

Thirlwall's Law and the Long-Term Equilibrium Growth Rate: an Application for Brazil (1951-2006)

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***Abstract:** This paper uses the balance-of-payments constrained theory to estimate the determinants of the long run rate of growth in Brazil. Contrary to the tests of the theory for the country present in the literature, the paper using a methodology to test the long-run relationship between actual growth rates and those predicted by Thirlwall's Law extended to include capital flows using a VAR model. The regressions' results, apart from providing renewed support for the thesis the country's growth rate has been constrained by the balance-of-payments, allows us to argue that Thirlwall's Law is associated with a notion of long run equilibrium rate of growth which is distinct from that of mainstream economics.*

Key Words: balance-of-payments, Brazil, Thirlwall's law, growth.

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1. Introduction

Thirlwall's Law and balance-of-payments constrained growth models (BOP) are about to reach their thirtieth anniversary. In spite of its vintage, the models remain remarkably popular. In the last decade a new wave of applications, particularly for developing countries, could be seen reflecting both the contemporaneity of the law as well as new developments of the theory to extend the original model to incorporate capital flows and various limits to current account deficit. This movement is intimately related to the increase of balance-of-payments crises that ensued from the commitment to liberal structural reforms carried out in many developing countries, particularly in South America. Amongst developing countries Brazil is an example of both the alignment to the reforms and of the macroeconomic instability associated particularly to trade and financial liberalisations. The increasing frustration caused by the inability to produce higher rates of output growth rates kept BOP models very much alive, as will be seen below.

From the exchange rate crisis of 1999 onwards, however, the commitment to the liberal reforms in the country subsided, particular after 2003, with the election of Lula da Silva as the new president. The liberal vocabulary left the political rhetoric much faster than its influence on the praxis of the economic policy. The changes were however, followed by a significant improvement in the external accounts once the turmoil caused by the political changes faded out. The end result has been higher rates of GDP growth which, despite of being short of spectacular, are in sharp contrast to those from the preceding twenty years.

In this paper we revisit Thirlwall's Law for Brazil, testing its validity from 1951 to 2006. The objective of the exercise is twofold. First, we provide new estimates seven years after the adoption of a floating exchange rate. During this time a significant change could be observed in the rate of growth of exports, in the management of the foreign debt, and in the monetary policy as a consequence, all of which have been allowing more breadth to the increase of economic activity.

The second aim of the paper is to build on previous tests of the law by applying a technique which allows us to work with a notion of long-term equilibrium which is peculiar to models of Kaldorian inspiration. The latest estimations apply cointegration techniques to estimate either the demand elasticity for imports, i.e., regressing imports, output and terms of

trade, or the implicit demand elasticity for imports, by regressing the rate of output and the rate of exports. The results are compared with the theoretical rate of growth consistent with the balance-of-payments equilibrium, usually by means of a hypothesis test. In our view, this method, although being best for testing the model's basic assumption, sub-utilises the full extent of the notion of cointegration and of vector auto-regressions (VAR) in particular. And the long run relationship between observed growth rates and those predicted by Thirlwall's Law remains rigorously untested. This is exactly the thesis advocated by Alonso (1999). As an alternative, Alonso proposes the estimation of a long series of growth rates consistent with balance-of-payments equilibrium and testing if this series and that of actual growth rates cointegrate. If this is the case, the economic interpretation is that there is a stable long-run equilibrium relationship around which predicted and actual growth rates fluctuate.

The paper is divided in four sections, apart from this introduction. Section 2 briefly presents Thirlwall's Law and its extension to account for capital flows. Section 3 presents the estimation strategies and evidence. Section 4 presents the methodology and estimation results and Section 5 concludes.

2. Balance-of-payments constrained growth model

(a) *The standard model*

The BOP model was formalised by Thirlwall (1979), adding an upper bound to Dixon and Thirlwall's (1975) cumulative causation model. The model and its subsequent extensions is composed by three equations:

$$x = \eta(p_d - p_f - e) + \varepsilon z \quad (1)$$

$$m = \psi(p + e - p_d) + \pi y \quad (2)$$

$$(m + p_f = p_d + x), \quad (3)$$

Equations (1) and (2) represent the traditional export and import demand functions, respectively, in which x represents exports, m represents imports, p_d and p_f are domestic and foreign prices, e is the exchange rate, z is the rate of growth of the income of the rest of the world, y is the rate of growth of real output, η is the price elasticity of demand for exports, ψ is the price elasticity of imports, ε is the income elasticity of demand for exports and π is the income elasticity of demand for imports. Equation (3) is the balance-of-payments equilibrium condition.

Solving the system of equations (1) to (3) gives us the rate of GDP growth consistent with the balance-of-payments equilibrium can be written as:

$$y_t = \frac{(1 + \eta + \psi)(p_{dt} - p_{ft} - e) + \varepsilon z_t}{\pi} \quad (4)$$

If relative prices do not significantly affect the balance-of-payments equilibrium growth rate, i.e., relative prices are neutral in the long-run, and if deficits cannot be financed by capital flows, equation (4) can be simplified to yield:

$$y_t = \frac{\varepsilon}{\pi} z_t \quad (5)$$

or

$$y_t = \frac{x_t}{\pi}, \quad (6)$$

which became known in the literature as Thirlwall's Law of growth. In that case, the equilibrium growth rate is determined by the rate of growth of exports divided by the income elasticity of demand for imports.

(b) Allowing for capital flows

Extensions of the original model were carried out with the objective of incorporating the impact of capital flows on the equilibrium growth rate. Such extensions involve the modification of equation (3) to add capital flows and the ratio of exports on total receipts. The first modified version of the model was carried out by Thirlwall and Hussain (1982). Analysing the post-war performance of developing countries, the authors argue that some countries were able to consistently increase current account deficits, enabling growth rates that were higher than those predicted by the canonical balance-of-payments constrained model.

The extended model departs from the same equations from the original model, adding the new balance-of-payments identity:

$$\theta(p_{dt} + x_t) + (1 - \theta) f_t = m_t + p_{ft} + e \quad (7)$$

where f_t is the rate of growth of net capital flows, and θ and $(1-\theta)$ are the shares of exports and capital flows on total receipts, defined as the sum of exports and capital flows, or $(X + F)$. Solving system we obtain:

$$y_{TH} = \frac{(\theta \eta + \psi)(p_{dt} - e_t - p_{ft}) + \theta \varepsilon z_t + (1 - \theta)(f_t - p_{dt})}{\pi} \quad (8)$$

Assuming once more that in the long-run the terms of trade remain constant, equation (7) becomes:

$$y_{TH}^* = \frac{\theta x_t + (1 - \theta)(f_t - p_{dt})}{\pi} \quad (9)$$

The new rate of growth consistent with the balance-of-payments equilibrium is a weighted sum growth of exports and the rate of growth of real capital flows, divided by the

income elasticity of demand for imports. It can be seen that if there is no initial disequilibrium, i.e. $\theta = 1$, y_{TH}^* becomes the original version of Thirlwall's Law.

A second generation of extensions of the original model aimed at establishing limits to the accumulation of deficits. According to McCombie and Thirlwall (1997), the notion that open economies can always finance balance-of-payments deficits ignores the limitations imposed by the increasing pressure of the stock of debts and the investor's unwillingness to finance countries running balance-of-payments deficits regardless of any interest rate differential. Using a more detailed condition of balance-of-payments equilibrium, the authors show that if the trade balance is not in equilibrium, the growth of real income must be higher than the rate of real interest. If this condition is not fulfilled, the debt to GDP ratio will increase. In this case, increasing amounts of capital inflows will be required to maintain the same level of equilibrium growth rates and a strategy to finance external accounts with the help of capital flows is unfeasible in practice.

Another modification of the model can be found in Moreno-Brid (1998-9), in which the author includes a condition to warrant a sustainable long-term trajectory of foreign debt. The solution involves the extension of the balance-of-payment equilibrium equation to include a constant current account deficit to GDP ratio, given by:

$$B = \frac{(P_f E M - P_d X)}{Y} \quad \text{or} \quad B = \frac{(M_d - X)}{Y} \quad (10)$$

in which M_d represents the import bill in local currency. It is possible to derive the long-term balance-of-payments equilibrium condition by differentiating both sides of the equation and equating to zero:

$$\begin{aligned} dB = 0 &= (M_d/Y)m - (X/Y)x - [(M_d - X)/Y]y + (M/Y)(p_f + e - p_d) \\ &= [(M_d - X)/Y][\Theta m - (\Theta - 1)x - \Theta((p_f + e - p_d) - y)] \end{aligned} \quad (11)$$

where $\Theta > 1$ is the current account deficit $[(P_f E M) / (P_f E M - P_d X)]$. If the equilibrium condition is not fulfilled and $B \neq 0$, equation (11) can be simplified through the division of both sides by B , yielding:

$$dB/B = [m\Theta - (\Theta - 1)x - \Theta(p_f + e - p_d) - y] \quad (12)$$

Hence, equations (12) and Θ can be used, together with the dynamic import and export functions to obtain the balance-of-payments equilibrium growth rate:

$$y_{MB1} = \frac{(\Theta(\eta + \psi + 1) - \eta)(p_{dt} - e_t - p_{ft}) + (\Theta - 1)\varepsilon z_t}{\pi\Theta - 1} \quad (13)$$

The previous models introduced significant improvements in relation to Thirlwall's original model by extending the balance-of-payments equilibrium identity to include capital flows. However, Moreno-Brid later acknowledged that the identity only warrants the equilibrium of debits and credits, without any reference to the sustainability of the foreign debt accumulation. In a later paper, the author expanded his (1998-9) model to account for interest payments, which is another key component of developing countries' frequent balance-of payments crisis (Moreno-Brid, 2003).¹

Moreno-Brid's (2003) further modifies the balance-of-payments equilibrium condition to allow:

$$\theta_1(p_{dt} + x_t) - \theta_2(p_{dt} + i_t) + (1 - \theta_1 + \theta_2)(p_{dt} + f_t) = m_t + p_{ft} \quad (14)$$

where i_t represents the rate of growth of real net interest payments abroad.

Apart from the inclusion of interest payments, θ_1 now represents the proportion of exports covered by imports and θ_2 the proportion of the interest payments covered by imports. The negative sign of the interest payments term implies that the country under consideration is a net debtor. In addition, for ease of exposition, the exchange rate is assumed to be fixed and equal to one. The current account deficit to income ratio is assumed to be constant, in order to prevent an explosive trajectory of the external debt. Hence, $F/Y = k$ or, in growth rates:

$$f_t + p_d = y_t + p_d \quad (15)$$

Solving the system given by equations (1), (2) and (14), the new equilibrium growth rate becomes:

¹ Barbosa-Filho (2001) introduced another alternative to account for interest payments. The author modifies Moreno-Brid's (1998-99) model to tackle a potential source of instability of that model, by allowing θ to depend on the rate of GDP growth.

$$y_{MB2} = \frac{\theta_1 \varepsilon z_t - \theta_2 i_t + (\theta_1 \eta + \psi + 1)(p_{dt} - p_{ft})}{\pi - (1 - \theta_1 + \theta_2)} \quad (16)$$

Equation (16) represents the new output growth rate consistent with the balance-of-payments equilibrium, including the impact of interest payments abroad. As the author points out, the notion of equilibrium in this case is related to the maintenance of a constant current account deficit to total output ratio, but other conditions such as the maintenance of constant interest rates would also be valid.² Once more, if terms of trade are neutral in the long-run, the equation can be reduced to become:

$$y_{MB2} = \frac{\theta_1 x_t - \theta_2 i_t}{\pi - (1 - \theta_1 + \theta_2)} \quad (17)$$

If interest payments are increasing but the current account deficit is zero, equation (2.52) yields:

$$y_{MB2} = \frac{\theta_1 x_t - (1 - \theta_1) i_t}{\pi} \quad (18)$$

3. Estimation strategies and evidence

(a) Testing the Law

Since its original formalisation by Thirlwall (1979), the balance-of-payments constrained growth model has been widely tested for a varied sample of developed and developing countries as well as for several individual countries, with the development of new time-series estimation techniques. These estimations of Thirlwall's Law, have been carried out using many different methods.³ Broadly speaking, there are two main strategies to test how well Thirlwall's Law can predict the actual rate of GDP growth of a country. The first is to estimate the full equation of the balance-of-payments constrained growth rate or one of the extensions. In this case, the estimation is carried out using time-series data for

² See Moreno-Brid (2003), footnote 6.

³ A comprehensive review of the estimation strategies and associated issues can be found in McCombie and Thirlwall (1994; 1997a; 1997b). McCombie (1997) reviews the model in the light of cointegration techniques. McCombie and Roberts (2002) and McCombie and Thirlwall (2004) offer reviews of recent tests and extensions of the model.

individual countries. The hypotheses behind the model are tested by assessing the size and the significance of the estimated coefficient for the world income growth (ε) and for the terms of trade. The model is confirmed if (ε) is statistically significant and if the coefficient for terms of trade is very low or insignificant, the country under analysis being balance-of-payments constrained.⁴

According to McCombie (1997) this method has the advantage of allowing for testing of the law for individual countries using time-series data. However, he argues that this strategy tests the model in the short-run, whereas imports and exports growth may diverge from the rates consistent with the balance-of-payments equilibrium, due, for instance, to domestic income growing beyond the level compatible with the external accounts equilibrium. In this case, the debt can be financed by capital flows. Over a longer period, however, imports and exports growth rates should converge to a level consistent with the balance-of-payments equilibrium. This short-term dynamic divergence from the long-term pattern predicted by the model and may lead to a failure to estimate the equation, even though the law holds in the long run.⁵

The second method to test Thirlwall's law has four variations and consists in testing how close the predicted growth rate (y^*) is to the actual growth rates (y_r). The first consists in calculating Spearman correlation tests between (y^*) and (y_r). A second early form of testing the model consisted in calculating the average deviation of (y_r) in relation to (y^*) (Thirlwall, 1979).⁶ A third test originally introduced by McGregor and Swales (1985) involves regressing (y_r) on (y^*), using pooled data and testing whether the intercept is not different from zero and the slope coefficient is not different from unity. However, there are two limitations with this method. First, the tests as specified by McGregor and Swales suffer from errors in the variables' problem, given that (y^*) is estimated using regression and thus has an associated standard error. In this case, the correct specifications for statistical reasons, and not for an implied *a priori* causality, is to regress (y^*) on (y_r). This is, however, only a partial solution. A second and potentially more serious problem stems from biased samples of countries included in the pooled regression, which can lead to the rejection of the balance-of-

⁴ See, for instance, Atesoglu (1993, 1994) and Alonso (1999).

⁵ One way to avoid the influence of short-run fluctuation can be found in Atesoglu (1993-4). The author uses moving averages to smooth the series and successfully test the model.

⁶ Thirlwall (1979) has shown that the deviation is usually less than one percentage point. Other authors, using different groups of countries and several time periods, found similarly low deviations. See, for instance, Bairam and Dempster (1991), Andersen (1993), Atesoglu (1993a, 1994a).

payments constrained hypothesis. The inclusion of a notorious outlier such as Japan in the sample may lead to the confirmation of the null hypothesis and to the rejection of the balance-of-payments model to all countries being analysed. Finally, the surpluses and deficits of the balance-of-payments from the countries in the sample may not balance out, leading to a bias for or against the model (McCombie, 1997).⁷

To avoid the shortcomings of regressing (y^*) on (y_r) , McCombie (1989) proposed a fourth method to test the model. The test, which became the standard practice, consists in estimating the income elasticity of demand for imports using a standard import function and testing whether the estimated value (π^*) differs from the hypothetical value consistent with the equilibrium of the balance-of-payments given by Thirlwall's Law (π_H) . The law is refuted if the test shows that both elasticities are significantly different from each other.⁸

The proliferation of the estimation of import demand functions to test the law using time-series occurred *pari passu* with the development of cointegration techniques. These developments raised questions about the stationarity of most series used in macroeconomics studies. If series are not stationary and/or are not cointegrated, the estimated coefficients from regressions will be spurious. Bairam (1993) showed that for a number of developing countries the series used are I(1), implying that the estimation of the import functions should be carried out in first differences. In addition, authors such as Andersen (1993) and Alonso (1999) have argued that the estimation in first differences leads to the loss of long-run information contained in the level variables. In this case, the suggested solution is the use of an error correction model to incorporate the impact of the short-run dynamics on the long-run coefficients.⁹

With this concern in mind, Alonso (1999) estimated Thirlwall's Law for Spain from 1960 to 1994. According to the author, the traditional strategies used to test the validity of the law suffer from a series of shortcomings that can be properly assessed using cointegration techniques. The first change proposed is to extend the standard export demand equation to account for changes in the composition of exported goods that take place over the years

⁷ McGregor and Swales (1985) applied the proposed test and rejected Thirlwall's Law for the reasons pointed out by McCombie (1989).

⁸ Some examples of applications of this test are Blecker (1992), Anderson (1993), Bairam (1993), McCombie (1997) and Perraton (2003).

⁹ McCombie disagrees with this view and argues: "the law pertains to long-run equilibrium growth rates and not to the determinants of the equilibrium levels of economic activity. Just as tests of the law mostly use growth rates and not levels, so the law is, strictly speaking, also an explanation of differing growth rates, and not levels, of income" (McCombie, 1997, p. 355).

because of changes in the productive structure. Hence, a term to measure technological payments was included in the estimated function. The second point of contention with other studies is the choice between using the variables in (log) levels or in growth rates. For the author, the long-term relationship between the variables of the trade functions should be estimated using levels, given that growth rates depend on the initial level of the variables. In this sense, he argues in favour of using cointegration to estimate the functions.

The third point assessed is the common assumption that terms of trade are neutral in the long run. According to Alonso, for many countries, prices do have an influence on the rate of growth, even if only a small one. However, if this is the case, it does not mean necessarily that the external accounts do not restrict the rate of growth. For the author, what is important is to show that the evolution of income, not prices, determines the adjustments in the balance of payments (Alonso, 1999, p. 250).

The alternative method involves calculating the rate of growth consistent with the balance-of-payments equilibrium, including terms of trade, and tests whether this series and the series of actual growth rates cointegrate. The focus of this method is strictly on the long-term relationship between both series, not on the short-term dynamic between both variables. Moreover, if the estimated coefficient is not statistically different from unity it means that both variables follow the same long-term trend. For Alonso, the economic interpretation of this result would be the existence of a long-term equilibrium growth path, which is given by the balance-of-payments constraints, around which the actual growth rates fluctuate.

The results of Alonso's regressions of (y_r) on (y^*) showed that the slope coefficient was not significantly different from one. The author then proceeded to test his proposed solution fitting a VAR using the log level of the GDP $(\ln Y_r)$, and that estimated using Thirlwall's Law extended to capital flows and terms of trade on $(\ln Y^*)$. The regressions yielded a slope coefficient of 0.90, which according to Wald's hypothesis test is not significantly different from one. The author concluded by arguing that the results confirmed the existence of a long-run relationship between $(\ln Y_r)$ and $(\ln Y^*)$, supporting the thesis that the Spanish economy was subject to an external constraint in the period considered.

(b) Tests for Brazil

To our knowledge, the first effort to test the balance-of-payments constrained growth model for Brazil is that of Thirlwall and Hussain (1982). Here, the authors test the first version of the model to extend the balance-of-payments equilibrium condition to account for the effects of the growth of capital flows on the external constraint. The model was tested for twenty developing countries from 1951 to 1966 or from 1951 to 1969, depending on the case. Specifically for Brazil, the authors estimated an income elasticity of demand for imports of 2.05. The authors' results showed that capital flows significantly relaxed the balance-of-payments constraint in the period.

Another application of Thirlwall's Law specifically to the Brazilian case can be found in Bertola et al. (2002). The study tests the model for a broad period that extends from 1890 to 1970. This time span covers two very distinct phases of Brazilian economic history. The first is an export-led growth period, from 1890 to 1930 and the second, 1930-1970, covers a large part of the import-substitution industrialisation period. Given that the model used does not allow for capital flows, the study ends in 1970. The authors' analysis revealed that the influence of the terms of trade was negligible in the long run, and the world income effect on the growth rate was strongly exogenous, confirming Thirlwall's Law. A short-run analysis was also conducted using an error correction model, which revealed that balance-of-payments constraints played a key role in short-run fluctuations. Almost half of real GDP changes in the short run could be attributed to adjustment towards the long-run solution.

Jayme Jr (2003) applied Thirlwall's Law from 1955 to 1998. The study used the same econometric approach as Bertola et al. (2002), i.e., cointegration and a vector correction model, but tested an expanded version of Thirlwall's Law by incorporating the influence of capital flows. The study shows that Thirlwall's Law holds in the long-run for the Brazilian economy. The rate of GDP growth cointegrates with that of exports for the period in question. The implicit income elasticity of demand for imports is 2.38, which is consistent with other studies. The author also used a VEC model to further investigate the causal relation between GDP and exports. The results obtained for the short run found inverse causality between GDP and exports, which contradicts the predictions of Thirlwall's model. Nevertheless, for Jayme Jr, this result is consistent with Brazilian history. This inverse

causality can be explained by terms of trade effects that were particularly important after 1981, when the exchange rate and fiscal incentives were used to promote exports. The short-term analysis does not offset the main finding of the study.

Ferreira and Canuto (2003) also find evidence to support the balance-of-payments constrained growth model using Brazilian data using a different methodology. Applying an ARDL model from 1949 to 1999, the authors find a low income elasticity of demand for imports of 1.05, in line with Lopez and Cruz's (2000) findings. Ferreira and Canuto proceeded to re-estimate the import function using rolling regressions, but the function lost significance during the 1980s. As an alternative, the import function was estimated for selected sub-periods, which were then used to build a series of growth rates as predicted by the balance-of-payments model extended to capital flows. The authors proceeded to estimate the connection between actual and predicted growth rates using an ARDL and found a coefficient of 0.40.

In another study, this time carried out for a number of Latin American countries, Holland et al. (2004) estimate Thirlwall's Law to test how closely the model predicts the long-term growth rates of these countries. The results showed that, even though countries' growth rates deviated from that predicted by the model in periods of adjustments to external shocks, the balance-of-payments represented the main limiting factor to long-run economic growth. In the case of Brazil, the VAR estimation produced a long-term income elasticity of demand for imports of 2.16 from 1951 to 2000.

Another large test of Thirlwall's Law for developing countries was carried out by Perraton (2003). This study estimated import and export functions for 34 developing countries from 1973 to 1995 using error correction techniques. The regressions confirmed the balance-of-payments hypothesis for the vast majority of the countries. Specifically for Brazil, the estimated income elasticity of demand for imports was 1.77. The author's analysis, however, focused on the standard specification of the model, leaving room for further studies on the impact of capital flows during the period.

The results obtained by Holland et al. (2004) and by Perraton (2003) sharply contrast with those by (López & Cruz, 2000), particularly for Brazil. The authors found support for Thirlwall's Law through the estimation of a close relationship between output and exports growth, using a VAR. The estimation of an import demand function yielded a low income elasticity coefficient of 1.03, from 1965 to 1996. The authors also argue that results show that the terms of trade did affect external constraint during the period.

A more complete test of Thirlwall's Law can be found in a recent paper by Santos et al. (2005) and Carvalho (2007). The authors estimate a VAR using data from 1948 to 2004 and estimate a VAR and find a long-run demand elasticity for imports of 1.77. The authors use McCombie's method to test if the demand elasticity of exports implied by the standard (1.71) and Moreno-Brid's extended specifications (1.80) are statistically different from that obtained in the cointegration vector. The results showed that the null hypothesis that both implicit elasticities are equal to that estimated value.

4. Methodology and Results

In this section we proceed to test the balance-of-payments constrained growth model in the case of Brazil from 1951 to 2006. The methodology to estimate the demand for imports function will be similar to that of Santos et al. (2005). The function will be estimated using a VAR for the entire period. The next step will be assessing the validity of Thirlwall's Law using McCombie's (1997) method of testing whether the hypothetical values of the income elasticity of demand for imports differ statistically from the estimated value.

The estimation will differ from previous studies in two ways. First, we carry out a detailed analysis of four different possible variables to represent terms of trade in the import demand function. We test all four series for unit roots in the presence of structural breaks, following the methodology advanced by Perron (1989). Secondly, we use the statistical properties of cointegration to test the long-term relationship of actual growth rates and those estimated using Thirlwall's Law extended to capital flows and interest rate payments, following the methodology proposed by Alonso (1999). In this sense, and giving economic interpretation to the cointegration vector, there is no need for the two series to be the same, i.e., the estimated coefficient to be equal to one. A significant cointegration vector means that there is a stable long-run relationship between the series, and deviations from the stable path are due to short-run phenomena.

4.1 Equations

In this paper, we estimate the import function given by equation (3) above.¹⁰ Having estimated the demand elasticity for imports, the next step is to test whether it differs statistically from the implicit demand elasticity of imports consistent with the balance-of-payments equilibrium. Two hypothetical values will be tested, assuming the neutrality of terms of trade in the long term. The first is given by solving the standard specification of Thirlwall's Law, given by equation (6) above, for the income elasticity of demand for imports, yielding:

$$\pi_T = \frac{x_a}{y_a}, \quad (19)$$

where, the subscript a represents average growth rates from 1951 to 2006. The second hypothetical value follows Moreno-Brid's (2003) extended version that included the effects of capital flows and interest payments:

$$\pi_{MB2} = (1 - \theta_1 + \theta_2) + \frac{\theta_1 x_a - \theta_2 i_a}{y_a} \quad (20)$$

Finally, to apply the test proposed by Alonso (2003), a series of hypothetical growth rates was calculated using annual values of each variable, according to the equation:

$$y_{MB2t} = \frac{\theta_1 x_t - \theta_2 i_t}{\pi - (1 - \theta_1 + \theta_2)} \quad (21)$$

This series and the series with actual growth rates will be included in a VAR, to test whether a stable long-run relationship exists between them.

¹⁰ The estimation of the import demand used annual imports, published by the Brazilian Central Bank, and converted to local currency using the nominal exchange rate. The values were then deflated to constant prices of 2003 using a wholesale price index. The local income is the GDP measured by the Brazilian Bureau of Geography and Statistics (IBGE), deflated using GDP deflator index. The value of interest payments was also obtained from the Central Bank.

4.2 Estimation

The estimation of the import function as well as the tests of Thirlwall's Law were carried out taking into consideration the stationarity of the variables included in the models. The concern regarding the stationarity of variables was raised in the mid-1980s, after the realisation that many variables used in macroeconomic studies were characterised by non-constant means and variances. The problem of non-stationarity of many economic variables cast doubt on the use of OLS and other standard methods, given that the violation of the constant variance assumption could render spurious regressions and biased forecasts (Rao, 1994). Under these circumstances, the use of cointegration techniques became standard practice. According to the definition, two variables are cointegrated if there is at least one stationary vector resulting from a linear transformation, i.e., whose mean does not change systematically over time.¹¹

Apart from the better statistical properties of the estimators obtained using cointegration, the concept of cointegration also has theoretical implications, particularly when dynamic economic models are taken under consideration. In particular, the definition is linked with a concept of long-run equilibrium that is qualitatively distinct from that commonly used by economists. This point is stressed by Enders:

In a sense, the use of the term equilibrium is unfortunate because economic theorists and econometricians use the term in different ways. Economic theorists usually use the term to refer to an equality between desired and actual transactions. The econometric use of the term makes reference to a long-run relationship among nonstationary variables. Cointegration does not require that the long run relationship be generated by market forces or by the behavioural rules of individual (Enders, 2004, p. 322).

Hence, the interpretation of the results of a cointegration regression should be consistent with the underlying economic theory. This point was stressed by Rao (1994) and is central for Alonso's (1999) argument in favour of his method to test Thirlwall's Law. For Rao:

¹¹ Formally, two time series x_t and y_t are cointegrated of order d, b , where $d \geq b \geq 0$, if two conditions are met: a) x_t and y_t are integrated of order d ; b) A third series can be constructed by a linear combination of x_t and y_t , is integrated of order $d - b$. If the conditions above are met, series x_t and y_t can even grow at different rates, but the deviations from the long-run path (cointegration vector) will be stable (Charemza & Deadman, 1997).

While much of the existing neo and new classical theories use the equilibrium framework, it is generally believed that the Keynesian theory is based on the disequilibrium framework. This does not, however, imply that cointegration is useful only for the estimation of neo and new classical models. If a distinction is made between equilibrium as merely a state of rest and a state of rest which is an optimal state, then Keynesian economics can also be interpreted as equilibrium economics, albeit an equilibrium in which resources are under employed. Consequently the usefulness of cointegration techniques to the Keynesian models should not be underestimated (Rao, 1994, p. 3).

In the next section, we follow the estimation strategy suggested by Rao (1994) and Charemza and Deadman (1997), which, in turn, follow the Johansen approach, used for I(1) series. The strategy involves i) carrying out unit root tests for all variables; ii) finding the lag order of the VAR system; b) finding the rank order in order to determine the number of cointegration vectors and, finally, estimating the vector and the error correction terms.

4.3. Unit Roots

One of the most problematic variables in the estimation of import functions for the Brazilian economy is the terms of trade. Throughout the 1980s and early 1990s, the country was subject to an acute inflationary process as well as to a series of currency devaluations following balance-of-payments crisis. These factors, inflation and devaluation, caused abrupt changes in series calculated using price indices, such as wholesale prices and even GDP deflator.

A common alternative to the use of price indices is the series of unit values for imports and exports, made available by International Financial Statistics from the IMF. Nevertheless, these series also have shortcomings. The main limitation originates from methodology to obtain such series, i.e., the use of the ratio between the total value and total quantum traded. In addition, unit values fail to consider the influence of tariffs on the terms of trade, which is particularly important in the case of Brazil.

All these factors place doubts on the reliability of the different series used to represent the terms of trade. Thus, two issues have to be taken into consideration when choosing the series to be used in the regression. Hence, we tested the stability of the series more carefully. Previous estimations of import and export functions for Brazil have usually restricted the test to Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests. However, these tests may

not be sufficient. The succession of currency devaluations and high inflation periods (followed by stabilization) is likely to have caused structural breaks that can lead to misleading results in the DF and ADF tests. For this reason, apart from the traditional tests, we also tested for unit roots in the presence of structural breaks. After testing a few alternatives, we chose the terms of trade given by the ratio between wholesale price index from the U.S.A. and the domestic GDP deflator, which is the most common option found in the literature.¹²

Having chosen the terms of trade series, augmented Dickey-Fuller (ADF) tests were estimated to test for the order of integration of the variables. Two different specifications (with and without a trend term) were tested. As Table 1 shows, all series can be considered I(1) at 95% confidence level.

Table 1 – ADF unit-root tests

Variable	Constant		Constant +trend	
	k	t-ADF	K	t-ADF
lnM	1	-1.363	1	-2.041
lnY	1	-2.326	0	-0.7829
lnTT	0	-2.442	1	-2.394
dlnM	0	-4.508**	0	-4.488**
dlnY	0	-3.562*	0	-4.301**
dlnTT	0	-6.854**	0	-6.774**

Note: M, Y, TT are the imports, domestic GDP, terms of trade.

* Significant at 5%, ** significant at 1%, k is the number of lags.

Despite the favourable results provided by the ADF tests, further tests must be carried out to account for the presence of structural breaks in the series. Perron (1989) has demonstrated that the presence of structural breaks in time series can lead to the overestimation of the unit root coefficient in the ADF tests when there is a structural break in the series. Table 2 shows the results of the unit root tests in the presence of structural breaks for imports, GDP and terms of trade. All series can be considered stationary at 5% level.

¹² In addition to the series for terms of trade presented in the paper, another three series were tested, using consumer prices and unit value indices. The length of the series, the inclusion of tradable goods only, and the possibility to compare the results with other papers guided the choice.

Table 2 – Unit-root tests in the presence of structural break

Series	Break Date	k	μ	β	θ	γ	ρ	t_a
lnM	1973	1	2.235 (26.0)	0.031 (5.94)	0.828 (5.23)	--	0.770 (9.43)*	(3.91)
lnY	1973	1	2.133 (79.1)	0.066 (29.4)	0.350 (10.6)	-0.038 (-15.1)	0.580 (4.39)*	(3.91)
lnTT	1981	0	4.647 (62.9)	--	0.701 (4.28)	-0.038 (-3.50)	0.605 (5.02)**	(3.94)
lnTT	1994	3	4.367 (41.1)	0.023 (5.37)	-1.049 (-6.97)	--	0.800 (5.60)**	(3.83)

Notes:

1) The test involves the pooled estimation of the equations:

$$y_t = \mu + \beta t + \theta DU + \gamma DT_t + \tilde{y}_t \quad \text{and} \quad \tilde{y}_t = \rho \tilde{y}_{t-1} + \sum_{j=0}^k d_j D(T_b)_{t-j} + \sum_{i=1}^k a \Delta \tilde{y}_{t-i} + e_t$$

where, t is a trend variable, DU_t is a dummy variable for the year of the

structural break, DT_t is a dummy for the trend break, and \tilde{y}_t are the residuals.

The test consists in testing if ρ is significantly different from zero.

1) Break tests chosen based on Chow tests (see appendix).

3) * = significant at 5%; ** significant at 1%.

The tests confirm the results obtained by the ADF tests, showing that even in the presence of a structural break all series are I(1). The need to take first difference of the series to obtain stationarity reveals the need to use an error correction mechanism in the estimation of the import demand function.

4.4 Regressions' Results

(a) Imports function

The formulation of the dynamic model started with an unrestricted VAR system with three lags, which was reduced to a VAR(2) using a series of tests. The next step was to test for reduced rank using Johansen's maximum likelihood approach as well as to determine the need to include an intercept and trend in the short and/or long run model. Based on the lag reduction tests, the import function was estimated using a VAR(2), which is equivalent to a VEC(1). The next step using Johansen's procedure was to determine rank order, which determines the number of cointegration vectors. The tests showed that, as both a part of the long-run systems and as a part of the short-run systems, the trend term is not significant. The

decision concerning the intercept is more doubtful. Table 3 shows the tests of the cointegration rank for the VAR(2) with unrestricted and restricted intercepts.

Table 3 – Import demand: VAR rank determination and VEC Model results

		Test for reduced rank ¹					
		Max eigenvalue			Trace test		
		H ₀	H ₁	LRS	H ₀	H ₁	LRS
unrestricted ($\alpha = 0$)	$r = 0$	$r = 1$		15.405*	$r = 0$	$r = 1$	31.146
	$r \leq 1$	$r = 2$		11.094	$r \leq 1$	$r = 2$	15.741
	$r \leq 2$	$r = 3$		4.647	$r \leq 2$	$r = 3$	4.647
restricted ($\alpha \neq 0$)	$r = 0$	$r = 1$		15.405*	$r = 0$	$r = 1$	41.591*
	$r \leq 1$	$r = 2$		11.094	$r \leq 1$	$r = 2$	23.976
	$r \leq 2$	$r = 3$		4.647	$r \leq 2$	$r = 3$	8.635

Estimation using Johansen's cointegration procedures

Cointegration vector		Adjustment matrix	
β		α	
LM	1	LM	-0.0283
LY	-1.7031	LY	0.0238
LTT4	-0.2385	LTT4	0.0512
Constant	11.9171		

Source: Own calculations using PcGive.

Notes: ¹Both tests are corrected for the number of observations.

As can be seen, the max eigenvalue test suggests for both specifications that the rank is one, indicating the existence of a single cointegration vector. Nevertheless, for the version in which the intercept is included in the cointegration vector, the trace test also confirms the existence of one cointegration vector. Based on these tests, the vector was estimated including a restricted constant term and rank=1.

The estimated cointegration vector is:

$$\ln(M) = 11.92 + 1.70 \ln(Y) + 0.24(TT)$$

The estimated income elasticity of demand for imports is well inside the range of previous estimations. The estimated coefficient of the terms of trade variable, however, is not significant and has the wrong sign. To further investigate the importance of the terms of trade variable to the cointegration vector, tests of weak exogeneity were carried out for all the variables. The results showed that output and imports could not be considered exogenous at 5%. The terms of trade on the other hand, was not only weakly exogenous, but also insignificant to the system. In the light of these results, the cointegration vector of the import

function was re-estimated without the terms of trade coefficient. The results showed very little change in the income elasticity of demand for imports. Hence, the estimated coefficient from the previous regression was used in the remainder of the paper.

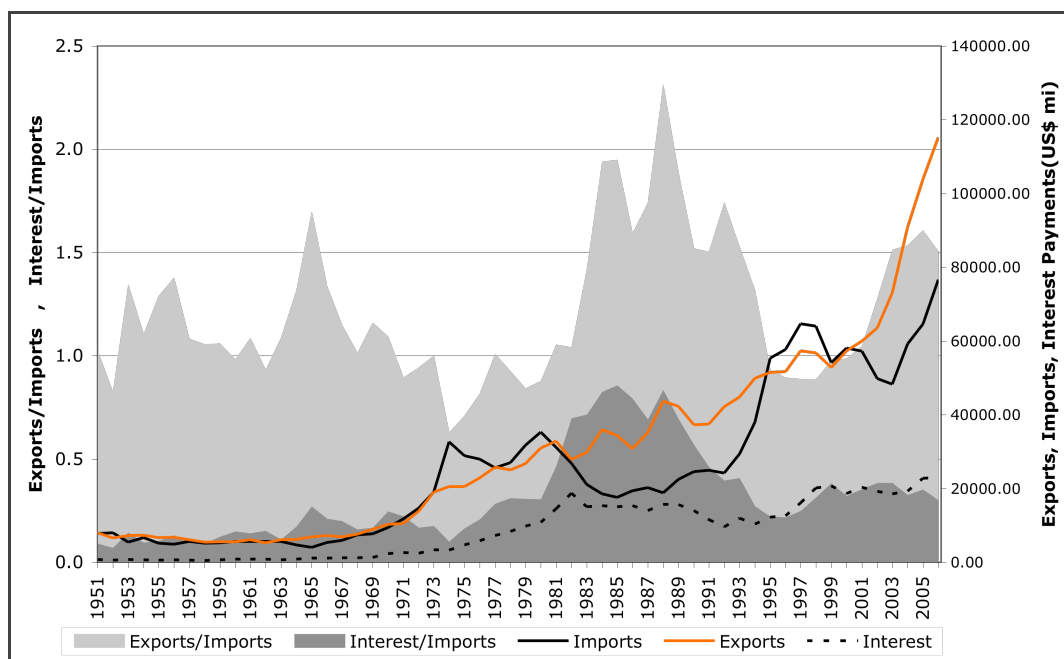
(b) Testing the external constraint: hypothetical x estimated import elasticity

Having estimated the import function, the next step consists in testing if Thirlwall's holds for Brazil. In this section, we adopt the strategy suggested by McCombie (1989, 1997). In the context of cointegration regressions, the strategy involves testing over-identifying restrictions on the import demand VAR(2). In addition, to test which version of Thirlwall's Law is more adequate, we used two hypothetical values given by the standard model and by Moreno-Brid's extended version to include interest payments, given by equations (19) and (20), respectively.

It is important to note that, in the calculation of the hypothetical elasticities, the exports to imports ratio and the interest payments to imports ratio are crucial. Figure 1 below shows the evolution of these ratios together with total imports and exports from 1951 to 2006. As is clear, the export to import ratio has been consistently higher than one throughout the series, apart from three periods. The first two occurred in the 1970s, following the oil shocks. The nature of the adjustment to the crisis that followed, i.e., "growing out" of the balance-of-payments crisis, is evident during the 1980s, with the ratio peaking at 2.3 in 1988.¹³

¹³ The combination of export promotion and import controls was crucial during this period.

Figure 1 – Brazil: imports, exports θ_1 and θ_2 , 1951-2006



Source: Own calculations based on data from Brazilian Central Bank.
 Note: Values are in constant U.S.\$ of 2003.

The second occasion in which the export to import ratio fell under one occurred after the stabilisation plan, in 1994. In this period, the impact of the process of trade liberalisation, started in the late 1980s, was combined with an overvalued exchange rate and with the recovery of economic activity following the control of inflation rates. The ratio remained below unity until the year 2000, after the sharp devaluation of the currency occurred in the final months of 1999. During this period, the balance-of-payments was financed through capital flows in the form of foreign direct investment and short-term speculative capital.

The evolution of interest payments reflects the effects of such strategy. From around 2.5 billion dollars in 1973, interest payments reached 18.7 billion in 1982. In 1994, the year of the stabilisation plan, payments were just over 10 billion dollars. The value rose to 20.7 billion dollars in 1999 and to 23 billion dollars in 2006. This dynamic, combined with the policy of import controls during the 1980s and the fast increase of imports during the 1990s, explains the behaviour of the interest to imports ratio during these two periods.

Table 4 – Thirlwall’s law: LR test of hypothetical import elasticities

Average growth rates 1951-2006	Exports 5.6	GDP 4.9	Interests 6.3
Export and interest to imports ratios	θ_1	θ_2	
Start (1951)	1.40	0.11	
Average (1951-2006)	1.21	0.24	
Hypothetical elasticities	Start	Average	
π_T	1.15	1.15	
π_{MB}	1.46	1.73	
LR test of identifying restrictions			
Restrictions	chi2	Prob.	
l _{mr} =1 ; l _y =1.15	6.454	0.011*	
l _{mr} =1 ; l _y =1.46	0.319	0.572	
l _{mr} =1 ; l _y =1.73	0.004	0.948	

Table 4 shows the hypothetical income elasticities of demand for imports calculated using the original specification of Thirlwall’s Law (π_T) and Moreno-Brid’s extended version (π_{MB}). Due to the variation of θ_1 and θ_2 over the years, two different values were used. The first option measures the ratios at the start of the series (1951) and the second represents the average value. The hypothetical elasticity calculated using the original specification of Thirlwall’s Law (π_T) was 1.15. For Moreno-Brid’s extended version (π_{MB}) the values for the ratios measured at the start of the series and the average values were 1.46 and 1.73, respectively.¹⁴

The values of the hypothetical elasticities were used for hypothesis tests by imposing restrictions on the cointegration vector. The results, also displayed in Table 4, show that the standard dynamic version of Harrod’s trade multiplier is not a good predictor of GDP growth rates in Brazil over the past 56 years. However, the results of the tests for the extended version to account for capital flows and interest payments show that the estimated income elasticity is not significantly different from both versions tested.

The hypotheses tests confirmed that Brazilian growth has been constrained by the balance-of-payments. Moreover, the estimations show that the high average rate of GDP growth of almost 5% p.a. during the last 56 years could only be reached through the maintenance of an even higher rate of exports growth (5.6%) and, more importantly, by large

¹⁴ It should be noted that hypothetical elasticity (π_T) is substantially lower than that found in other works using similar time spans. Santos et al. (2005), for instance, calculates the hypothetical values for (π_T) and (π_{MB}) from 1949 to 2004 and finds values of 1.71 and 1.80 respectively. The authors use start-of-the-period values for θ_1 and θ_2 and measure interest payments and net factor services.

sums of capital inflows. One of the more apparent consequences of such strategy is the extremely high average rate of growth of interest payments in the same period, over 6% p.a.

(c) Testing the external constraint: hypothetical x real growth rates import

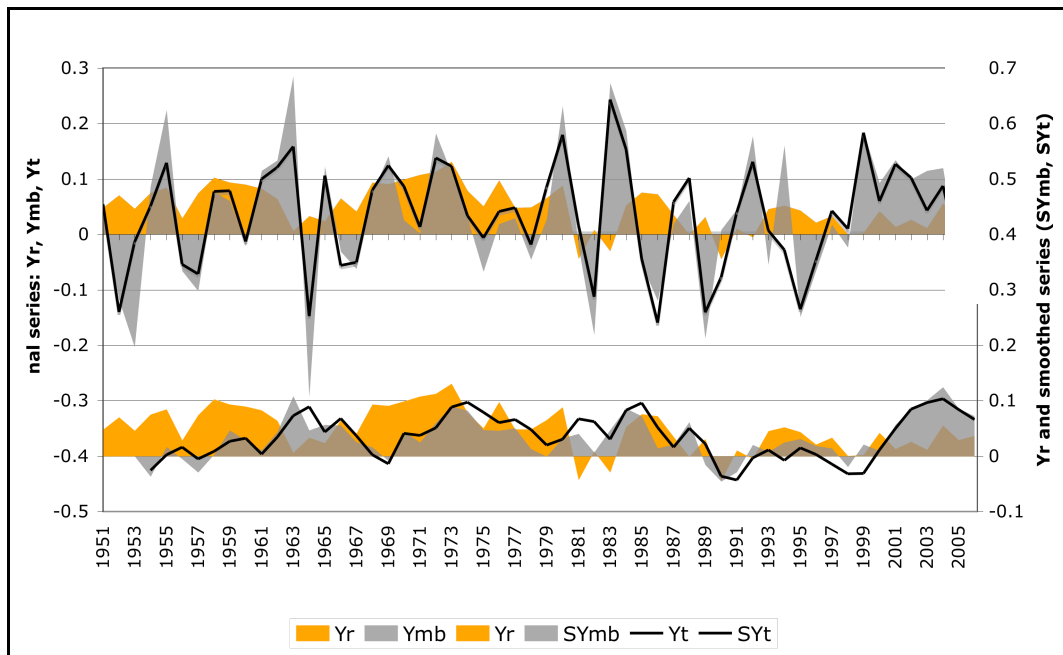
Having tested Thirlwall's Law using the hypothetical income elasticities of demand for imports, we now turn to the second strategy to test the model for individual countries. In particular, we focus on Alonso's (1999) contention that a significant cointegration vector between the series of actual growth rates, calculated using the estimated income elasticity for imports, can be interpreted economically as the existence of an equilibrium growth rate around which the two series fluctuate. In this sense, the regressions will use the logarithmic growth rates of actual and hypothetical growth rates compatible with the balance-of-payments equilibrium extended to include interest rates payments, according to Moreno-Brid (2003).

To test this hypothesis, two series were calculated. The first followed Alonso (1999). The second series was based on Atesoglu (1993, 1994) and used moving averages (five years) to smooth the hypothetical growth rate series. Here, the idea was to eliminate the sharp short-term fluctuations of the growth rates that can be found for exports and interest payments growth throughout the series.¹⁵

For the sake of comparison, apart from the extended version we calculated a series of growth rates compatible with the original version of Thirlwall's Law. Figure 2 shows the evolution of hypothetical and real GDP growth rates, as well as the smoothed series, from 1951 to 2006.

¹⁵ The calculation of first series of hypothetical growth rates bears two significant differences in relation to Alonso's method. First, terms of trade were assumed constant. This decision follows McCombie's (1997) contention that one of the reasons to test Thirlwall's Law is to test its assumptions. Secondly, the series is composed of growth rates, not levels.

Figure 2 – Real and hypothetical GDP logarithmic growth rates



Source: own calculations

Legend: Yr = actual growth rates; Yt = predicted by Thirlwall's Law,
 Ymb = predicted Thirlwall's Law with capital flows and interest payments
 S = denotes smoothed series.

The figure has two important features that should be noted. The first is, as expected, the influence of short-term variations of export and interest payments growth on hypothetical growth rates. A series of spikes follow external shocks throughout the period. As an example, the two oil shocks in 1973 and 1979 are followed by negative hypothetical growth rates, indicating the pressure on the balance-of-payments. A positive spike follows in 1980, indicating the relief provided by growing exports and capital flows. The same can be observed after the crisis in 1981 and the strong effort to “export out” of the crisis as already stressed before. The second important characteristic is that capital flows tend to be procyclical in the short-term. Graphically, this can be seen in the figure by the grey area, representing y_{MB} , spiking above y_T in periods of growth, and below y_T in periods of recession.

Two VAR models were estimated to test the long-run relationship between actual and predicted growth rates given. The first refers to yearly growth rates of both variables (y_r and y_{MB}) and the second uses the smoothed series of the extended model (y_{MBS}). Table 5 below displays the regressions' results, together with the LR test of over-identifying restrictions.

Table 5 – VAR: actual and hypothetical GDP growth rates and hypothesis tests

Yearly growth rates – VAR(1)		
	β	α
y_{MB}	1	-0.8831
y_r	-0.8347	0.0341
Constant	-0.0123	
$y_{MB} = 0.012 + 0.835y_r$		
Smoothed series – VAR(1)		
	β	α
y_{MBS}	1	-0.2106
y_r	-1.1628	0.2620
Constant	0.0172	
$y_{MBS} = -0.017 + 1.163y_r$		
LR test of identifying restrictions		
Restrictions	chi2	Prob.
$y_{MB} = 1 ; y_r = -1$	0.0858	0.770
$y_{MBS} = 1 ; y_r = -1$	0.0397	0.842

The results show the existence of a significant cointegration vector between predicted (y_{MB}) and actual growth rates (y_r) as well as between the smoothed (y_{MBS}) series of predicted growth rates and that of actual growth rates. In statistical terms, the results confirm the existence of a stable long-term relationship between predicted and actual growth rates. In addition, for both vectors estimated, the constant is very close to zero and the slope coefficients are reasonably close to one. The results of the LR tests of over-identifying restrictions formally confirmed that the slope coefficients of both vectors are not statistically different from one.

The regressions' results represent a significant advance in relation to previous tests for Brazil on two fronts. Firstly, it represents another way to test the model's central hypothesis that terms of trade are neutral in the long run, and that real income bears all the adjustment when actual growth rates deviates (in the short-term) from that consistent with the balance-of-payments equilibrium. Secondly, and more importantly, from an economic point of view, the cointegration of the series indicates the existence of a long-run path of growth from around which actual growth rates fluctuate, given short-run shocks. This long path can be interpreted as an equilibrium path given by Thirlwall's Law.

The VAR regressions provide a neat illustration of the notion of equilibrium growth rates in the Kaldorian framework. In this sense, growth rates, in spite of being clearly

demand-led, depend crucially on supply-side characteristics of the local production that are crystallised in the long-run income elasticity of demand for imports *and* exports.

5. Concluding remarks

The results of the estimations carried out in this paper revealed that the balance-of-payments has been a significant constraint to Brazilian GDP growth rates in the last fifty – five years. The tests of the hypothesis carried out using McCombie’s method refuted the original version of Thirlwall’s Law and accepted Moreno-Brid’s extended specification. These results stress the importance of capital flows to reduce the external constraint, allowing faster GDP growth rates.

The results of the hypothesis tests were strengthened by a second set of regressions, this time, following Alonso’s (1999) methodology. The results revealed the existence of a significant cointegration vector between actual growth rates and hypothetical series. The economic interpretation of the results indicates the existence of a long-term path of economic growth, defined as that compatible with the balance-of-payments equilibrium, around which actual growth rates fluctuate.

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