i.e. $E(c_i \mid x_{it}) = 0$, the model should be estimated by an RE estimator since under this assumption the estimator is consistent and efficient. It should be noted that if the hypothesis of no correlation is valid, both POLS and FE estimators are also consistent, but inefficient due to serial autocorrelation generated by the individual effect term. The RE estimator involves estimating equation (20) by generalized least squares (GLS) since the structure of the covariance matrix is already known for this model.

Since the choice between FE and RE estimators depends on the assumptions underlying them, Hausman (1978) proposed a test to evaluate this hypothesis. The Hausman statistic, which follows a qui-squared distribution $\left(\chi^2\right)$, is given by:

$$H = \left(\hat{\delta}_{RE} - \hat{\delta}_{FE}\right)' \left[A\hat{\text{var}}\left(\hat{\delta}_{FE}\right) - A\hat{\text{var}}\left(\hat{\delta}_{RE}\right)\right]^{-1} \left(\hat{\delta}_{RE} - \hat{\delta}_{FE}\right) \tag{21}$$

The null hypothesis is $H_0 : H = 0$, which implies $E\left(c_i \mid x_{it}\right) = 0$. Therefore, rejection of the null hypothesis means that only the FE estimator is consistent and, thus, should be used. Under H_0, both estimators are consistent, but the RE is the efficient one and, then, should be used.

A test for the presence of individual effects in equation (20) could be performed by Breusch-Pagan test. This is a Lagrange Multiplier (LM) test with null hypothesis that the variance of the individual effects is zero, i.e. $H_0 : Var\left(c_i\right) = 0$. This test is used to choose between RE and POLS since we have already rejected the FE estimator.

4 Evaluating the MSTL: non-parametric and regression test analysis

4.1 Estimation results of the sectoral elasticities

Applying the econometric methods presented in the preceding section, the following equations for sectoral imports and exports demand functions were estimated:

$$\ln M_{jit} = \pi_j \ln gdp_{it} + \psi_j \ln rer_{it} + c_{ji} + u_{jit}, \text{ for } j=1,2,...,11 \tag{22}$$

$$\ln X_{jit} = \varepsilon_j \ln gdpw_{it} + \eta_j \ln rer_{it} + c_{ji} + u_{jit}, \text{ for } j=1,2,...,11 \tag{23}$$

where i is an index representing countries, t is a time index and j represents sectors according to Leemer's classification. The parameters π_j, ψ_j, ε_j and η_j are, respectively, the income and price elasticities of demand for imports of sector j and the income and price elasticities of demand for exports of sector j. The estimations were made individually for each one of the sectors. However, as sectoral price indices are not available for our sample, it is not possible to compute sectoral real exchange rates or sectoral terms of trade (which, in theory, might be more suitable to the estimation of sectoral export and import demand functions). Therefore, the overall real exchange rate was used as a proxy for the sectoral real exchange rates.

A proxy variable must comply with two formal requirements in order to eliminate, or at least mitigate, the omitted variable bias (Wooldridge, 2001, p. 63). First, the proxy variable should be redundant in the structural equation. Therefore, if z is the proxy variable (overall real exchange rate) and q is the unobserved variable (sectoral real exchange rate), the following condition must be satisfied:

$$E(y \mid x,q,z) = E(y \mid x,q) \tag{24}$$

Condition (24) means that z is irrelevant for explaining y, in a conditional mean sense, once x and q have been controlled for. This condition is often satisfied and, for this specific case, it is reasonable to assume that, once controlled for sectoral real exchange rate, overall real exchange rate is not relevant to explain sectoral demand for exports and imports. The second requirement of a good proxy is that the correlation between the omitted variable q and each xj must be zero once we partial z out. Expressing this requirement in terms of linear projection:

$$L(q \mid 1, x1, \ldots, xj, z) = L(q \mid 1, z) \tag{25}$$

In the demand functions, besides the exchange rate variable, there is only domestic income in the case of imports and world income in the case of exports. Therefore, to satisfy the second requirement is necessary that, once eliminating the effect of the real exchange rate on the other variables, the correlation between the sectoral real exchange rate and income variables is zero. Though there is evidence that the real exchange rate is relevant to economic growth (Rodrik, 2008; Razmi et al., 2009), it is reasonable to assume that a specific sectoral real exchange rate does not matter for the determination of output once it is controlled for the overall real exchange rate. As a result, we assume in the empirical exercises that follow that the overall real exchange rate is a good proxy for the sectoral real exchange rates.

Though we estimated equations (22) and (23) for each sector using the three estimators described above, the results are shown for the FE estimator only as we expect that countries' individual effects are correlated with the observable variables. The results of the RE and

POLS estimators, and the Hausman and Breusch-Pagan tests, are shown in Appendix 1.[5] Table 2 presents the results for the FE estimations. In all estimated equations (for exports and imports), the estimated price elasticities have a low value, being higher than one in absolute value only for the estimation of import demand of sector *Others*. It is worth of mention that in the case of exports only the price elasticity of sector *Others* is significant and has the expected (positive) sign and only the price elasticity of sector *Tropical Agriculture* is significant but has the unexpected sign. For the other sectors, only the exports price elasticity of sectors *Forest Products*, *Animal Products*, *Labor Intensive* and *Capital Intensive* have the expected sign, even if not significant. For import demand functions the price elasticities are significant and have the expected (negative) sign. Hence the sectoral results, in line with the aggregate ones, reveal that price elasticities have a lower impact on the behavior of exports and imports and, therefore, have a considerably lower effect on the long-run growth rate.

Table 2 - Estimation results of the sectoral export and import functions estimated by FE: 1965-1999

Exports						
Sectors	RER	GDPW	Constant	Nº of Obs.	Nº of Countries	R^2
Petroleum	-0.0659	2.096***	-52.69***	679	90	0.195
Raw Materials	-0.111	0.715***	-9.766***	716	90	0.081
Forest Products	0.0559	1.103***	-23.40***	714	90	0.154
Tropical Agriculture	-0.184**	0.681***	-8.007***	717	90	0.130
Animal Products	0.0689	1.021***	-19.79***	718	90	0.204
Cereals	-0.134	0.174	6.897**	716	90	0.009
Labor Intensive	0.0756	2.163***	-54.37***	719	90	0.416
Capital Intensive	0.0194	1.544***	-36.00***	715	90	0.292
Machinery	-0.0811	2.376***	-60.80***	718	90	0.427
Chemical	-0.160	1.640***	-38.75***	717	90	0.257
Others	0.372***	3.269***	-91.99***	716	90	0.418
Imports						
Sectors	RER	GDP	Constant	Nº of Obs.	Nº of Countries	R^2
Petroleum	-0.269**	0.890***	-7.811***	718	90	0.147
Raw Materials	-0.148	1.129***	-14.85***	717	90	0.399
Forest Products	-0.270***	1.113***	-13.75***	718	90	0.514
Tropical Agriculture	-0.238**	0.754***	-5.261***	718	90	0.287
Animal Products	-0.201**	1.127***	-14.33***	719	90	0.445
Cereals	-0.123**	0.889***	-8.135***	720	90	0.356
Labor Intensive	-0.141**	1.556***	-23.57***	719	90	0.561
Capital Intensive	-0.261***	0.920***	-7.793***	718	90	0.414
Machinery	-0.257***	1.473***	-19.76***	718	90	0.660
Chemical	-0.186***	1.294***	-17.09***	718	90	0.700
Others	-1.068**	0.585***	-0.138	544	90	0.099

[5] As a matter of robustness, we also conducted the regression test with the elasticities computed by the models indicated by Hausman and Breush-Pagan tests. This analysis indicated that even using another strategy to choose the estimators the results did not change.

Source: Authors' calculations

For all sectors income elasticities of exports are significant and have the expected (positive) sign. The results for the exports of primary goods, which have production structures mostly based on natural resources, indicate that these products have lower elasticities (even when they are higher than one)than other sectors – more precisely: *Raw Materials* (0.72), *Animal Products* (1.02), *Cereals* (0.17), *Tropical Agriculture* (0.68) and *Forest Products* (1.20). *Petroleum* has a differentiated demand structure given its singular importance as energetic resource, which is reflected in its considerably higher income-elasticity (2.09) in relation to other products mostly based on natural resources. *Labor Intensive* sector has elasticity at same level as Petroleum (2.16), and even higher than *Capital Intensive* sector (1.54). Machinery and Chemical sectors also have high elasticities (2.38 and 1.64, respectively), with the former's elasticity being the highest among all sectors but *Others* (3.27). However, note that sector *Others* has almost a null impact on the MSTL growth rate because its share in exports composition is negligible (recall that this sector is formed by not identified information, cf. footnote 4).

The estimation results for the import demand functions also showed significant income elasticities having the expected sign for all sectors. Among products mostly based on natural resources, *Cereals*, *Tropical Agriculture* and *Petroleum* have income elasticities lower than one (0.89 and 0.75, respectively) and *Animal Products*, *Raw Materials* and *Forest Products* have income elasticities slightly higher than one (1.13, 1.13 and 1.11, respectively). Meanwhile, *Labor Intensive* products have an income elasticity (1.55) which is higher than the one for *Capital Intensive* products (0.92). *Machinery* and *Chemicals* income elasticities are, respectively, 1.47 and 1.29. Expectedly, the income elasticity of imports of sector *Others* is lower than the corresponding income elasticity of exports, as there is less not identified information for imports than for exports (Feenstra et al., 2005).

4.2 Non-parametric analysis and regression test

Having estimated the sectoral income elasticities, we computed the weighted income elasticities of exports and imports. We then used equation (19) to compute the growth rate predicted by the MSTL for each country of our sample, with Table 3 reporting the results.

Table 3 – Weighted income elasticities, average per capita GDP growth rate, MSTL and prediction absolute error (1965-1999).

High Income: OECD

Country Code	Country	Weighted Income Elasticity of Exports	Weighted Income Elasticity of Imports	*Per capita* GDP growth rate (1)	MSTL (2)	|Error: 1-2|
AUS	Australia	0.95	1.27	2.17	1.33	0.84
AUT	Austria	1.80	1.25	2.87	2.57	0.30
CAN	Canada	1.54	1.29	2.16	2.13	0.03
DNK	Denmark	1.61	1.20	2.20	2.39	0.19
FIN	Finland	1.54	1.21	2.84	2.26	0.58
FRA	France	1.75	1.20	2.54	2.60	0.06
GRC	Greece	1.28	1.21	2.67	1.89	0.77
IRL	Ireland	1.56	1.22	4.11	2.27	1.84
ISL	Island	0.96	1.24	2.67	1.39	1.28
ITA	Italy	1.91	1.15	2.83	2.96	0.13
JPN	Japan	2.09	1.11	3.74	3.36	0.37
KOR	Korea, Rep.	1.83	1.17	6.19	2.79	3.40
NLD	Netherlands	1.62	1.19	2.51	2.42	0.08
NZL	New Zealand	1.02	1.23	1.14	1.48	0.35
NOR	Norway	1.57	1.26	3.16	2.21	0.95
PRT	Portugal	1.68	1.18	3.85	2.53	1.33
ESP	Spain	1.62	1.18	2.94	2.45	0.49
SWE	Sweden	1.78	1.23	1.91	2.59	0.69
CHE	Switzerland	1.99	1.26	1.26	2.80	1.55
GBR	United Kingdom	1.93	1.22	2.09	2.82	0.73
USA	United States	1.75	1.25	2.22	2.51	0.28
	Average	**1,61**	**1.22**	**2.76**	**2.37**	**0.77**

High Income: Non-OECD

Country Code	Country	Weighted Income Elasticity of Exports	Weighted Income Elasticity of Imports	*Per capita* GDP growth rate (1)	MSTL (2)	|Error: 1-2|
BHS	Bahamas, The	1.81	1.20	1.10	2.68	1.58
BRB	Barbados	1.46	1.22	2.43	2.13	0.30
HKG	Hong Kong	2.08	1.23	4.94	3.02	1.92
ISR	Israel	1.75	1.25	2.76	2.49	0.27
MLT	Malta	1.97	1.20	6.31	2.93	3.37
OMN	Oman	2.05	1.24	6.93	2.95	3.98
SGP	Singapore	1.87	1.18	6.36	2.83	3.54
TTO	Trinidad and Tobago	1.89	1.13	1.07	2.97	1.90
	Average	**1,86**	**1.21**	**3.99**	**2.75**	**2.11**

Table 3 (continued)

Country Code	Country	Weighted Income Elasticity of Exports	Weighted Income Elasticity of Imports	*Per capita* GDP growth rate (1)	MSTL (2)	|Error: 1-2|
		Low Income				
BEN	Benin	0.57	1.11	0.30	0.91	0.61
BFA	Burkina Faso	0.70	1.19	1.45	1.05	0.39
BDI	Burundi	0.98	1.22	0.56	1.43	0.88
CAF	Central African Republic	1.34	1.24	-0.75	1.93	2.68
TCD	Chad	0.38	1.21	-0.63	0.56	1.19
ZAR	Congo, Dem. Rep.	1.26	1.23	-3.35	1.83	5.17
CIV	Cote d’Ivoire	0.85	1.20	-0.20	1.27	1.47
GHA	Ghana	0.92	1.23	-0.21	1.33	1.55
HTI	Haiti	1.56	1.18	-1.11	2.35	3.46
KEN	Kenya	0.94	1.23	1.40	1.37	0.02
LBR	Liberia	1.47	1.38	-2.20	1.90	4.11
MDG	Madagascar	0.91	1.21	-1.28	1.33	2.62
MWI	Malawi	0.43	1.26	1.42	0.61	0.81
MRT	Mauritania	0.84	1.16	0.33	1.29	0.96
NPL	Nepal	1.19	1.18	1.25	1.80	0.55
NER	Niger	1.17	1.18	-2.00	1.76	3.77
NGA	Nigeria	1.85	1.25	0.57	2.65	2.08
PAK	Pakistan	1.24	1.14	2.58	1.93	0.65
PNG	Papua New Guinea	0.96	1.24	1.34	1.39	0.04
RWA	Rwanda	0.84	1.21	1.39	1.24	0.15
SEN	Senegal	0.76	1.14	-0.51	1.20	1.71
SLE	Sierra Leone	1.39	1.18	-1.30	2.11	3.41
TGO	Togo	0.73	1.14	0.40	1.14	0.74
ZMB	Zambia	0.78	1.26	-1.49	1.10	2.59
ZWE	Zimbabwe	0.97	1.28	1.10	1.34	0.24
	Average	**1,00**	**1.21**	**-0.04**	**1.47**	**1.67**

Country Code	Country	Weighted Income Elasticity of Exports	Weighted Income Elasticity of Imports	*Per capita* GDP growth rate (1)	MSTL (2)	|Error: 1-2|
		Low Middle Income				
DZA	Algeria	1.84	1.19	1.37	2.76	1.40
BOL	Bolivia	0.89	1.23	0.14	1.29	1.16
CMR	Cameron	1.13	1.22	0.73	1.65	0.92
CHN	China	1.55	1.15	6.94	2.40	4.55
COL	Colombia	1.13	1.25	1.91	1.61	0.30
COG	Congo, Rep.	1.69	1.24	1.35	2.43	1.08

Table 3 (continued)

Country Code	Country	Weighted Income Elasticity of Exports	Weighted Income Elasticity of Imports	*Per capita* GDP growth rate (1)	MSTL (2)	|Error: 1-2|
DOM	Dominican Republic	1.23	1.19	2.78	1.85	0.93
ECU	Ecuador	1.23	1.25	1.18	1.75	0.58
EGY	Egypt, Arab. Rep.	1.46	1.19	3.06	2.19	0.87
SLV	El Salvador	1.11	1.20	0.51	1.64	1.14
GUY	Guyana	0.99	1.23	1.39	1.44	0.05
HND	Honduras	1.00	1.23	1.08	1.45	0.37
IND	India	1.42	1.14	2.32	2.22	0.10
MAR	Morocco	1.15	1.13	1.94	1.81	0.12
NIC	Nicaragua	0.83	1.21	-1.06	1.22	2.29
PRY	Paraguay	0.60	1.21	1.95	0.88	1.07
PER	Peru	0.84	1.22	0.37	1.23	0.85
PHL	Philippines	1.32	1.21	1.12	1.93	0.81
LKA	Sri Lanka	1.24	1.12	3.10	1.98	1.12
SDN	Sudan	0.49	1.18	0.89	0.75	0.14
SYR	Syrian Arab Republic	1.65	1.17	2.33	2.50	0.17
THA	Thailand	1.13	1.21	4.98	1.66	3.32
TUN	Tunisia	1.60	1.17	2.95	2.43	0.52
	Average	**1,20**	**1.20**	**1.88**	**1.79**	**1.04**

Upper Middle Income

Country Code	Country	Weighted Income Elasticity of Exports	Weighted Income Elasticity of Imports	*Per capita* GDP growth rate (1)	MSTL (2)	|Error: 1-2|
ARG	Argentina	0.84	1.24	1.23	1.20	0.02
BLZ	Belize	1.07	1.25	3.32	1.53	1.79
BRA	Brazil	1.10	1.18	2.50	1.67	0.83
CHL	Chile	0.81	1.23	2.65	1.17	1.48
CRI	Costa Rica	1.07	1.24	2.37	1.54	0.83
GAB	Gabon	1.68	1.27	2.36	2.37	0.01
MYS	Malaysia	1.38	1.22	4.16	2.01	2.14
MEX	Mexico	1.67	1.28	1.88	2.32	0.44
PAN	Panama	1.59	1.27	1.92	2.23	0.31
SYC	Seychelles	1.06	1.19	3.23	1.59	1.64
ZAF	South Africa	1.26	1.28	0.49	1.75	1.26
URY	Uruguay	1.11	1.19	1.53	1.66	0.14
VEN	Venezuela	1.95	1.27	-0.62	2.73	3.35
	Average	**1,28**	**1.24**	**2.08**	**1.83**	**1.10**
	Overall Average	**1,31**	**1.21**	**1.77**	**1.93**	**1.26**

Note: Countries were grouped accordingly to World Bank classification.
Source: Authors' elaboration.

As can be seen by inspecting Table 3, the correspondence between the actual growth rates and those predicted by the MSTL varies among different groups of countries. The last column shows the absolute deviation between actual *per capita* growth rate and the predicted one. When we analyze results in Table 3 by income level we note that the average per capita GDP growth rate of the high income non-OECD countries is 3.99, while the average growth rate predicted by the model is 2.75. These figures for the high income OECD countries are, respectively, 2.76 and 3.37. The average per capita GDP growth of the lower middle income countries is 1.88, of the upper middle income is 2.08 and of the low income is -0.04. Meanwhile, the growth rates given by the MSTL for these groups are, respectively, 1.79, 1.83 and 1.47.

The average absolute deviation for the whole sample (1.26) can be considered relatively low (recall that, like the TL, the MSTL does not include terms of trade and capital flows). Only for the low income and high income non-OECD groups the average absolute deviations (1.67 and 2.11, respectively) are higher than the overall one. The OECD group has the lowest average absolute deviation, followed by the low middle income (1.04) and upper middle income (1.10) groups. Note that, when we compute the average absolute deviation excluding countries with negative growth rates over the period (a result not predictable by the MSTL if the growth of world income is positive[6]) the average absolute deviation for the upper middle income (0.91), the low middle income (0.98) and the low income (0.63) groups all become lower than one (a residual which is mostly explained by movements in terms of trade and capital flows, both not considered in the derivation of the TL and the MSTL).

The first parametric test to evaluate how close to the actual growth rate is the growth rate predicted by TL was proposed by McGregor and Swales (1985). They suggested that the predictive power of the BOPC growth model could be measured by regressing the actual growth rate on the predicted growth rate and testing whether the slope is equal to unity and the constant term is equal to zero. If these two conditions were satisfied, then we could conceive of the latter as a good estimate of the former. Yet McCombie (1989) pointed out two shortcomings of the test proposed by McGregor and Swales (1985). First, as the predicted growth rate is derived from prior estimated coefficients, it is more appropriate to rather regress it on the actual growth rate to avoid a misspecification analogous to “measurement

[6] Of course, the impossibility of predicting negative growth rates when the world income is growing does not apply to balance-of-payments-constrained growth models incorporating capital flows and terms of trade.

errors in variables". Second, outlier countries running huge payments surpluses may lead to rejection of the model for all individual countries, yet it is necessary only a few countries not to be balance of payments constrained for all the rest to be so. An analogous result could emerge if the sample of countries under consideration were not completed in the sense that their balance of payments surpluses or deficits would not cancel out. These shortcomings led McCombie (1989) to suggest the following alternative test that could be applied to individual countries. First, it is necessary to define the hypothetical income elasticity of demand that exactly equates the actual and the balance-of-payments growth rate given by TL. Then, if this elasticity and the estimated one are not statistically significantly different, the predicted growth rate is a good predictor of the actual growth rate. Unfortunately, though, this test is not applicable to the MSTL as it is not possible to compute the hypothetical sectoral elasticities to be tested with the estimated ones. Hence, even being aware of the shortcomings of the regression test, we believe that its application to the MSTL provide useful preliminary results.

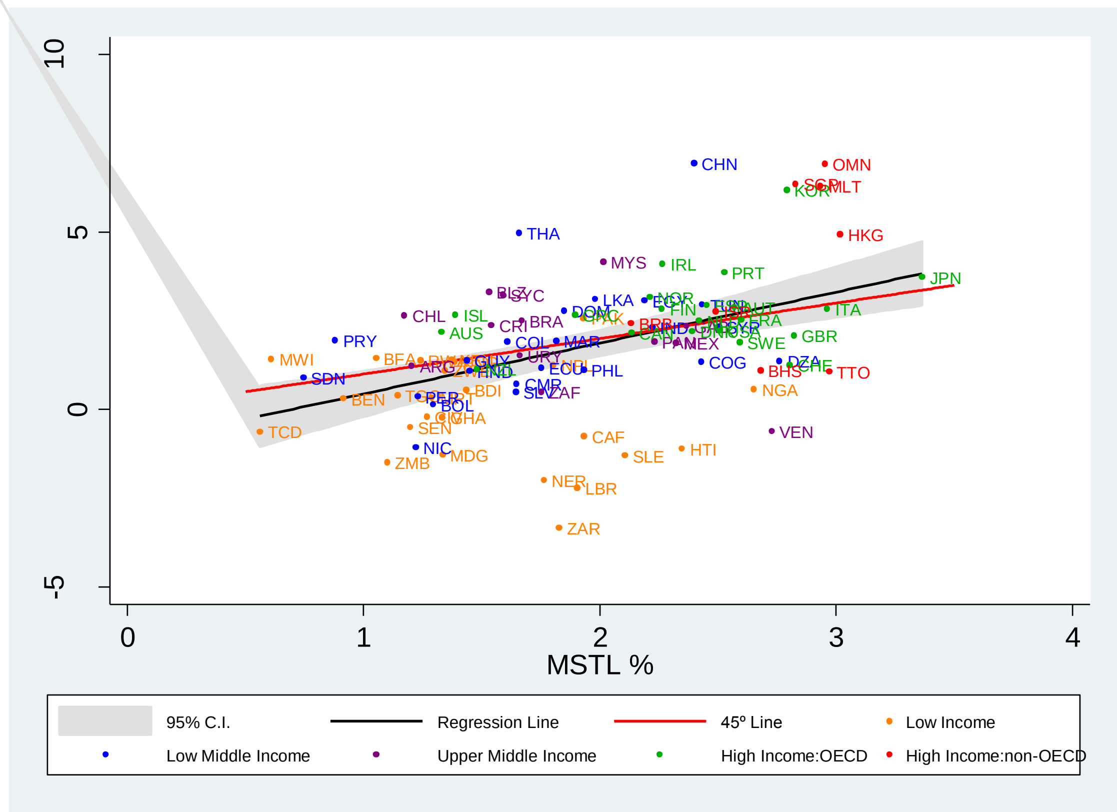
Table 4 reports the results obtained by applying the test suggested by McGregor and Swales (1985) to the estimated MSTL. As it is not possible to reject that the slope coefficient is equal to unity and the constant term is equal to zero, the results provide preliminary evidence that the growth rate predicted by the MSTL is actually a good predictor of the actual growth rate. These results do not change if we leave out of the sample countries with a negative average growth rate (which is, as noted above, a result incompatible with the MSTL if the growth rate of the world economy is positive). The same result is illustrated in Figure 1, in which it can be seen that the 45 degree line is located in the region of the regression confidence interval.

Table 4 – Cross-country regression test of the Multisectoral Thirlwall's Law: 1965-1999

Variables	*per capita GDP growth rate*[(a)]	*per capita GDP growth rate*
MSTL	1.254***	1.434***
	(0.270)	(0.280)
Constant	-0.173*	-0.993
	(0.471)	(0.509)
Number of Observations	76	90
Adjusted R-squared	0.253	0.212
Regression Test: slope=1 and constant=0	0.102†	0.109††

Robust square-errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1
(a) Only countries with positive average per capita income growth rate were used in the regression.
† p-value F(2,88) statistic
†† p-value F(2,74) statistic
Source: Authors' Elaboration

Figure 1 - Average GDP per capita growth rates, average predicted growth rates, estimated regression line and 45° line.



5 Concluding remarks

Though the notion that changes in the structure of production affect the income elasticities of imports and exports has been made explicit in some balance-of-payments-constrained growth models, the empirical literature dealing explicitly with this issue is quite scant. In this context, this paper contributed to the empirical literature on balance-of-payments-constrained growth dynamics by investigating the validity of a Multisectoral Thirlwall's Law for a considerable panel data set of 90 countries over the period 1965-1999. Therefore, the value added of our contribution is the use of disaggregated trade data in conjunction with modern panel data econometric techniques to obtain sectoral empirical estimates on the balance-of-payments constraints to long-run economic growth for an unprecedently large sample of countries.

After the estimation of the sectoral exports and imports demand functions, the validity of the Multisectoral Thirlwall's Law was evaluated by both a non-parametric analysis and a regression test. Despite varying among income level groups of countries the correspondence between the actual growth rates and those predicted by the Multisectoral Thirlwall's Law (which does not include terms of trade and capital flows) nonetheless resulted in low prediction errors and average absolute deviations. Moreover, the difference between the estimated regression line and the 45 degree line was found to be not statistically significant. As a result, we could not reject the validity of the Multisectoral Thirlwall's Law in the large panel data set used in this paper, which provides further understanding of the determinants of the uneven international development related to the external competitiveness reflected in the sectoral income elasticities of exports and imports.

Besides, the novel empirical results obtained in this paper have relevant policy implications in so far as they provide guidance for the design of growth-enhancing structural policies. In fact, as catching-up countries must pursue supply-side policies to alter the structure of production, the estimated sectoral exports and imports demand functions can be used to guide the design of effective sectoral balance-of-payments-constraint-alleviating strategies such as import substitution and export promotion. After all, a major implication of the multisectoral balance-of-payments-constrained growth model estimated here is that changes in the composition of demand or in the structure of production which are not reflected in changes in income elasticities of exports and imports, but come through changes in the share of each sector in aggregate exports or imports, also matter for economic growth in the long run. Given the income elasticities of imports and exports, the original Thirlwall's Law implies that a country's growth rate will rise only in case the growth rate of income outside it rises, whereas the Multisectoral Thirlwall's Law implies that a country can still raise its growth rate even in case such a rise in the growth of outside income does not occur, provided it can manage to change the sectoral composition of exports and/or imports conveniently. Clearly, how effective in this respect are trade, industrial and technological policies intended to stimulate and/or protect specific domestic sectors, for instance, is a public policy issue which must be addressed by means of a multisectoral approach.

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Appendix 1 –Estimation Results of the Sectoral Elasticities

Table 5 – Estimation results of the sectoral demand for exports: 1965-1999

Variables	Petroleum			Raw Materials		
	POLS	FE	RE	POLS	FE	RE
log Exchange Rate	-0.260***	-0.0659	-0.201*	-0.231***	-0.111	-0.156**
	(0.0584)	(0.163)	(0.108)	(0.0389)	(0.0944)	(0.0733)
log World GDP	2.581***	2.096***	2.122***	0.699**	0.715***	0.717***
	(0.396)	(0.180)	(0.173)	(0.322)	(0.112)	(0.108)
Constant	-66.88***	-52.69***	-53.33***	-8.899	-9.766***	-9.732***
	(12.07)	(5.600)	(5.340)	(9.804)	(3.419)	(3.320)
Observations	679	679	679	716	716	716
R-square	0.089	0.195		0.050	0.081	
Breusch-Pagan Test	-	-	1346.37***	-	-	1984.62***
Hausman Test	-	2.77	-	-	0.98	-
Variables	**Forest Products**			**Tropical Agriculture**		
	POLS	FE	RE	POLS	FE	RE
log Exchange Rate	-0.251***	0.0559	-0.0549	-0.171***	-0.184**	-0.180***
	(0.0487)	(0.0766)	(0.0738)	(0.0359)	(0.0718)	(0.0673)
log World GDP	1.150***	1.103***	1.110***	0.680**	0.681***	0.681***
	(0.373)	(0.110)	(0.108)	(0.266)	(0.0776)	(0.0780)
Constant	-23.88**	-23.40***	-23.32***	-8.012	-8.007***	-8.029***
	(11.37)	(3.355)	(3.307)	(8.130)	(2.361)	(2.387)
Observations	714	714	714	717	717	717
R-square	0.052	0.154		0.046	0.130	
Breusch-Pagan Test	-	-	2062.22***	-	-	2073.68***
Hausman Test	-	28.42***	-	-	0.01	-
Variables	**Animal Products**			**Cereals**		
	POLS	FE	RE	POLS	FE	RE
log Exchange Rate	-0.244***	0.0689	-0.0584	-0.225***	-0.134	-0.177**
	(0.0352)	(0.0814)	(0.0690)	(0.0378)	(0.101)	(0.0764)
log World GDP	1.006***	1.021***	1.029***	0.126	0.174	0.176*
	(0.270)	(0.0885)	(0.0877)	(0.288)	(0.107)	(0.105)
Constant	-18.34**	-19.79***	-19.63***	8.647	6.897**	6.943**
	(8.236)	(2.688)	(2.690)	(8.777)	(3.272)	(3.171)
Observations	718	718	718	716	716	716
R-square	0.088	0.204		0.054	0.009	
Breusch-Pagan Test	-	-	2056.1***	-	-	1871.02***
Hausman Test	-	F	-	-	0.43	-

Robust squared-errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
F means that Hausman test have failed. This happens when estimated variance-covariance matrix is positive definite.

Table 5 (continued)

Variables	**Labor Intensive**			**Capital Intensive**		
	POLS	FE	RE	POLS	FE	RE
log Exchange Rate	-0.304***	0.0756	-0.0878	-0.331***	0.0194	-0.0876
	(0.0445)	(0.0781)	(0.0703)	(0.0501)	(0.0836)	(0.0777)
log World GDP	2.170***	2.163***	2.173***	1.525***	1.544***	1.551***
	(0.339)	(0.116)	(0.115)	(0.387)	(0.101)	(0.102)
Constant	-53.38***	-54.37***	-54.16***	-34.29***	-36.00***	-35.89***
	(10.33)	(3.570)	(3.601)	(11.80)	(3.123)	(3.176)
Observations	719	719	719	715	715	715
R-squared	0.120	0.416		0.084	0.292	
Breusch-Pagan Test	-	-	2022.92***	-	-	2105.7***
Hausman Test	-	24.53***	-	-	4.73*	-
Variables	**Machinery**			**Chemicals**		
	POLS	FE	RE	POLS	FE	RE
log Exchange Rate	-0.474***	-0.0811	-0.227**	-0.355***	-0.160	-0.236**
	(0.0533)	(0.114)	(0.0951)	(0.0526)	(0.123)	(0.101)
log World GDP	2.330***	2.376***	2.384***	1.589***	1.640***	1.644***
	(0.391)	(0.123)	(0.120)	(0.381)	(0.121)	(0.119)
Constant	-58.15***	-60.80***	-60.61***	-36.59***	-38.75***	-38.66***
	(11.91)	(3.784)	(3.758)	(11.59)	(3.701)	(3.642)
Observations	718	718	718	717	717	717
R-squared	0.155	0.427		0.095	0.257	
Breusch-Pagan Test	-	-	2105.74***	-	-	2053.65***
Hausman Test	-	5.8*	-	-	1.15	-
Variables	**Others**					
	POLS	FE	RE			
log Exchange Rate	-0.365***	0.372***	-0.0971			
	(0.0462)	(0.115)	(0.0834)			
log World GDP	3.195***	3.269***	3.295***			
	(0.370)	(0.172)	(0.173)			
Constant	-87.38***	-91.99***	-91.30***			
	(11.28)	(5.263)	(5.355)			
Observations	716	716	716			
R-squared	0.168	0.418				
Breusch-Pagan Test	-	-	1578.97***			
Hausman Test	-	32.38***	-			

Robust squared-errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
F means that Hausman test have failed. This happens when estimated variance-covariance matrix is positive definite.

Table 6- Estimation results of the sectoral demand for imports: 1965-1999

Variables	**Petroleum**			**Raw Materials**		
	POLS	FE	RE	POLS	FE	RE
log Exchange Rate	-0.0767***	-0.269**	-0.112**	-0.0559***	-0.148	-0.0771**
	(0.0262)	(0.121)	(0.0520)	(0.0148)	(0.0916)	(0.0330)
log GDP	0.944***	0.890***	0.923***	1.205***	1.129***	1.181***
	(0.0237)	(0.0949)	(0.0466)	(0.0159)	(0.0515)	(0.0300)
Constant	-9.682***	-7.811***	-9.066***	-16.94***	-14.85***	-16.30***
	(0.608)	(2.340)	(1.200)	(0.394)	(1.263)	(0.761)
Observations	718	718	718	717	717	717
R-squared	0.711	0.147		0.904	0.399	
Breusch-Pagan Test	-	-	815.66***	-	-	871.24***
Hausman Test	-	2.06	-	-	2.11	-

Variables	**Forest Products**			**Tropical Agriculture**		
	POLS	FE	RE	POLS	FE	RE
log Exchange Rate	-0.0689***	-0.270***	-0.109***	-0.0543***	-0.238**	-0.108***
	(0.0160)	(0.0729)	(0.0378)	(0.0154)	(0.103)	(0.0332)
log GDP	0.971***	1.113***	1.008***	0.869***	0.754***	0.819***
	(0.0138)	(0.0433)	(0.0273)	(0.0146)	(0.0470)	(0.0295)
Constant	-11.08***	-13.75***	-11.82***	-8.533***	-5.261***	-7.195***
	(0.353)	(1.088)	(0.729)	(0.367)	(1.202)	(0.758)
Observations	718	718	718	718	718	718
R-squared	0.889	0.514		0.828	0.287	
Breusch-Pagan Test	-	-	1089.09***	-	-	1174.08***
Hausman Test	-	17.73***	-	-	4.12	-

Variables	**Animal Products**			**Cereals**		
	POLS	FE	RE	POLS	FE	RE
log Exchange Rate	-0.0358*	-0.201**	-0.0689*	0.0245*	-0.123**	-0.00185
	(0.0188)	(0.0873)	(0.0412)	(0.0146)	(0.0547)	(0.0345)
log GDP	0.846***	1.127***	0.952***	0.789***	0.889***	0.813***
	(0.0198)	(0.0726)	(0.0529)	(0.0185)	(0.0727)	(0.0507)
Constant	-8.266***	-14.33***	-10.65***	-6.254***	-8.135***	-6.730***
	(0.500)	(1.781)	(1.366)	(0.462)	(1.769)	(1.312)
Observations	719	719	719	720	720	720
R-squared	0.779	0.445		0.823	0.356	
Breusch-Pagan Test	-	-	1323.81***	-	-	996.01***
Hausman Test	-	14.42***	-	-	10.05***	-

Robust squared-errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
F means that Hausman test have failed. This happens when estimated variance-covariance matrix is positive definite.

Table 6 (continued)

Variables	**Labor Intensive**			**Capital Intensive**		
	POLS	FE	RE	POLS	FE	RE
log Exchange Rate	-0.0860***	-0.141**	-0.0622*	-0.0307**	-0.261***	-0.0744**
	(0.0161)	(0.0697)	(0.0361)	(0.0148)	(0.0749)	(0.0325)
log GDP	0.844***	1.556***	1.053***	0.815***	0.920***	0.837***
	(0.0182)	(0.0734)	(0.0462)	(0.0148)	(0.0434)	(0.0272)
Constant	-7.083***	-23.57***	-12.05***	-6.080***	-7.793***	-6.467***
	(0.448)	(1.767)	(1.163)	(0.371)	(1.081)	(0.699)
Observations	719	719	719	718	718	718
R-squared	0.804	0.561		0.852	0.414	
Breusch-Pagan Test	-	-	812.69***	-	-	985.34***
Hausman Test	-	61.99***	-	-	14.47***	-
Variables	**Machinery**			**Chemicals**		
	POLS	FE	RE	POLS	FE	RE
log Exchange Rate	-0.0636***	-0.257***	-0.0814**	-0.0302***	-0.186***	-0.0475*
	(0.0144)	(0.0620)	(0.0349)	(0.0112)	(0.0650)	(0.0278)
log GDP	0.873***	1.473***	1.086***	0.913***	1.294***	1.036***
	(0.0173)	(0.0542)	(0.0382)	(0.0138)	(0.0338)	(0.0249)
Constant	-6.318***	-19.76***	-11.26***	-8.663***	-17.09***	-11.48***
	(0.431)	(1.302)	(0.957)	(0.333)	(0.832)	(0.630)
Observations	718	718	718	718	718	718
R-squared	0.850	0.660		0.915	0.700	
Breusch-Pagan Test	-	-	1024.84***	-	-	984.77***
Hausman Test	-	79.3***	-	-	101.22***	-
Variables	**Others**					
	POLS	FE	RE			
log Exchange Rate	-0.0458	-1.068**	-0.0770*			
	(0.0323)	(0.414)	(0.0447)			
log GDP	0.921***	0.585***	0.876***			
	(0.0282)	(0.220)	(0.0401)			
Constant	-11.21***	-0.138	-10.05***			
	(0.719)	(5.806)	(0.990)			
Observations	544	544	544			
R-squared	0.628	0.099				
Breusch-Pagan Test	-	-	132.05***			
Hausman Test	-	5.61*	-			

Robust squared-errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
F means that Hausman test have failed. This happens when estimated variance-covariance matrix is positive definite.