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Applying Thirlwall's Law to the Portuguese economy: a sectoral analysis

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Applying Thirlwall's Law to the Portuguese economy: a sectoral analysis

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Abstract

International trade is definitely one of the most relevant factors when considering the economic expansion of a small country like Portugal and as such, this work analyzes the impact that the Balance of Payments can have on economic growth. For that, we apply Thirlwall's Law. In addition, following the international economic and financial crisis of 2008, that among others, led to a fall in Private Investment and Public and Private Consumption, this work aims at verifying whether international trade can contribute to growth. Moreover, we examine whether the production structure can influence national growth, by using Thirlwall's Multi-Sectoral Law. Furthermore, the evolution of the main exporting and importing sectors is described for the period 1994-2013 and the import and export demand functions are estimated both at an aggregated and sectoral level, in order to obtain the income elasticities that allow the computation of the Balance-of-Payments equilibrium growth rate. The results show Thirlwall's Law is not as accurate as usual, probably due to the peculiarity of the period of analysis. In addition, the multi-sectoral perspective proves to be a better approximation to the period's effective growth rate.

JEL Classification: E12; F31; F43

Keywords: Economic Growth, Income-elasticities, Thirlwall's Law, Multi-sectoral Thirlwall's Law.

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1. Introduction

Within the framework of the theories of economic growth, several studies, either supply or demand-side oriented, have focused on examining possible factors of growth. Following the demand-led growth approach, some authors have pointed out foreign trade, more specifically the export component, as a significant variable to explain the growth of an economy (Balassa, 1978; World Bank, 1987), since exports enable the existence of positive externalities (economies of scale, reallocation of existing resources, extension of the internal market and promotion of competition (Medina-Smith, 2001)).

Therefore, according to the export-led growth approach, exports are not only accountable for growth but are inclusive one of the reasons for the existence of different growth rates (Feder, 1982). Thirlwall's Law (1979) appears in the context of the demand-led growth approach, arguing that the growth of a country can be constrained by deficits on the trade balance and therefore external relations affect economic growth profoundly. Over the years, several studies have been showing evidence of Thirlwall's law and many extensions have been put forward, namely to include capital flows and external debt. On the other hand, various criticisms have also been pointed out, regarding the assumption of price stability in the long run and the exclusion of interest rates of the external debt from the model.

With this general theoretical context in mind, we focus on Portugal, a small economy with an open economy, especially after the access to the European Economic Community (EEC) in 1986, and that is trying to recover from the international economic and financial crisis of 2008.

In a first stage, we verify if Thirlwall's Law reasonably explains Portuguese economic growth between 1994 and 2013. After that, from a sectoral perspective, we analyze if the country's productive structure is relevant to promote growth, by using the Multi-Sectoral Thirlwall's Law. Moreover, income elasticities of the demand for exports and imports of the most relevant sectors are analyzed, to check out if resources are being oriented to those sectors that display the highest income elasticities of exports.

The work is divided into five sections, being the first the introduction. In the second section we emphasize some of the most relevant studies regarding the importance of trade to growth and we focus especially on Thirlwall's Law, both general and at the sectoral level. Section 3 characterizes the evolution of the Portuguese current account, the performance of exports and imports as well as the weight of the main groups of products traded, for the

period 1994-2013. In the fourth section the methodology is discussed, the equations are estimated to obtain the income elasticities of exports and imports and the Thirlwall's Law is computed, both at the aggregated and at the sectoral level. The last section discusses the main outcomes obtained at the light of economic theory.

2. Economic growth and foreign trade: Literature Review

Foreign trade has been considered relevant for explaining economic performance, dating back to the classics, namely to Adam Smith (1776) and David Ricardo (1817) and the principles of absolute and comparative advantages, respectively. Later on, neoclassics assume essentially a supply-side approach to growth, as in Solow's model (1956; 1957), based on an aggregate production function and where a country's growth rate is essentially explained by three factors: the quantity of labor used, the stock of physical capital and the exogenous technical progress (total factor productivity)[1].

In the context of the theories of endogenous growth, Romer (1986, 1990) considers that it is the accumulation of technology and knowledge that allows increasing returns to capital due to economies of scale and learning by doing originated by foreign trade, contrary to the hypothesis defended by the neoclassical theory (diminishing returns of capital and labor and technical progress in a closed economy). Both the neoclassical theory and the theories of endogenous growth argue that the pace of growth is determined by the supply side, through the production factors and their productivity, but do not explain why supply factors and productivity grow at different rates between countries (Lamonica *et al*, 2009; Antunes, 2010).

Within the demand-led growth approach (Keynesian view), the export-led growth justifies the importance of this component of demand for growth. In this context, we focus on Thirlwall's Law (Thirlwall, 1979), which aims at explaining the growth of an economy, taking into account external constraints on the Balance of Payments.

Thirlwall (1979) assumes that the trade balance is initially in equilibrium and relative prices are not relevant in the long run, arguing that no country can have growth rates consistently higher than that consistent with the balance-of-payments equilibrium; otherwise, it would tend to lose international reserves, thereby incurring in external deficits. Thus, economic growth of a country can be constrained by its Balance of Payments in the

[1] According to Solow (1956) the exogenous technical progress increases the productivity of factors, generating positive effects on growth.

long run [2]. It is considered that a country grows at a sustainable rate when it grows at a rate consistent with the balance of payments equilibrium. When there are imbalances, the adjustment is provided by income. According to Thirlwall's Law, the growth rate compatible with the balance of payments equilibrium is given approximately by the ratio between the income elasticity of demand for exports and the income elasticity of demand for imports, multiplied by the growth rate of the rest of the world. Alternatively, the rate can be given by the ratio between the growth rate of exports and the income elasticity of demand for imports (ratio known in the literature as Thirlwall's Law)[3]. The author derived Thirlwall's Law after examining 18 developed countries and testing two sets of data regarding growth of output and exports. Generally, there was a tendency for the estimates of the equilibrium rates to be higher than the actual growth rates, i.e., most of the countries grew less than it would be consistent with the balance of payments equilibrium, thus justifying a surplus in the trade balance.[4] This relationship has also been empirically verified by other authors, including McCombie and Thirlwall (1994) that, like Thirlwall (1979), considered that a country can grow faster by increasing the income elasticity of demand for exports and/or by decreasing the income elasticity of demand for imports.[5] Although Thirlwall (1979) had mentioned that it is mainly the aggregate demand that restricts economic growth, he did not ignore non-price characteristics such as quality, brevity in deliveries and technological innovation which are all supply factors (McCombie and Thirlwall, 1994).

Thirlwall's initial assumptions -trade balance initially in equilibrium and no impact of relative prices in the long run- have been criticized in the literature, as well as the fact that the author did not initally considered the possibility of capital inflows to finance trade deficits.

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[2] The Balance of Payments is the sum of the current account, the capital account and the financial account. Balance of Payments is always in equilibrium; therefore, whenever we refer to balance of payments, we are in fact referring to the trade balance of goods and services, which is a sub balance of current account, that reflects the real competitiveness of countries.

[3] The model will be presented with more detail in section 4.1.

[4] According to Thirlwall's Law, an external trade deficit is expected when the growth rate compatible with the balance of payments equilibrium is lower than the actual growth rate. This is the case, for example, if actual growth is due to increased purchases abroad, which in turn deteriorates the balance of payments (regarding the trade balance) and forces the existence of external deficits, which are not sustainable in the long run unless capital flows are obtained to finance the imbalances occurred in the BP. In case of a surplus, this occurs when the rate compatible with the balance of payments equilibrium is greater than the effective rate, which may be due, for example, to more investment, or an improvement in internal productivity, thus enabling growth through the increase in domestic demand and exports.

[5] It also follows from Thirlwall's Law that for a country to grow faster, it should turn exports more attractive and, on the other hand, it should decrease the income elasticity of demand for imports.

According to McCombie and Roberts (2002), even if relative prices vary in the short run, in the medium and long term they do not have a sustainable impact on the exchange rate and therefore it is unlikely to impact on the growth rate compatible with the balance of payments equilibrium. Several studies, including Leon-Ledesma's (1999) for Spain (1965-1993) and Bianchi and Lorenzini's (2014), for the Eurozone (1970-2012), concluded that in general relative prices showed a reduced relevance, despite the fluctuations in oil prices resulting from the two oil crises. Soukiazis and Antunes (2011), in a study for Portugal for the period 1965-2008, observed that it was reasonable to assume that relative prices were constant in the long run.

Other authors were interested in the question of capital flows (Thirlwall and Hussain, 1982; Moreno-Brid, 1998-99; 2003; Blecker, 2009). Thirlwall and Hussain (1982) verified that capital flows can contribute to alleviate the restrictions on the BP (Balance of Payments), but they do not address properly the unsustainability of the interest rate payment caused by the accumulated foreign debt, which is an important indicator for long-term growth, as pointed out by Moreno-Brid (2003).

In fact, although Thirlwall (1979) admits that characteristics at the structural level are relevant to increase the growth rate compatible with the balance of payments equilibrium, through the increase (decrease) in the income elasticity of demand for exports (imports), it does not explain how structural changes can influence these elasticities in order to improve that rate. In an attempt to incorporate these effects on growth models with restrictions on BP, Araujo and Lima (2007) combine the approach of structural economic dynamics (SED) [6] with Thirlwall's Law, thus originating the Multi-Sectoral Thirlwall's Law. The authors concluded that the *per capita* growth rate of a country is given in a simplified way by the product between the growth rate of the rest of the world and a ratio of elasticities; more specifically, the ratio between the sum of income elasticities of sectoral exports and the sum of income elasticities of sectoral imports, with all elasticities weighted by the share of each sector in total exports and imports, respectively. Thus, even if sectoral income elasticities remain constant, the growth rate compatible with balance of payments equilibrium can vary as a result of changes in the productive structure arising from different preferences,

[6] According to the approach of the structural economic dynamics (Pasinetti, 1981; 1993), changes in the production pattern lead to changes in the rate of economic growth of a country, since each sector has different income elasticities and as such, each sector is associated with a distinct rate of growth. This approach was conceived in the context of a closed economy.

according to Engel's Law[7]. Therefore, a country can increase its growth rate, even when there is no change in the growth rate of the rest of the world, if the production structure can be properly reorganized.[8].

Studies carried out about the multi-sectoral Thirlwall's Law are still scarce, and are mostly focused on the Brazilian economy. One of those studies was conducted by Gouvêia and Lima (2010) over a set of countries of Latin America and Asia between 1962 and 2006. The authors analyzed the demand for imports and exports, in aggregate and sectoral terms, concluding that both Thirlwall's original approach and the multi-sectoral approach seemed to explain growth reasonably. However, the multi-sectoral approach apparently performed better, closer to the actual growth rate. Gouvêia (2010) performed a similar study for Brazil for the same period, focusing on several sectors and concluded that the actual growth rate did not differ much from the rate compatible with the balance of payments equilibrium, either by the original law or by the multi-sectoral law.

Another study for the Brazilian economy, for the 1962-2006 period, is Carbinato's (2010). The author observed the income elasticities of demand for exports and imports for 10 sectors, and concluded, based on the multi-sectoral approach, that the productive structure is relevant for the country's growth rate. Moreover, this multi-sectoral approach proved to reasonably explain the Brazilian economic performance in the long run. Lastly, the author also found that more than 50% of the Brazilian exports were concentrated in sectors with low income elasticities of demand and 42% of imports were concentrated in sectors with high income elasticities, thus showing that Brazil is dedicated to less dynamic markets in terms of technology.

In the next section, a descriptive analysis of the evolution of Portuguese exports and imports, as well as of the main groups of products traded with the Eurozone, is performed.

3. Evolution of Portuguese exports and imports

In this section we present an overview of the evolution of the Portuguese current account, exports and imports, as well as of the top five groups of products traded with the Eurozone, for the period 1994-2013. The top five sectors represented, on average, 55.6% of exports and 64.2% of imports for this period. The sectors with the highest shares in exports and imports and that are thus in the top five are: *Agricultural*; *Chemicals*; *Machinery and*

[7] According to Engel's Law, the proportion of income of a household for food decreases with the increase in income, even though in absolute terms the amount spent on food increases.

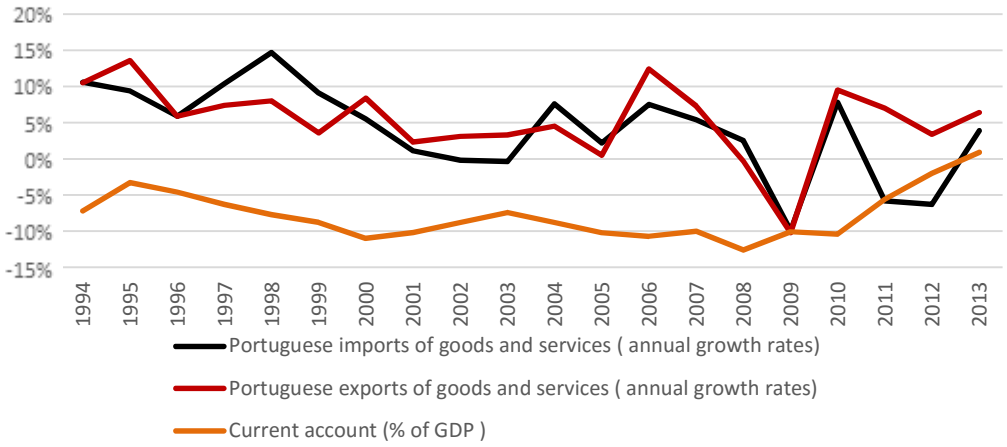
[8] Both the global and the sectoral model will be developed with more detail in section 4.2.

equipment; *Common Metals*; *Plastics and Rubbers*; *Vehicles and other transport equipment* and *Clothing,*[9] from the aggregation of product groups following the Classification of the Combined Nomenclature (NC), of the " Harmonized Commodity Description and Coding System (HS) of the EU of the Customs Cooperation Council (Instituto Nacional de Estatística, 2014b).[10]

3.1. Evolution of Portuguese exports and imports

On January 1st, 1986, Portugal joined the European Economic Community (EEC). Later on, with the entry into force of the Single Market on January 1st, 1993, all customs controls related to trade of goods between Member States of the European Union were abolished, in the light of the "four freedoms": free movement of goods, services, people and capital. Figure 1 illustrates the performance of the Portuguese current account and of both exports and imports of goods and services for the period 1994-2013.

Figure 1: Evolution of the Current Account and of exports and imports, Portugal, 1994-2013



Source: Authors' elaboration with data from European Commission (2015).

Generally, the current account balance displays a deficit between 1994 and 2012; the only positive figure was registered in 2013 (0.9%). The most marked negative values were

[9] Some sectors appear both in the top 5 exporter and the top 5 importer groups, but there are 2 cases where a given sector only appear in one of the tops. For that reason, we have a total of seven sectors analyzed.

[10] According to the *Nomenclatura Combinada* (Instituto Nacional de Estatística, 2014b), the "Combined Nomenclature (CN) is the nomenclature of EU goods that meets the requirements of International trade statistics (intra and extra) and the Customs Tariff in accordance with article 9 of the Treaty establishing the European Economic Community", and the HS is a reference worldwide for the classifications of international trade statistics and for customs tariffs.

in the year following the adoption of the single currency, in 1999 (-11%), and in 2008, the first year of the international economic and financial crisis (-12.6%). 2013 shows a slight sign of recovery (0.9%); however, the poor performance for most of the period possibly influences negatively the Portuguese growth. It is also possible to observe that the current account improves when exports grow more than imports; both are part of the trade balance, which in turn is the sub balance with the highest weight on the current account.[11].

It is also evident that exports and imports registered lower growth rates in 2013 (6.4% and 3.9%, respectively) than in 1994 (10.5% and 10.6%), and while in 1994 exports and imports grew at almost the same rhythm, in 2013 exports grew faster.

According to the publication regarding foreign trade statistics, published by Instituto Nacional de Estatística (2014a), *Estatísticas do Comércio Internacional* -and despite the decrease since 1994-, the EU is the foreign market that has most contributed to the development of national trade. In fact, in 2013 the EU represented about 70% of Portuguese exports and 72% of imports, with 59.3% and 65.4% of Portuguese exports and imports coming to and from the Eurozone.

3.2. Evolution of the main groups of products traded with the Eurozone

In order to determine the five sectors with the highest weights in Portuguese exports and imports, annual average weights were computed for each of the 17 sectors, for the period 1994-2013. For that, the total value exported and imported by each sector to each Eurozone country was summed up[12]. Next, the weight of each sector in total exports and imports was computed, annually. Finally, the average weight was computed, for each sector, regarding exports and imports and the period 1994-2013.[13]

In the following tables we display the main groups exported and imported by the Portuguese economy in trade with the Eurozone.

[11] The current account is formed by the balance of goods and services, balance of income and the balance of current transfers.

[12] The figures were about total values (€) of exports and imports of each of the 17 sectors, relatively to each of the Eurozone countries.

[13] View the designation and composition of each group of products in Appendix 2.

Table 1: ***Evolution of the weight of the main exported product groups to the Eurozone, 1994-2013***

Group	Sector	1994	2013	Average weight, 1994-2013
14	Machinery and equipment	18.10%	12.80%	16.70%
15	Vehicles and other transport equipment	6.40%	12.60%	15.30%
10	Clothing	19.70%	6.80%	11.00%
13	Common Metals	3.90%	7.40%	7.10%
5	Plastics and Rubbers	3.20%	8.20%	5.40%

Source: Authors' elaboration based on data provided by Instituto Nacional de Estatística, *Comércio Internacional de Bens* (may, 2015).

According to Table 1, the product groups with higher average weight in exports, are, in descending order: *Machinery and equipment; Vehicles and other transport equipment; Clothing; Common Metals* and *Plastics and Rubbers*. These sectors represented an average weight of 55.5% of Portuguese exports in 1994-2013. We can also observe that the weight of the main group, *Machinery and equipment*, decreased over the period, and *Clothing* suffered a more evident break, from 19.7% in 1994 to 6.8% in 2013. Moreover, the group *Vehicles and other transport equipment*, *Common Metals and Plastics and Rubbers* increased their weight between 1994 and 2013; it is noticeable the increase in the *Plastics and Rubbers* group in more than 100%.

Next, we show the evolution of the main product groups imported from the Eurozone countries.

Table 2: ***Evolution of the weight of the main imported product groups from the Eurozone, 1994-2013***

Group	Sector	1994	2013	Average weight, 1994-2013
14	Machinery and equipment	22.1%	16.9%	21.5%
15	Vehicles and other transport equipment	17.6%	11.1%	15.8%
4	Chemicals	8.9%	11.6%	9.4%
1	Agricultural	8.6	11.6%	8.8%
13	Common Metals	8.5%	9.1%	8.7%

Source: Authors' own elaboration based on data provided by Instituto Nacional de Estatística, *Comércio Internacional de Bens* (may, 2015).

The groups with the highest average weights in imports between 1994 and 2013 were *Machinery and equipment* and *Vehicles and other transport equipment*, with 21.5% and 15.8%, respectively. The weight of the main group has decreased, though smoothly. It is still possible to observe that the group *Vehicles and other transport equipment* shows a marked decrease (36.9%) in the share of imports when compared to the beginning of the period, in

contrast with the increase verified in exports (50.1%). Also note that the individual weight of product groups like *Machinery and equipment*, *Vehicles and other transport equipment* and *Common Metals* is higher for imports than for exports. After determining the sectors with the highest average weights in Portuguese exports and imports between 1994 and 2013, in the next section we verify the impact of sectoral composition of the Portuguese economy over growth.

4. Methodology and Results

In this section we first use Thirlwall's Law at the aggregate level and next we apply Multi-Sectoral Thirlwall's Law to the 17 sectors of the economy. This way we intend to verify whether the original Thirlwall's Law can contribute in any way to explain the Portuguese growth performance over the last years. Moreover, we aim at confirming if the multi-sectoral version, which takes into account the national production structure, is more adequate to explain national growth.

Although in the previous section we have focused on the top 5 Portuguese exporters and importers groups for the period in question, to compute the multi-sectoral Thirlwall's Law it is necessary to consider all the 17 sectors.

4.1. Thirlwall's Law

Thirlwall's Law (1979) incorporates the external constraint on growth and can be described in three equations, with the variables expressed in growth rates:

Export Growth Function

$$x_{t=} \varepsilon z_t + \eta\ (pd_t - pf_t - e_t) \qquad (1)$$

Import Growth Function

$$m_{t=} \pi\ y_t + \psi\ (pd_t - pf_t - e_t) \qquad (2)$$

Trade Balance Equation starting from equilibrium

$$pd_t + x_t = pf_t + e_t + m_t \qquad (3)$$

where x_t, m_t, z_t , y_t are the rates of growth of real exports, imports, foreign income[14] and domestic income, respectively. pd_t is the rate of growth of domestic prices, pf_t is the rate of growth of import prices and e_t is the rate of change of the nominal exchange rate. The proxy for the relative prices of exports, rpx_t, is the difference between the growth rate of export prices and growth rate of import prices. As for the relative prices of imports, rpm_t, it is the difference between the growth rate of domestic prices and the growth rate of import prices, considering that imports can be a substitute of domestic production.[15]

Finally, ε and π are the income elasticities of demand for exports and imports, and η and ψ are the price elasticities of demand for exports and imports. It is expected that these income elasticities have a positive sign, $\varepsilon > 0$ and $\pi > 0$, since when external income increases the demand for domestic products tends to expand and therefore exports rise . An analogous reasoning comes for imports, given that if domestic income increases more purchases are possible, including those made abroad. With respect to price elasticities, it is expected that the price elasticity of exports has a negative effect ($\eta < 0$), since when the relative price of exports rises (either due to an increase in the price for exports or a decrease in the price for imports) it means a loss of relative competitiveness and therefore the demand for domestic products drops. With regard to price elasticity of imports, we expect it to have a positive sign ($\psi > 0$), since following an increase in the relative price of imports (either due to an increase in domestic prices or a decrease of import prices), it is expected a loss of national competitiveness with foreign products being relatively cheaper than domestic ones, thus resulting in increasing imports.

Substituting Equations (1) and (2) in Equation (3) and solving in order to income growth (y), assuming that relative prices remain constant in the long run, the growth rate compatible with the balance of payments equilibrium is obtained:

$$Y_{BP,t} = \frac{\varepsilon\,(z_t)}{\pi} \qquad \text{(4a)} \qquad \text{or} \qquad Y_{BP,t} = \frac{x_t}{\pi} \qquad \text{(4b)}$$

Expression (4b) is known in the literature as Thirlwall's Law. In our study we focus on the alternative form, expression (4a), to enable comparisons with the outcomes from the Multi-Sectoral Thirlwall's Law. Thus, according to expression (4a), the growth rate compatible with the balance of payments equilibrium is given by the ratio between income

[14] Foreign income is proxied by income of the 19 Eurozone countries.
[15] For a description of the variables and data sources, see the Appendix 1.

elasticity of exports and income elasticity of imports multiplied by the income growth rate of the rest of the world.

To compute this ratio, we need the income elasticities of demand for exports and imports (ε and π, respectively), obtained through the regression of the demand for exports and imports. Given that we are working with time series data, it was necessary to previously check for stationarity[16] to ensure that statistical inferences are valid. For that, we used the Augmented Dickey Fuller Test (ADF) and the Kwiatkowski, Phillips, Schmidt and Shin Test (KPSS), as shown below:

Table 3: ***Stationarity Tests ADF and KPSS***

	ADF		KPSS	
Variable	**Statistical test**	**p value**	**Statistical test**	**Critical value at 1%**
x_t	-4.1373	0.0055	0.0938	0.205
m_t	-16.0068	3.297e-048	0.0588	0.206
rpx_t	-6.7091	1.967e-009	0.1749	0.694
rpm_t	-4.1991	0.0001	0.3131	0.694
y_t	-3.4520	0.04473	0.0772	0.206
z_t	-6.2182	3.322e-007	0.0761	0.205
c_t	-3.9696	0.0096	0.1201	0.205
i_t	-5.8816	2.238e-006	0.0621	0.206

Source: Author's elaboration using Gretl's output.
Notes: Regression without constant and without trend for rpm_t; Regression with constant for rpx_t; Regression with constant and trend for x_t; m_t; y_t; z_t; c_t e i_t. 0 lags for m; rpx_t; rpm_t; y_t e i_t; 1 lag for c_t e z_t; 2 lags for x_t.

The ADF test checks whether a given variable is a unit root or not. The null hypothesis is that the variable is non-stationary (i.e., is a unit root) against the alternative hypothesis of stationarity. Checking the outcomes of Table 1 and using the notion of p-value, we conclude that in all cases, the p-value is less than the conventional 5% critical value and thus we are led to reject the null hypothesis, meaning that the variables are stationary. In the case of the KPSS test, the null hypothesis is the stationarity of the variable; when the value of the test statistic is less than the critical value that hypothesis is not rejected, which is the case for all variables. Therefore, from both tests we conclude that all the variables are stationary (being expressed in growth rates).

Given the stationarity of the variables, we proceed to the estimation of the demand for exports and imports at the aggregate level. The first function was estimated by the method

[16] A variable Y_t is stationary when the mean ($E(y_t)=\mu$), variance ($Var(y_t)=E(y_t-\mu)^2=\sigma^2$) and covariance ($Cov(y_t, y_{t+k})= E(y_t-\mu)(y_{t+k}-\mu))=\Upsilon_t$) are constant over time.

of ordinary least squares (OLS), as in Atesoglu (1995) or Antunes (2010) and can be presented as follows:

$$x_{t=} \beta + \varepsilon (z_t) + \eta (rpx_t) + v_t \qquad (5)$$

As can been seen in Table B of Appendix 3, the income elasticity of demand for exports (ε) displays a positive sign (2.32), being significant at the 1% level; the price elasticity has no significance, as expected.[17] We also performed the autocorrelation test (LM test) and heteroskedasticity test (White test). For both of them the null hypothesis is not rejected (absence of autocorrelation and homoskedasticity, respectively), thus ensuring the properties which define the OLS estimator as BLUE.

The demand for imports can be presented as follows:

$$m_{t=} a + \pi(y_t) + \psi (rpm_{t-1}) + \omega_t \qquad (6)$$

This equation was estimated by two-stage least squares method (2SLS). The justification is related to the possible endogeneity of the variable y_t (growth of income) [18] since, on the one hand, domestic output and imports are related through the National Income Identity equation and thus whenever imports change, gross domestic product (GDP) also changes[19]. On the other hand, through our equation of demand for imports we are able to infer that an increase in domestic income promotes the demand for imports.

Analyzing the results of the estimation, we observe that the income elasticity of demand for imports has a positive sign (π = 2.24), as expected, significant at the 1% level. Moreover, this income elasticity is slightly lower than that of exports. Regarding price elasticity ($\psi = 0.2$)[20], it presents a positive sign but without statistical significance.

In order to check for the endogeneity of income and consequently the validity of the 2SLS method, a Hausman test was performed. The null hypothesis is the consistency of the

[17] Although the sign of price elasticity is contrary to what would be expected, as in Soukiazis and Antunes (2011-2012), the impact of prices on exports does not reveal to be significant.

[18] The violation of the exogeneity assumption produces biased and inconsistent OLS estimators. Biasedness occurs because the variable is correlated with the error term and inconsistency is present because the estimated value does not converge asymptotically to the actual value of the parameter. Prices are assumed to be exogenous, thus instrumenting themselves in the 2SLS regression.

[19] GDP= Private Consumption + Public Expenditure + Private investment + (Exports - Imports).

[20] The estimation with the current year's prices showed the existence of a sign contrary to what would be expected and as such we used the relative prices lagged one period, justified by the fact that the impacts of prices on imports are not immediate.

OLS method, which was rejected (Table B of Appendix 3). The use of the 2SLS method implies using instruments that are correlated with the endogenous explanatory variable (property of relevance), and not correlated with the error term (property of exogeneity). In this sense, we used the Private Consumption growth rate (c_t), the Private Investment growth rate (i_t) and the Exports growth rate (x_t), as instruments for the domestic product growth rate (y_t). Table 4 displays the linear correlations between the endogenous variable and its instruments:

Table 4: ***Linear Correlation Matrix, 1994-2013***

	c_t	x_t	i_t
y_t	0.93782199	0.51837169	0.93671038

Source: Author's elaboration using Gretl's output.

The Sargan test was performed to determine the validity of the instruments and an F-test was applied to test for weak instruments. Both tests indicate that the assumptions of validity and non-weakness of instruments are respected. Moreover, there is no autocorrelation nor heteroskedasticity and therefore the estimators are efficient and consistent.

According to the aggregate estimates, income appears to have impact both on export growth and import growth, being higher in the former case. On the other hand, price elasticities are not significant. These results agree with the ideas of Thirlwall's Law, namely that imbalances are restored through income and that relative prices are not relevant in the long run. The fact that the income elasticity of demand for exports (2.32) is higher than that of imports (2.24) would result, according to Thirlwall's Law, in a domestic growth higher than that of the rest of the world. But that is not the case in our study: we have a domestic annual growth of 1.31% and a foreign growth of 1.55% for the period under study. When we compute the growth rate compatible with the BP equilibrium according to Thirlwall's Law we obtain the following result:

$$Y_{BP,t} = \frac{\varepsilon}{\pi} * z_t = \frac{2.32485 * 1.55500}{2.24415} = 1.61 > Y^* = 1.31$$

The growth rate compatible with the balance of payments equilibrium is greater than the actual growth rate (Y *) observed in Portugal for 1994-2013, which according to Thirlwall's Law would implicate a surplus in the BP when in fact there was an average deficit in the current account of 7.83% during the period. Therefore, Thirlwall's Law is

apparently unable to explain the Portuguese performance accurately. The time period under study is short and includes the years of economic and financial crisis and the Troika intervention, which may have influence on the results. On the other hand, internal restrictions such as the public deficit and public debt which have been affecting the Portuguese growth performance to a greater extent, are not included in the original Thirlwall's Law[21]. This difference in growth rates may also be related to supply constraints such as low productivity and low labor mobility. On the other hand, the use of simultaneous equations estimated by a more efficient method (3SLS – Three Stage Least Squares) could possibly allow more interesting results, in the line with Soukiazis *et al.* (2013).

Taking into account the results obtained, in the next section we use the Multi-Sectoral Thirlwall's Law, which takes into account not only the income elasticities and the growth of the rest of the world to explain the domestic growth but also the internal productive structure.

4.2. Multi-Sectorial Thirlwall's Law

According to the Multi-Sectoral Thirlwall's Law a country's production structure can influence growth (Araujo and Lima, 2007). If an economy has various sectors to which correspond, individually, different income and price elasticities of demand for exports and imports, then the equations of exports and imports, (1) and (2) respectively, can be presented as follows (adapted to our notation from Romero and McCombie (2014)):

$$x_t=\sum_{i=1}^{k} \Phi_{it}\, \varepsilon_i z_t + \sum_{i=1}^{k} \sigma_{it}\eta_i\, (pd_{it} - pf_{it} - e_t) \quad (7)$$

$$m_t=\sum_{i=1}^{k} \theta_{it}\, \pi_i y_t + \sum_{i=1}^{k} \omega_{it}\psi_i\, (pd_{it} - pf_{it} - e_t) \quad (8)$$

where Φ_{it} and θ_{it} are the weights of each sector in total exports and imports, respectively, and σ_{it} , ω_{it} , represent the weight of each sector in total export and import prices, respectively. The index *i*= 1, ,…, k corresponds to the number of sectors, with $\sum_{i=1}^{k} \Phi_{it}$=1, $\sum_{i=1}^{k} \theta_{it}$=1, $\sum_{i=1}^{k} \sigma_{it}$=1, $\sum_{i=1}^{k} \omega_{it}$=1. Every aggregated elasticity can be obtained by the weighted sum of sectoral elasticities, $\varepsilon = \sum_{i=1}^{k} \Phi_{it}\, \varepsilon_i$, $\pi = \sum_{i=1}^{k} \theta_{it}\, \pi_i$, $\eta = \sum_{i=1}^{k} \sigma_{it}\, \eta_i, \psi = \sum_{i=1}^{k} \psi_{it}\, \eta_i$. Substituting equations (7) and (8) in the balance of payments

[21] Soukiazis and Antunes (2011-2012) observed that for Portugal, for 1965-2008, the actual growth rate (3.58%) was higher than the rate consistent with the balance of payments equilibrium (2.82%), which would be in line with external trade deficits. As such, the results found by the authors were in accordance with Thirlwall's Law.

equilibrium, Equation (3), and assuming that prices remain constant in the long term, we obtain, the multi-sectorial version of Thirlwall's Law:

$$Y_{BP,t} = \frac{\sum_{i=1}^{k} \Phi_{it}\varepsilon_i}{\sum_{i=1}^{k} \theta_{it}\pi_i} z_t \quad (9)$$

The growth rate of a country compatible with the balance of payments equilibrium is given by the ratio of the sum of the income elasticities of demand for exports and the sum of the income elasticities demand for imports, weighted by the respective share of each sector in total exports and imports, respectively. Finally, the ratio is multiplied by the income growth of the rest of the world. Even if the income from the rest of the world remains constant, the country can increase its growth rate, if it is able to change appropriately the productive structure. To compute this rate we first estimated the demand for exports and imports for each sector individually to obtain the respective income elasticities. The demand function for exports and imports, for the *i* sector (*i*=1,…,17), is given by:

$$x_{it=} \beta_i + \varepsilon_{i} (z_t) + \eta_i (rpx_{it}) + v_{it} \quad (10)$$

$$m_{it=} a_i + \pi_{i} (y_t) + \psi_i (rpm_{it}) + \omega_{it} \quad (11)$$

where x_{it}, m_{it} is the growth of real exports and imports of the *i* sector in year *t* and, rpx_{it}, rpm_{it}[22] are the growth rates of the relative prices of exports and imports, respectively, of the *i* sector in year *t*. ε_{i}, π_i and η_i, ψ_i are the sectoral income and price elasticities of exports and imports, respectively.

We analyzed the existence of unit roots for export growth (x_{it}), import growth (m_{it}) and relative prices growth (rpx_{it} e rpm_{it}) for each sector. In all cases, it was concluded the existence of stationarity (Appendixes 4 and 5). Next, the demand for exports and imports were estimated for each group, using the same methods as previously. For the demand for imports, the instruments used for endogenous domestic income growth were also maintained.

[22] The procedures to obtain the relative prices of exports and imports are explained in Appendix 1.

Analyzing the outcomes from Tables E and F (Appendix 6)[23], the income elasticities are usually significant; concerning to the sectoral price elasticities, they are not significant in the demand function for exports but generally demonstrate to be relevant for imports. The estimated equations revealed no signs of heteroskedasticity nor autocorrelation. The Hausman test confirmed the endogeneity of y_t in all cases; the Sargan test allows us to conclude that the instruments are valid and the F-test test demonstrates that instruments are not weak. After obtaining the sectoral elasticities, each sector was weighed up in terms of its contribution for total exports and imports.[24] Combining this information, it was possible to compute the growth rate compatible with the balance of payments equilibrium, according to the Multi-Sectoral Thirlwall's Law:

$$Y_{BP,t} = \frac{\sum_{i=1}^{n} \Phi_{it} \varepsilon_i}{\sum_{i=1}^{n} \theta_{it} \pi_i} * z_t = \frac{271.8213}{323.4719} * 1.555 = 1.35 > Y^* = 1.31$$

The growth rate compatible with the balance of payments equilibrium (1.35%) is higher than the effective average growth rate (1.31%) observed in Portugal in the period 1994-2013. Thus, Portugal grew, on average, at a slower rate than that compatible with the balance of payments equilibrium. However, contrary to what would be expected, the country displayed a deficit in the current account during this period (-7.83%). Although the multi-sectoral approach indicates a growth rate compatible with external equilibrium above the effective, both figures are very close, closer than when the original Thirlwall's Law is applied. Thus, the productive structure seems to be a relevant contribute to improve the explanatory power of Thirlwall's Law regarding the Portuguese economy.

However, it is important to note that the specificity of the period analyzed, partially capturing the international financial and economic crisis, together with the short time span (20 observations) and the non-inclusion of other factors affecting growth[25], may partially justify the fact that Thirlwall's Law does not explain efficiently Portuguese growth. Moreover, the aggregation of productive sectors in a smaller number of groups, according

[23] Given the existence of heteroskedasticity in the regression function of demand for exports for sector 10 it was necessary to correct it by the method of generalized least squares.

[24] For an analysis on the weight of each sector, see Appendix 7.

[25] Soukiazis et al. (2013), considered public debt and public deficit (internal constraints to growth) in the Portuguese economy, for 1986-2010, as well as relative prices. The results showed that Thirlwall's Law thus modified, known as SCA2, was more likely to explain the Portuguese performance than the original Law.

to some criterion of technological specialization, could allow for more consistent results in the context of the Multi-Sectoral Thirlwall's Law.

4.3. Combined analysis of sectoral income elasticities of exports and imports with the weights of the main groups exported and imported, 1994-2013

As an informal check to perceive if Portugal is concentrating its resources on those sectors that can contribute more to growth, a combined analysis of the income elasticities and the respective weights in total exports and imports, was performed for the five main exporter and importer groups. Table 5 displays income elasticities and weights of the following product groups: *Agricultural* (A); *Chemicals* (CH); *Plastics and Rubbers* (P.R.); *Clothing* (C); *Common Metals* (C.M.); *Machinery and equipment* (M.E.) e *Vehicles and other transport equipment* (V.TE.):

Table 5: ***Income elasticities and relative weights of the main groups exported and imported, 1994-2013***

	A.	CH.	P.R.	C.	C.M.	M.E.	V.TE.
Income Elasticities							
Exports	-	-	2.8435 ***	1.2385	5.5572 ***	3.7212 ***	2.7812 ***
Imports	3.7319 **	0.6891 **	-	-	5.45791 **	1.4940 **	5.1387 ***
Relative average weight (%)							
Exports Position in top 5	-	-	5.4329 (5º)	10.9729 (3º)	7.1271 (4º)	16.7102 (1º)	15.3263 (2º)
Imports Position in top 5	8.7661 (4º)	9.4042 (3º)	-	-	8.7495 (5º)	21.5415 (1º)	15.7514 (2º)

Source: Author's elaboration with data provided by Instituto Nacional de Estatística, *Comércio Internacional de Bens* (may, 2015).
Notes: * Coefficient statistically significant at the 10% level;** Coefficient statistically significant at the 5% level; *** Coefficient statistically significant at the 1% level.

As shown in Section 3, the five most exported groups in the period 1994-2013 are *Machinery and equipment*; *Vehicles and other transport equipment*; *Clothing*; *Common Metals*; and *Plastics and Rubbers*, in descending order of importance. From Table 5 it is possible to verify that the groups *Common Metals* and *Machinery and equipment* present the highest income elasticities (5.6 and 3.7, respectively) and that *Clothing; Plastics and Rubbers;* and the *Vehicles and other transport equipment* present the lowest figures (1,6; 2,7

e 2,8, respectively). Concerning the average weight of each sector, the groups *Machinery and equipment* and *Vehicles and other transport equipment* are the ones with the highest weights in exports; those with lower weights are *Clothing; Common Metals* and *Plastics and Rubbers*. It is worth noting that *Common Metals*, despite being fourth in the group of the most exported products, has the highest income elasticity of exports of this top 5. It should also be noted that the *Vehicles and other transport equipment* is the second most exported group (with a share of 15.3%; however, it has one of the lowest income elasticities of exports (2,8).

With regard to imports, the five most imported groups are *Machinery and equipment*; *Vehicles and other transport equipment*; *Chemicals*; *Agricultural* and *Common Metals*, in descending order of importance. The groups *Common Metals* and *Vehicles and other transport equipment* are those with the highest income elasticities and the groups of *Agricultural* products; *Machinery and equipment*; and *Chemicals* display the lowest income elasticities. The *Common Metals* group is the one with the lowest weight in imports (8.7%), although it has the highest income elasticity of demand for imports. Regarding the average weight of each sector, the *Machinery and equipment* and *Vehicles and other transport equipment* occupy, as in exports, the first and second positions (21.5% and 15.8%), respectively. The product groups with the lowest weights are *Chemicals*; *Agricultural* and *Common Metals* (9,4%, 8,8% and 8,7%, respectively). Although the group *Machinery and equipment* is the one with the highest weight in total imports, 21.5%, it has one of the lowest income elasticities.

From the previous analysis, *Common Metals* is the group with the highest income elasticity for both exports and imports; however, it is not the group with the highest shares. Regarding exports, *Vehicles and other transport equipment* is one of the groups with higher weight (second place), but, it has one of the lowest income elasticities. With regard to the more exported and imported group, *Machinery and equipment*, it has one of the highest income elasticities of demand for exports, surpassed only by the *Common Metals* group; while at the same time it has one of the lowest income elasticities of demand for imports. Apparently, the country's productive structure is more concentrated in groups of intermediate nature such as *Common Metals* and *Plastics and Rubbers* and, in groups of technological nature such as *Machinery and equipment* and *Vehicles and other transport equipment*.[26]

[26] For a description of the composition of each group, see Appendix 2.

Therefore, in order to promote growth, Portugal should relocate resources for groups like *Common Metals*, with a high income elasticity of exports; therefore, a growth of foreign income would lead to a more than proportional growth in exports. Moreover, by focusing on this sector Portugal could possibly focus on products that are currently imported, such as flat-rolled products of iron or non-alloy steel, thereby helping to reduce external dependence and the share of that group in total imports. Additionally, resources could also be oriented to the *Machinery and equipment* group for the same reasons (it is one of the groups with the highest impact on the growth of total exports). Moreover, by improving non-price characteristics, such as quality, product diversity, and innovation, Portugal would be promoting the increase on the income elasticity of demand for exports. On the other hand, the focus should also lay on reducing the income elasticity of demand for imports for the *Vehicles and other transport equipment* sector, which is the second highest (5.1) as it has a very significant weight in total imports (second, with 15.8 %).

5. Conclusion

International trade has been pointed out as one of the main factors contributing to economic growth, mostly through exports, according to the export-led-growth approach. In the context of the Keynesian view, Thirlwall argues that the existence of differences in growth rates between countries lays in balance of payments constraints originated particularly by foreign demand.

Applying the original Thirlwall's Law to the Portuguese economy for 1994-2013, as well as its multi-sectoral version, in order to compute the growth rate compatible with the balance of payments equilibrium, several steps were taken. First, the demand functions for exports and imports were estimated, in aggregate terms, by OLS and 2SLS, respectively, to obtain the elasticities of demand for exports and imports. By applying the original Thirlwall's Law, the growth rate compatible with the balance of payments equilibrium (1.61%) was higher than the Portuguese average growth rate observed during this period (1.31%). Therefore, we proceeded to a multi-sectoral analysis to check if the production structure can have an impact on growth; thus, we performed the same regressions at the sectoral level. For that, we considered 17 groups of products. Additionally, we computed the average weight of each sector in total exports and imports. The growth rate compatible with the balance of payments (1.35%) turned out to be much closer to the effective growth rate

than previously, but still slightly higher, thus implying a surplus, according to Thirlwall's Law (which was not the case). We interpret this outcome as a sign that the domestic productive structure can contribute to explain the Portuguese growth performance when compared to the original Thirlwall's Law, where this feature was not considered.

Moreover, the *Common Metals* sector is the one that could possible assist to a more pronounced exports growth, in case of a rise in the growth of the income of the rest of the world, since this is the sector with the highest income elasticity of demand for exports.

The outcomes obtained in terms of Thirlwall's Law and Multi-Sectoral Thirlwall's Law are encouraging, from our point of view. First, the short time span considered may have influenced the results, especially when we bear in mind that during part of the period Portugal was suffering the consequences of the international financial and economic crisis. The Multi-Sectoral Thirlwall's Law results show an improvement regarding those from Thirlwall's Law, namely the fact that the predicted rate is very close to the effective rate. There are some factors that, from our perspective, can help explaining why the Law's implications regarding the current account are not verified, namely the non-inclusion of internal constraints in the computation of the Law.

There are, therefore, different directions we can follow from here regarding future work, including the consideration of the impact of the international crisis and of internal constraints, the estimation of a full system of equations using a more efficient method, or the grouping of sectors according to a technological specialization criterion.

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Appendices

Appendix 1: Description of variables and sources of data

- *m* –Annual growth rate of real imports.
  Imports of goods and services at 2010 prices (national currency; annual percentage change)

- *x* - Annual growth rate of real exports.
  Exports of goods and services at 2010 prices (national currency; annual percentage change)

- *y* – Annual growth rate of real GDP.
  GDP at 2010 market prices (national currency; annual percentage change)

- *z*- Annual growth rate of real foreign income (Eurozone 19 countries)
  GDP at 2010 market prices (national currency; annual percentage change)

- *c*- Annual growth rate of real private consumption.
  Private final consumption expenditure at 2010 prices (national currency; annual percentage change)

- *i* - Annual growth rate of real investment.
  Gross fixed capital formation at 2010 prices (national currency; annual percentage change)

- *py*- Annual growth rate of domestic prices.
  Price deflator GDP at 2010 prices (national currency; annual percentage change)

- *px*- Annual growth rate of exports prices.
  Price deflator exports (national currency; annual percentage change)

- *pm*- Annual growth rate of imports prices.

Price deflator imports (national currency; annual percentage change)

- *rpm*- Annual growth rate of the relative prices of imports (*py – pm*).
- *rpx*- Annual growth rate of the relative prices of exports (*px – pm*).

- Aggregate data drawn from European Commission (2015).

- m_i - Annual growth rate of real imports for the sector *i*.
  Imports (quantity) of goods (annual percentage change)
- x_i - Annual growth rate of real exports for the sector *i*.
  Exports (quantity) of goods (annual percentage change)
- px_i - Annual growth rate of exports prices for the sector *i*.
  Laspeyres price indexes of exports (national currency; annual percentage change).
- pm_i- Annual growth rate of imports prices for the sector *i*..
  Laspeyres price indexes of imports (national currency; annual percentage change).
- rpm_i- Annual growth rate of the relative prices of imports for the sector *i*. ($py - pm_i$).
- rpx_i - Annual growth rate of the relative prices of exports for the sector *i*.
  ($px_i - pm_i$).

- Sectoral data calculated from data provided by Instituto Nacional de Estatística (*Comércio Internacional de Bens*, may, 2015).

The data provided by Instituto Nacional de Estatística (*Comércio Internacional de Bens*, may, 2015) were about the values (€) and total exports and imports (kg) for each of the 17 product groups, relatively to each of the Eurozone countries. In order to obtain the annual growth rates of exports (px_i) and imports prices (pm_i) necessary to compute the annual growth rates of relative prices of exports and imports (rpx_i and rpm_i), several steps were taken to transform the data. For each sector, we had information on the value (€) and quantity (Kg) exported to and imported from each Eurozone country. Initially we aggregated, for

each product group and for each year, the values (€) and quantity (kg) exported and imported to each Eurozone partner. Then, for each year, we divided nominal exports and imports by quantities, to get unit prices. After that, we computed a Laspeyres price index (base 2010) and used it to obtain the annual growth rates of prices for each sector. Finally, in order to obtain the annual growth rates of relative prices of exports (rpx_{it}) the difference between the annual growth rate of export prices of sector i (px_i) and the annual growth rate of import prices of sector i (pm_i) was performed. To compute the annual growth rates of relative prices of imports for sector i (rpm_i), the difference between the annual growth rate of domestic prices (py) and the rate of annual growth rate of import prices for sector i (pm_i) was computed. We also computed the annual growth rates of exports (x_i) and imports (m_i) for each sector, based on quantities exported and imported (kg).

Appendix 2

Table. A: Designation and Composition of Product Groups

Group	Designation	Composition (examples)
1	Agricultural	live animals; milk and dairy products; horticultural products; fruits; coffee; cereal, among others.
2	Foodstuffs	preparations of meat, of fish, of crustaceans; beverages, alcoholic liquids and vinegar; sugars and sugar confectionery
3	Mineral fuels	mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes
4	Chemicals	pharmaceutical products; organic and inorganic chemicals; manures (fertilizers); gunpowder and explosives;
5	Plastics and Rubbers	plastics and their works; rubber and their works.
6	Pelts and Hides	pelts, except pelts with hair, and hides; pelts with hair and their works; pelts with hair, artificial
7	Wood and Cork	wood, charcoal and wood works; cork and his works
8	Cellulose folders and paper	wood folders or of other fibrous cellulosic material; paper and paperboard; books, newspapers, pictures and other products of the printing industry
9	Textiles	silk; wool; cotton; synthetic filament or artificial; knitted fabrics; carpets and other textile floor coverings
10	Clothing	clothing and their accessories, mesh and excluding mesh
11	Footwear	footwear, gaiters and the like, and parts thereof
12	Minerals and ores	salt; sulfur; earths and stone; plaster, cal and cement; ores, slag and ash; ceramic products; glass and their works
13	Common Metals	flat rolled products, of iron or non-alloy steel; iron and steel; copper, nickel, aluminium, lead, zinc, tin, and his works
14	Machinery and equipment	nuclear reactors, boilers, machinery, equipment and mechanical instruments, electrical equipment and parts thereof; equipment of recording or sound reproducing apparatus and image
15	Vehicles and other transport equipment	vehicles and materials for railways or similar, and parts thereof; mechanical appliances; automobiles vehicles, tractors, cycles and other land vehicles and parts thereof; vessels and floating structures
16	Optics and Precision	instruments and optical equipment, photography, cinematography, of measuring, of control, precision; watches; musical instruments; parts and accessories thereof
17	Other Products	tobacco and manufactured tobacco substitutes; Hats and artifacts and parts thereof; umbrellas, parasols, sunshade, walking sticks, seat-sticks, whips and parts thereof;

		natural or cultured pearls, precious or semi-precious stones; arms and munitions; furnishings; medical-surgical furniture; mattresses, pillow; toys, fun articles or for sports; art objects, of collection and antiquities

Source: Author's elaboration with data provided by Instituto Nacional de Estatística, *Composição dos grupos de produtos* (july, 2015)**.**

Appendix 3

Table. B: Estimation results of demand functions for export and imports, in aggregate terms

Variable		Exports (OLS)	Imports (2SLS)
Constant		1.6383 (1.2345)	0.4776 (0.7087)
z_t		2.3249 (0.4928)***	-
y_t			2.2442 (0.3485)***
rpx_t		0.2732 (0.3745)	-
rpm_{t-1}			0.2026 (0.1959)
Instruments		-	c_t ; i_t ; x_t
R^2		0.61	0.79
Tests			
		Exports (OLS)	Imports (2SLS)
Heteroskedasticity (White)	χ2	2.0334	0.2902
	p value	0.8445	0.7717
Autocorrelation (LM)	χ2	2.7431	0.0450
	p value	0.1171	0.8351
Hausman (Endogeneity of y_t)	χ2	-	19.4437
	p value	-	1.04e-005
Sargan (Validity of instruments)	χ2	-	3.7564
	p value	-	0.1530
F (weak instruments) #		-	95.6586

Source: Author's elaboration using Gretl's output.

Notes: *** Coefficient statistically significant at the level of 1%.

A statistic greater than 10 indicates that the instruments are not weak and consequently, the coefficients are not biased

Appendix 4

Table. C: Augmented Dickey Fuller test (ADF)

Variable		Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17
Test statistic	x_t	-4.0110	-3.5380	-4.3659	-4.0406	-4.7660	-5.8340	-3.1628	-4.9491	-5.3964	-4.0347	-4.3248	-3.6308	-10.5122	-4.6014	-3.5763	-4.7428	-6.7447
	m_t	-2.3774	-6.3206	-2.4830	-4.3562	-3.7550	-2.5503	-5.4031	-6.4167	-6.8557	-2.5301	-3.6720	-5.0628	-5.9401	-4.0472	-3.9099	-5.7111	-5.7901
	rpx_t	-6.5142	-4.8253	-4.1575	-5.8902	-6.0054	-6.7253	-2.1242	-6.2374	-5.6504	-4.2653	-26.2188	-2.7425	-4.1910	-5.3544	-3.8719	-4.6159	-5.9480
	rpm_t	-17.1176	-4.4128	-4.4038	-6.6943	-4.6373	-4.2687	-2.9494	-4.2425	-7.5385	-3.5992	-4.0615	-10.0942	-6.2241	-4.0005	-5.8760	-5.0405	-6.6434
P value	x_t	0.0084	0.0354	0.0138	0.0079	0.0014	0.0001	0.0223	4.649e-005	1.831e-005	0.0066	0.0036	0.0273	6.757e-022	0.0010	0.0318	0.0006	1.587e-009
	m_t	0.0169	0.0004	0.0126	0.0025	0.0189	0.0104	2.71e-005	1.019e-007	1.871e-005	0.0147	0.0139	0.0036	1.621e-006	0.0074	0.0117	0.0010	0.0001
	rpx_t	3.841e-005	0.0013	0.0051	2.191e-007	0.0001	2.467e-005	0.0324	6.823e-005	7.709e-006	0.0041	4.024e-052	0.0089	0.0007	0.0004	0.0092	4.497e-006	1.551e-006
	rpm_t	4.63e-041	0.0001	0.0001	1.013e-010	0.0001	2.091e-005	0.0031	0.0006	1.07e-011	0.0161	0.0245	3.545e-020	4.663e-006	0.0014	0.0008	0.0038	2.931e-005

Source: Author's elaboration using Gretl's output.

Notes: The number 1, 2, 3…k in the variable designation corresponds to the group 1, 2, 3…k:

Regression *without constant* and *without trend* for $m1_t$; m3t; rpm2t; $rpm3_t$; $rpm4_t$; $m6_t$; $rpm6_t$; $rpx7_t$; $rpm7_t$; $x8_t$; $x9_t$; $m10_t$; $rpx12_t$; $rpm13_t$ e $rpx16_t$.

Regression *with constant* and *without trend* for $rpx1_t$; $rpm1_t$; $rpx2_t$; $rpx3_t$; $x4_t$; $rpx4_t$; $x5_t$; $rpx5_t$; $rpm5_t$; $x6_t$; $rpx6_t$; $x7_t$; $rpx8_t$; $rpm8_t$; $m9_t$; $rpm9_t$; $x10_t$; $rpx10_t$; $rpm10_t$; $x11_t$; $m11_t$; $rpx11_t$; $rpx13_t$; $rpx14_t$; $rpm14_t$; $rpx15_t$; $x17_t$; $m17_t$ e $rpm17_t$.

Regression *with constant* and *with trend* for $x1_t$; $x2_t$; $m2_t$; $x3_t$; $m4_t$; $m5_t$; $m7_t$; $m8_t$; $rpx9_t$; $rpm11_t$; $x12_t$; $m12_t$; $rpm12_t$; $x13_t$; $m13_t$; $x14_t$; $m14_t$; $x15_t$; $m15_t$; $rpm15_t$; $x16_t$; $m16_t$; $rpm16_t$ e $rpx17_t$.

0 lags for $x1_t$; $m1_t$; $rpx1_t$; $rpm1_t$; $x2_t$; $rpx2_t$; $rpm2_t$; $x3_t$; m3t; $rpx3_t$; $rpm3_t$; $m4_t$; $rpx4_t$; $rpm4_t$; $x5_t$; $m5_t$; $rpx5_t$; $x6_t$; $m6_t$; $rpx6_t$; $rpm6_t$; $x7_t$; $rpx7_t$; $x8_t$; $m8_t$; $rpx8_t$; $rpm8_t$; $x9_t$; $m9_t$; $rpx9_t$; $x10_t$; $rpx10_t$; $rpm10_t$; $x11_t$; $m11_t$; $rpx11_t$; $rpm11_t$; $x12_t$; $rpx12_t$; $rpm12_t$; $x13_t$; $m13_t$; $rpx13_t$; $rpm13_t$; $x14_t$; $m14_t$; $rpx14_t$; $rpm14_t$; $rpx15_t$; $rpm15_t$; $x16_t$; $m16_t$; $rpx16_t$; $rpm16_t$; $x17_t$; $m17_t$; $rpx17_t$ e $rpm17_t$.

1 lag for $m2_t$; $rpm7_t$; $rpm9_t$; $m10_t$; $x15_t$; $m15_t$. **2 lags for** $x4_t$ e $m12_t$. **3 lags for** $rpm5_t$ e $m7_t$.

Appendix 5

Table. D: Kwiatkowski, Phillips, Schmidt and Shin Test (KPSS)

Variable		Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17
Statistical test	x_t	0.0816	0.0553	0.0718	0.2432	0.2511	0.2147	0.1188	0.0736	0.3199	0.2169	0.1630	0.0971	0.0596	0.0564	0.1224	0.0803	0.1580
	m_t	0.1270	0.1118	0.1177	0.1637	0.0753	0.1299	0.1542	0.0879	0.1847	0.1728	0.2028	0.0817	0.0903	0.0630	0.0766	0.1224	0.3755
	rpx_t	0.1195	0.2027	0.0707	0.112	0.0802	0.1247	0.1364	0.1633	0.0709	0.1114	0.1346	0.1995	0.2250	0.0743	0.2254	0.1351	0.1096
	rpm_t	0.1047	0.1099	0.0788	0.1205	0.1497	0.0836	0.2009	0.1526	0.2176	0.1858	0.0981	0.0672	0.1343	0.0891	0.0868	0.1873	0.2604
Critical value at 1%	x_t	0.206	0.206	0.206	0.685	0.694	0.694	0.694	0.694	0.694	0.694	0.694	0.205	0.206	0.206	0.205	0.206	0.694
	m_t	0.694	0.205	0.694	0.206	0.206	0.694	0.204	0.206	0.694	0.692	0.694	0.206	0.206	0.206	0.205	0.206	0.694
	rpx_t	0.694	0.694	0.694	0.694	0.694	0.694	0.692	0.694	0.206	0.694	0.694	0.694	0.694	0.694	0.694	0.694	0.206
	rpm_t	0.694	0.694	0.692	0.694	0.685	0.694	0.694	0.694	0.692	0.694	0.206	0.206	0.694	0.694	0.206	0.206	0.694

Source: Author's elaboration using Gretl's output.

Appendix 6

Table. E: Estimation results of demand functions for export by ordinary least squares method (OLS)

Variable	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17
Constant	5.497 (2.872)*	6.620 (3.394)*	5.593 (13.585)	0.078 (3.087)	4.878 (2.647)*	9.622 (4.017) **	-0.787 (3.7480)	4.147 (1.982)*	-1.331 (1.472)	0.805 (2,579)	45.375 (79.147)	-2.884 (1.853)	-0.911 (3.860)	-2.346 (1.894)	1.804 (3.386)	2.166 (4.065)	8.607 (1931)***
z_t	2.955 (1.460)*	2.106 (0.466)***	0.070 (5.477)	3.454 (1.371)**	2.844 (0.632)***		4.249 (1.557)**		2.289 (0.411)***			5.234 (0.799) ***	5.557 (1.602) ***	3.721 (0.781)***	2.781 (0.745)***		
z_{t-1}										1.239 (1.302)							1.634 (0.813)*
z_{t-3}											1.044 (31.107)					2.518 (0.964)**	
$z_t - z_{t-1}$						6.758 (1.830)***		1.985 (0.653)***									
$rpx1_{t-1}$	-0.065 (0.011)***																
$rpx2_t$		-0.401 (0.085) ***															
$rpx3_{t-3}$			-0.116 (0.159)														
$rpx4_t$				-0.037 (0.088)													
$rpx5_t$					-0.095 (0.059)												
$rpx6_t$						-0.480 (0.142)***											
$rpx7_{t-1}$							-0.112 (0.115)										
$rpx8_t$								-0.264 (0.212)									
$rpx9_t$									-0.131 (0.212)								
$rpx10_t$										-1.179 (0,344)***							

Table. E: Estimation results of demand functions for export by ordinary least squares method (OLS) - continuation

Variable	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17
$rpx11_t$											-0.002 (0.146)						
$rpx12_t$												-0.419 (0.238)*					
$rpx13_{t-1}$													-0.403 (0.246)				
$rpx14_{t-1}$														-0.049 (0.100)			
$rpx15_{t-2}$															-0.008 (0.153)		
$rpx16_t$																-0.467 (0.120)***	
$rpx17_t$																	-0.480 (0.124) ***
R^2	0,26	0,46	0.008	0.28	0.17	0,59	0.38	0.15	0.25	0.61	0,00008	0.48	0.48	0.60	0.13	0.52	0.48

Source: Author's elaboration using Gretl's output.

Notes: * Coefficient statistically significant at the level of 10%;** Coefficient statistically significant at the level of 5%; *** Coefficient statistically significant at the level of 1%

For each variable is associated with their corresponding standard deviation and this is within ( ).

Table. E: Estimation results of demand functions for export by ordinary least squares method (OLS) - continuation

Tests		Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17
Heteroskedasticity (White)	χ2	1.623	5.074	5.471	2.900	2.908	5.693	4.302	0.979	5.662		3.698	4.619	4.679	5.732	2.382	5.423	0.992
	p value	0.898	0.407	0.361	0.715	0.714	0.337	0.507	0.964	0.340		0.594	0.464	0.456	0.333	0.794	0.366	0.963
Autocorrelation (LM)	χ2	0.948	0.210	0.119	0.00005	0.315	0.717	0.007	0.001	1.870		0.046	0.026	2.112	1.242	1.450	0.300	0.613
	p value	0.346	0.653	0.735	0.995	0.582	0.411	0.935	0.974	0.190		0.833	0.875	0.167	0.283	0.248	0.593	0.446

Source: Author's elaboration using Gretl's output.

Table. F: Estimation results of demand functions for imports by two-stage least squares method (2SLS)

Variable	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17
Constant	-2.249 (2.467)	2.296 (1.807)	11.547 (5.943)*	3.209 (1.145)***	1.457 (1.539)	1.148 (1.930)	7.695 (4.146)*	-1.260 (0.691)	-2.894 (2.178)	3.383 (1.710) **	13.751 (16.716)	-0.933 (3.263)	3.933 (2.152) *	2.237 (1.988)	-3.979 (2.545)	-0.217 (1.663)	9.365 (4.069) **
y_t				0.689 (0.350)**		0.522 (0.732)	3.141 (1.193)***				0.937 (1.857)			1.494 (0.757)**	5.139 (0.953)***	1.689 (0.626)***	
y_{t-1}	3.732 (1.612)**	2.578 (0.686)***			2.397 (0.901)***			3.847 (1.016)***	2.8157 (0.934)***	2.957 (0.844)***		2.844 (1.377)**					
$y_t - y_{t-1}$			7.095 (3.622)*										5.458 (1.196)***				4.264 (1.535)***
$rpm1_t$	-0.016 (0.016)																
$rpm2_t$		0.947 (0.127)***															
$rpm3_t$			0.421 (0.185)**														
$rpm4_t$				0.230 (0.091)**													
$rpm5_t$					0.003 (0.037)												
$rpm6_t$						0.404 (0.238)*											
$rpm7_t$							1.226 (0.152)***										
$rpm8_t$								0.335 (0.190)*									
$rpm9_t - rpm9_{t-1}$									1.057 (0.358)***								
$rpm10_t$										0.696 (0.087)***							

Table. F: Estimation results of demand functions for imports by two-stage least squares method (2SLS) - continuation

Variable	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17
$rpm11_t$											0.121 (0.087)						
$rpm12_t$												1.783 (0.232)***					
$rpm13_t$- $rpm13_{t-1}$													0.503 (0.170)***				
rpm14t														0.973 (0.133)***			
rpm15t															0.549 (0.270)**		
rpm16t																0.549 (0.153)***	
$rpm17_t$- $rpm17_{t-1}$																	0.583 (0.225)***
R^2	0.08	0.67	0.03	0.31	0.08	0.18	0.77	0.15	0,38	0.81	0.09	0.83	0.33	0.77	0.65	0.34	0.34
Instruments	xt ; ct ; it ; rpm1t	xt ; ct ; rpm2t	xt ; ct ; rpm3t	ct ; rpm4t ; m4t-1	ct ; it ; rpm5t	ct ; it ; rpm6t	ct ; it ; rpm7t	ct ; it ; rpm8t	ct ; it ; rpm9t - rpm9t-1	xt ; it ; rpm10t	ct ; it ; rpm11t	ct ; it ; rpm12t	xt ; it ; rpm13t - rpm13t-1 ; m13t-1	xt ; ct ; rpm14t	xt ; ct ; rpm15t	ct ; it ; rpm16t	xt ; ct ; rpm17t - rpm17t-1

Source: Author's elaboration using Gretl's output.

Notes: * Coefficient statistically significant at the level of 10%; ** Coefficient statistically significant at the level of 10%; *** Coefficient statistically significant at the level of 1%

Table. F: Estimation results of demand functions for imports by two-stage least squares method (2SLS) - continuation

Tests		Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11	Group 12	Group 13	Group 14	Group 15	Group 16	Group 17
Heteroskedasticity (White)	χ2	0.830	0.329	0.028	1.369	0.732	1.463	0.774	0.566	1.638	0.199	0.299	0.503	0.245	0.813	0.786	0.915	1.869
	valor p	0.406	0.742	0.977	0.171	0.440	0.143	0.439	0.571	0.101	0.842	0.765	0.615	0.245	0.416	0.432	0.360	0.062
Autocorrelation (LM)	χ2	0.622	0.514	0.106	1.027	0.879	0.052	0.455	0.024	0.252	1.689	1.634	0.526	1.865	0.317	1.378	0.191	0.038
	valor p	0.444	0.485	0.750	0.328	0.364	0.822	0.510	0.880	0.624	0.215	0.219	0.480	0.194	0.581	0.258	0.664	0.644
Hausman (endogeneity of *y*)	χ2	0.380	6.890	15.796	6.980	4.982	8.406	5.080	34.708	4.346	5.498	8.433	4.982	13.916	6.227	5.399	4.218	4.250
	valor p	0.004	0.009	0.00007	0.008	0.026	0.004	0.024	3.8e-009	0.037	0.019	0.004	0.026	0.0001	0.013	0.020	0.040	0.039
Sargan (Validity of instruments)	χ2	4.772	0.019	0.074	1.059	0.064	0.277	0.0004	0.051	0.364	1.821	0.025	0.095	2.286	3.545	0.003	0.459	1.048
	valor p	0.092	0.890	0.786	0.304	0.801	0.599	0.983	0.822	0.546	0.177	0.875	0.758	0.319	0.060	0.957	0.498	0.306
F (weak instruments) #		14.392	10.804	15.062	114.93	17.193	211.56	170.61	27.024	23.157	10.574	161.90	17.81	24.72	137.58	131.03	180.02	20.819

Source: Author's elaboration using Gretl's output.

Notes: # A statistical greater than 10 indicates that the instruments are not weak and consequently, the coefficients are not biased

Appendix 7

Table. G: Relative average weight of each group in total exports and imports

Group	Exports (%)	Imports (%)
1	4.267	8.766
2	3.838	3.970
3	2.129	3.767
4	4.421	9.404
5	5.433	5.768
6	0.361	1.308
7	4.054	1.179
8	4.920	3.042
9	4.707	4.332
10	10.973	3.484
11	5.355	0.971
12	4.980	1.990
13	7.127	8.750
14	16.710	21.542
15	15.326	15.752
16	1.021	2.330
17	4.376	3.647

Source: Author's elaboration with data provided by Instituto Nacional de Estatística, *Comércio Internacional de Bens* (may, 2015)

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