Balance-of-Payment Constrained Growth: The Case of South Africa

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Abstract

The paper contributes to the theory of balance of payments constrained growth, particularly by testing whether the South African balance of payments equilibrium growth rate can explain the actual growth rate in the economy. The paper uses Thirlwall's law and its methodology for estimations. Running an ordinary least squares regression on the quarterly data from the South African Reserve Bank (SARB) on exports, imports, exchange rate, price of exports, price of imports and actual growth rate from 1960 - 2016, it shows that the South African economy is balance of payments constrained. Policy positions on exchange rate and export promotion are discussed and policy recommendations are presented.

1. Introduction

Over the years, there has been a great amount of literature from different schools of economic thought on the topic of how best to promote sustained economic growth. The schools of thought differ about what factors stimulate and constrain growth and why growth rates differ across different countries and over time.

Previously, many economists looked at economic growth primarily as a supply-side phenomenon. It was argued that economic growth can be explained by the growth rate of supply factors, to which demand would inevitably adapt (Solow, 1956). Moreover, the supply-side model can be augmented to include variables such as human capital, education, health and research and development to better explain differences in growth rates across countries (Mankiw, 1992). These variables are postulated as accelerators rather than direct determinants of economic growth.

In an open macroeconomic context, a popular Keynesian demand-oriented approach emphasising the external constraints to growth is the so-called theory of 'balance-of-payments-constrained growth' (Lima R. A., 2007). This was formalised in what came to be widely known as Thirlwall's law, named for work presented by Anthony Thirlwall in his seminal 1979 paper titled 'The balance of payments constraint as an explanation of the international growth rate differences' (Thirlwall A. , 1979). In his paper, Thirlwall argued that growth rates differ because the growth of demand, particularly open-economy-related demand, differs between countries.

Thirlwall's insight harkened after Keynes in that it directed government to grow the economy by stimulating aggregate demand. More particularly Thirlwall expounded the idea that the economy should be export oriented as exports constitute, at least potentially, a significant component of aggregate demand (Palley, 2012). Put succinctly, the balance-of-payments-constrained growth model suggests that the growth rate of the economy can be explained by the growth rate of the balance of payments equilibrium.[1]

This paper contributes to the literature in that it seeks to assess the applicability of Thirlwall's law of balanced of payments constrained growth as an explanation of various periods of

[1] Even though Thirlwall's model posits itself as a demand-driven one, it has been argued that the model acknowledges the significance of supply-side factors on growth in the long-run.

growth in the South African economy. In answering this question, this paper, firstly, provides a brief overview on the theory of growth from different schools of thought, namely; neo-classical and Keynesian. Furthermore, it elaborates on the importance of the balance of payments as a constraint to growth and provides a recap of previous studies that tested the validity of Thirlwall's law.

Secondly, it gives a formal presentation of Thirlwall's law. Thirdly, it explains the methodological framework used for testing the applicability of Thirlwall's law to various periods of economic growth in South Africa. Fourthly, the paper analyses and interprets the key findings developed in the testing phase of the research. Fifthly, it discusses policy implications of Thirlwall's law and, finally, the paper concludes.

2. Literature Review

Economic growth theory must be perceived as a study of the 'undisturbed' evolution of potential output (Solow, 1999). Economists for many centuries have preoccupied themselves with economic growth theories in an attempt to understand and advise why economies grow differently, what leads economic growth and why other economies grow faster than others. Three schools of thought have emerged as dominant when it comes to growth theory, namely; Neoclassical, Keynesian and Classical. However, this paper only discusses the neoclassical as well as the Keynesian models of economic growth.

2.1 Neoclassical supply-determined growth

Neoclassical economics present an aggregate production function that is well-behaved with either constant, increasing or decreasing returns to scale (Fisher, 2003). This production function puts forward output determination as a function of aggregate capital and labour. (Solow, 1956) paper argued that the growth rate of output can be explained by supply-side factors only (Romer, 2012). Solow also argued that the growth rate of output equals the growth rate of technical progress and labour at steady-state level of growth (Solow, 1956). Furthermore, most neoclassical models assume a closed economy operating at full employment. The assumption of a closed economy presupposes that saving equals investment.

In the neoclassical conjecture, at the centre of economic growth is capital accumulation (Schiantarelli, 2010). This capital accumulation is driven by investment which is ultimately funded by savings. Moreover, the neoclassical growth model is a long-run growth model.

Plausibly, Solow's growth model shows that in the long-run output grows at the level consistent with growth in technical progress and labour, all else constant (Solow, 1956).

Since its emergence in the 1940s, supply-side determined growth theory has evolved along various lines of thinking, with endogenous growth theory occupying the predominant position since the 1980s. The endogenous growth model argues that variables such as human capital, education, health, research and development are critical to the country's economic growth (Blanchard, 2014). They use these variables to augment Solow's growth model and arrive at the same conclusions as Solow (Bloom, 2001), that the growth rate of output is determined by the growth rate of inputs, all else constant. It is noteworthy; the endogenous growth theory does not presuppose that the economy will reach some steady-state level of growth rate as Solow growth in the long-run.

However, there are a number of contradictions that arise from within the neoclassical growth model that may lead to its collapse. Firstly, the long-run growth model has always been seen as a supply-side process. The limitation of this idea is that severe effective demand problems create a role for aggregate demand in determining the utilization rates of productive resources. In the long-run, the demand-led actual rate of growth influences both the accumulation and productivity of factor inputs, and hence the economy's potential rate of growth (Setterfield, 2003).

Secondly, the aggregate production function may be exposed to aggregation problems. While thinking of the gross domestic product (GDP) as the sum of aggregate demand components may be correct, thinking about GDP as a function of aggregate capital and labor may be incorrect (Felipe, 2003). This is because capital and labor are measured in different units which therefore bear no theoretical basis to measure output as a function of these aggregates.

Thirdly, the usual assumption of a closed economy limits any role for balance of payments constrained growth theory or limitations arising due to the scarcity of foreign exchange (Thirlwall, 2011). Furthermore, it suggests that potential output is always equal to actual output and that all savings in the economy are invested (Dutt, 2006), stylized facts that are not normally observed in any economy.

Finally, the neoclassical growth theory implies that there will be convergence in the standard of living in the long-run across and within countries (Mankiw, 1992). However, holding population growth and capital accumulation constant, countries will have to increase their

productive capacity to maintain a universal level of growth. Furthermore, convergence in the standard of living is seemingly not borne out by the experience developing economies.

2.2 Keynesian: demand-determined growth model

Keynesian economists make the argument that aggregate demand plays an important role in economic growth. In equilibrium, the growth rate of output must equal the growth rate of aggregate demand, which implies that aggregate demand is a potential constraint to growth (Pilley, 1996). Effectively, the growth rate of output can be increased by increasing aggregate demand (Dutt, 2006). Ultimately, increases in output lead to increases in supply and hence the argument that demand creates its own supply, within limits.

Additionally, capital accumulation is driven by investment such that it is investment spending that determines the rate of capital accumulation (Pilley, 1996). However, unlike in the neoclassical framework, investment varies independently of savings in the Keynesian conjecture (Setterfield, 2003). Countries are not seen as resource constrained in the Keynesian framework and therefore aggregate demand matters in the long-run as well as in the short-run. In other words, full employment is not a prerequisite for economic growth (Pilley, 1996).

Initially, the Keynesian growth theory was widely regarded as a closed macroeconomic model until Thirlwall's law was presented in 1979 which forcefully argued that demand-led growth could best be explained through an open economy lense, thus opening the way for balanced-of-payments-constrained economic growth theory (Lima R. A., 2007).

The idea of a closed economy presumed that economic growth difficulties may be attributed to governments' inability to expand demand. However, this argument was theoretically not satisfactory and (Thirlwall A. , 1979) argued that, for any open economy, the dominant constraint to growth is the result of factors embedded in that economy's balance of payments.

2.3 The balance of payments and growth theory

The balance of payments is best defined as the difference in total value between payments into and out of a country over a period of time. The main accounts are the current account and the financial account (previously known as the capital account).

Most economists argued that the balance of payments was self-adjusting through relative price adjustments without any change in income, output and employment. Then in the 1970s Thirlwall published work on the balance of payments as a potential constraint to growth.

He argued that we can use 'the balance of payments constraints as an explanation of international growth differences' (Thirlwall A. , 1979).[2]

Constructively, Thirlwall argued that exports play a pivotal role, being an autonomous variable, which governs output and employment. Basically, the theory of balance of payments as a constraint to growth submits that the balance of payments of a country is the main constraint to its growth, since it imposes a limit on demand to which supply inevitably adapts (Thirlwall A. , 1979). Furthermore, he derived a relation that states that the estimated growth rate is equal to the ratio of the growth of exports demand to the income elasticity of demand for imports (Jeon, 2009). Since then, it has become generally accepted that a country's economic growth rates appear equiproportional to the ratio of export demand to the income elasticity of demand for imports.

This derivation has become known as Thirlwall's law. This law implies that to achieve faster growth rates in the presence of balance of payments difficulties, an economy should enjoy a low-income elasticity of demand for imports (Holland, 2004). Also, (Krugman, 1989) emphasized that countries with fast growing economies tend to enjoy high income elasticities of demand for exports and or low-income elasticities of demand for imports. Therefore, Thirlwall's model is Keynesian in that it is demand-led.

(Kaldor, 1970) also put forward exports as the main driver of economic growth since exports are a significant component of aggregate demand (Canuto, 2004). This notion highlights the role of the growth rate of external demand in the domestic economy. At an aggregate level, it can be stated that there is no country that can grow faster than the rate consistent with its balance of payments equilibrium in the long-run unless it can finance ever growing deficits (Thirlwall A. , 2016).

[2] However, it is contended by some writers that the first contribution to the theory of balance of payments as a constraint to growth was by Harrod through his trade multiplier concept in the 1930s (McCombie, 1997). Thirlwall claims that he was unaware of Harrods' trade multiplier rule at the time he was writing his 1979 paper. It is contended that approach is not precisely the same as Harrods' rule, but that it is simply analogous to it.

There have been a number of critiques levelled at Thirlwall's theory of balance of payments constrained growth. Firstly, some argue that Thirlwall's law does not account for the role of price changes in different economies. However, price changes between countries measured under common currency play a minor role in the balance of payments adjustment and do not serve to relax the balance of payments constraint on growth (Thirlwall A. , Economic Growth and the Balance-of-Payments Constraint, 2016).

Secondly, Thirlwall's assumption that the terms of trade between countries must be balanced in the long-run has been challenged as, in fact, that there are vast historical and structural differences in the terms of trade experienced by countries at different stages of development.

Thirdly, Thirlwall assumes that the exchange rate is constant in the long-run. The assumption of constant real exchange rate implies that the theory is based on non-price competitiveness (Lima R. A., 2007). However, in fact, relative prices can differ drastically in different countries and this can impact on external demand.

2.4 Studies testing Thirlwall's law

Since Thirlwall's first publication in 1979, there have been a number of studies seeking to test Thirlwall's law with some arguing strongly that the law is theoretically and empirically robust (Setterfield, 2011). Economists began to test the validity of the law across different countries and different continents such as Asia, Latin American, Africa and many member countries of Organizations for Economic Corporation and Development (OECD) and over time. Almost all studies support that a country cannot grow faster than the rate consistent with its balance of payments equilibrium without creating external imbalances (Porcile, 2002).

Furthermore, other scholars investigated whether the law held across multi economic sectors. For instance, (Lima, 2010) demonstrated for Latin American countries that structural changes in the sectoral composition of exports and imports affect the extent of the external constraint. Thus, it is only exports that bestow an ability to increase an economy's expenditure without generating external disequilibrium (León-Ledesma, 1999). Studies such as those done by (Porcile, 2002) even attempted to prove that over time the law would still hold; testing the effectiveness of an export-led growth in Brazil since 1890 to 1973. Effectively, Thirlwall's law has been able to pass the test of time, space and even different estimation procedures.

Constructively, some economists pondered on the durability of the assumptions that Thirlwall bases the theory on, such as, the convergence in exchange rates in the long-run (Thirlwall A. , The balance of payments constraint as an explanation of the international growth rate differences, 1979). The exchange rate regime of any country still remains a policy mechanism that can be used to generate external demand. Accordingly, (Cruz, 2000) argues that despite notable fluctuations in the exchange rate over time that may affect the competitiveness of tradeable goods, there still exists a stable relationship between domestic output and real exchange rate in the long-run.

Even though Thirlwall's law was tested generally across countries with flexible exchange rate, there is no statistically significant role that has been found to be played by the terms of trade in long-run growth (Cruz, 2000). However, it remains of research interest to study the implications of exchange rate policies on long-run growth. A country can devalue its currency in an attempt to improve the balance of payments equilibrium growth rate provided the sum of the own price elasticities of demand for imports and exports exceeds unity in absolute value (as per the well-known Marshall-Lerner condition) (Thirlwall, 2011).

Some have argued that Thirlwall's law may run into competitiveness problems. However, this argument remains trivial in the Keynesian sense as a country is seen to be uncompetitive if it is compelled to reduce its income and employment in order to avoid severe trade deficits (Blecker, 1998). Thirlwall's law is based on this analysis in that it is only relative income adjustments that are required to balance trade and given relative prices.

Scholars did not only test the applicability and validity of the results across countries and time, but they also ran numerous econometric diagnostic tests to qualify theory. The theory of the balance of payments constrained growth involves long-run relationships between involved variables. Therefore, (Bagnai, 2010) warns us to be careful about apparent structural breaks and the presence of cointegration at some unknown date in long-run relationships. Structural breaks may lead to bias and inconsistent estimates as well as misspecification problems.

Effectively, (Bagnai, 2010) study supports Thirlwall's law because even in the presence of structural breaks in long-run relationships, the predictive performance of the income elasticity of imports remains plausible. On the other hand, (Podkaminer, 2017) uses a two-stage-least-squares (2SLS) approach to test the validity of the law. Surprisingly, when estimating the parameters of the import function one has to allow data on real exchange rate

and domestic income only and there is no window to incorporate external imbalances (Podkaminer, 2017).

The same issue arises when estimating parameters of the export function. Therefore, how do we capture the effect of external balances such as trade surplus or deficit when estimating these equations? This is why Podkaminer concluded that Thirlwall's law may only be necessary to explain international growth rate differences but not sufficient. Other scholars tested the robustness of the results by correctly running causality tests, significance tests, autocorrelation and specification errors, and all these have largely supported the theory of balance of payments as a constraint to growth.

Some studies have proposed augmentation of the basic law to incorporate some variable. For instance, (Blecker, 1998) argued that without disregarding external constraints to growth; fundamentally it is savings and rigid wages domestically that may act as a constraint to growth. Furthermore, to incorporate income distribution to the theory of balance of payments constrained growth, (Blecker, 1998) conveniently adopts the hypothesis of markup pricing.

On the other hand, (Podkaminer, 2017) points out that trade that is not permanently balanced implies the presence of financial flows. Thus, we must augment the trade balance equation at given relative prices to incorporate the dynamics of non-tradable payments. Clearly, the augmented equation would then posit growth rates expected to be consistent with the overall balance of payments equilibrium growth rate (Podkaminer, 2017). Furthermore, (Moreno-Brid, 2003) proposed that we augment the equation to include interest payments as that is the popular balance of payments crisis for developing countries.

3. Formal presentation of Thirlwall's law

Let us assume a small open economy. We argue that the growth rate of the economy is tied to the state of the balance of payments accounts. Let the aggregate macro economy be given by;

$$Y = C + I + G + (X - M) \qquad (1)$$

And;

$$Y = C + S + T \qquad (2)$$

Where Y represents output, C – consumption, I – investment, G – government spending, X – exports, M – imports, S – aggregate savings and T – taxes. Then, we subtract (2) from (1) to get;

$$0 = (I - S) + (G - T) + (X - M) \qquad (3)$$

The equation (3) can be written as follows;

$$I = S - (G - T) - (X - M) \qquad (4)$$

From equation (4), we can say that indeed investment may been seen as an expenditure that creates income and ultimately improves the economy's current account (Lianos, 1979). Assume that the government is running a balanced budget, that is;

$$G - T = 0 \qquad (5)$$

And;

$$S - I = X - M \qquad (6)$$

We further assume that all saving is done for investment. Then, if 'leakages' exceed 'injections' exports will exceed imports and we do not have a balance of payments constraint, but if 'injections' exceed 'leakages' there will be such a constraint; and the question is then how long the deficit can prevail without corrective action being taken (Thirlwall A. , 2011) .Ultimately, if relative price changes are ineffective, output would have to be contracted through government contraction of demand. Such a situation would lead where the level as well as growth of output is fundamentally determined by the level as well as growth of export demand in relation to the propensity to import (Thirlwall A. , 2011).

It is crucial to note that trade relations do not play a role in long-run growth. We assume that the real exchange rate is independent of trade volumes. We also assume that trade is balanced in the long-run in real terms (Podkaminer, 2017). Then the balance of payments equilibrium on current account may be expressed as seen in (Thirlwall A. , The balance of payments constraint as an explanation of the international growth rate differences, 1979), and we get;

$$P_{dt}X_t = P_{ft}M_tE_t \qquad (7)$$

Where P_d represents the domestic price of exports in national currency, X – quantity of exports, P_f - foreign price of imports in foreign currency, M – quantity of imports and E –

exchange rate, and t represents time. Importantly, we assume non-price competitiveness in the long-run and this assumption implies that differences in relative prices can only affect short-run growth and in the long-run the exchange rate is balanced (Setterfield, 2011).

Thirlwall argues that the balance of payments equilibrium through time is that the rate of growth of the value of exports equals the rate of growth of imports, and we get;

$$p_{dt} + x_t = p_{ft} + m_t + e_t \qquad (8)$$

where the lower-cases represent continuous rates of change of the variables. The openness of the economy implies that it is prescribed by two conventional demand equations; one for its exports and the other for its imports and both in real terms (Podkaminer, 2017). Therefore, the import demand relation may be given as a multiplicative function of imports, the price of import substitutes, and domestic income;

$$M_t = (P_{ft}E_t)^{\psi} P_{dt}^{\phi} Y_t^{\pi} \qquad (9)$$

Where $\psi\ (< 0)$ represents the price elasticity of demand for imports, $\phi\ (> 0)$ - cross price elasticity of demand for imports, Y – domestic income and $\pi\ (> 0)$ - income elasticity if demand for imports. Then, the rate of growth of imports which is derived by linearizing (9) may be expressed as;

$$m_t = \psi(p_{ft}) + \psi(e_t) + \phi(p_{dt}) + \pi(y_t) \qquad (10)$$

Again, the lower cases represent continuous rates of change of variables. The quantity of exports may be stated as a multiplicative function of the price of exports in foreign currency, the price of goods competitive with exports, and the level of world income;

$$X_t = (\frac{P_{dt}}{E_t})^{\theta} P_{ft}^{\delta} Z_t^{\epsilon} \qquad (11)$$

Where X_t represents quantity of exports, P_{dt} – domestic price of exports, P_{ft} – price of goods competitive with exports, Z – level of world income, $\frac{1}{E_t}$ – foreign price of domestic currency, $\theta\ (< 0)$ - price elasticity of demand for exports, $\delta\ (> 0)$ cross elasticity of demand for exports and $\epsilon\ (> 0)$ – income elasticity of demand for exports. Then, the rate of growth of exports may be expressed as;

$$x_t = \theta(p_{dt}) - \theta(e_t) + \delta(p_{ft}) + \epsilon(z_t) \qquad (12)$$

Substituting (10) and (12) into (8), and we can solve for the growth rate of domestic output consistent with the balance of payments equilibrium growth rate; call it y_{Bt} .

$$y_{Bt} = \frac{p_{dt}(1+\theta-\phi)-p_{ft}(1-\delta+\psi)-e_t(z_t)}{\pi} \qquad (13)$$

Furthermore, if the Marshall-Lerner condition holds or relative prices measured in a common currency do not change in the long-run, then equation (13) can be expressed as follows:

$$y_{Bt} = \frac{x_t}{\pi} \qquad (14)$$

Equation (14) is famously called Thirlwall's law and states that the estimated growth rate of an economy is equiproportional to the growth rate of exports (x_t) divided by the income elasticity of imports (π).

Looking into (13), and recalling the signs of parameters $\eta<0$; $\Phi>0$; $\delta>0$; $\Psi<0$; $\varepsilon>0$, and $\pi>0$), (Thirlwall A. , 1979) makes some familiar economic propositions. Firstly, if the sum of the price elasticity of demand for exports and the cross elasticity of demand for imports is greater than one in absolute terms, then inflation in the domestic economy will lower the balance of payments equilibrium growth rate. However, if the sum of the price elasticity of demand for imports and the cross elasticity of demand for exports is greater than one in absolute terms, then inflation abroad will result in improvements in the domestic economy's balance of payments equilibrium growth rate.

Secondly, the Marshall-Lerner condition must hold moderately; currency depreciation will improve the balance of payments equilibrium growth rate given that the sum of price elasticities of demand for imports and exports exceed one in absolute terms, but not for long.

However, policies designed to increase productive capacity will not stimulate the equilibrium growth rate because it is demand-led (Setterfield, 2011). Thirdly, a faster growth of world income will raise the balance of payments equilibrium growth rate. Lastly, high income elasticity of demand for imports leads to lower balance of payments equilibrium growth rate and vice versa.

4. Explain method for testing Thirlwall's law: South Africa

This research paper uses the ordinary least squares regression technique to estimate the parameters to test for Thirlwall's law in South Africa. It is assumed that South Africa runs

balanced trade in the long-run. Furthermore, it is assumed that the real exchange rate is constant in the long-run since despite fluctuations in the exchange rate there is still a balanced relationship between real exchange rate and output (Cruz, 2000). Assuming that the Marshall-Lerner condition holds, this paper uses the traditional import function given above by equation (9).

The import function is empirically advantageous because it requires the estimation of only two basic parameters; the price and income elasticity of demand (Hussain, 1999).

$$M_t = (P_{ft}E_t)^{\psi}P_{dt}^{\phi}Y_t^{\pi} \qquad (9)$$

We rewrite the import function as a multiplicative function of real exchange rate and income;

$$M_t = A_t(RER_t)^{\mu}Y_t^{\pi} \qquad (9)^*$$

Where RER is the real exchange rate, A is a constant term, μ is the real price elasticity of demand for imports and other variables are as define above. Then we take natural logs, differentiate with respect to time and add a constant term to give us the estimating equation of the form;

$$m_t = a_t + \mu\,(rer_t) + \pi(y_t) + (e_t) \qquad (10)^*$$

We run equation (10)* to get the estimates for the income elasticity of demand for imports (π), and the last term of (10)* being the error term, (e_t). The growth rate of exports (x_t) is then divided by the income elasticity of demand for imports (π) to give an estimate of the balance of payment constrained growth rate (y_{Bt}) that should be achievable in terms of Thirlwall's law.

In order to test Thirwall's law, the following data from the South African Reserve Bank (SARB) from 1960 to 2016 is used: For imports, the paper uses the volume of imports from SARB series 5034 (quarterly) from 1960 to 2016 and for the growth rate of exports, the paper uses the rate of growth of exports from SARB time series 6013Z (yearly) from 1960 to 2016. For the price of imports, the paper uses the price of imports from SARB series 5035 (quarterly) from 1960 to 2016 and, for the price of exports; the paper uses the price of exports from SARB series 5031 (quarterly).

For the nominal exchange rate, the paper uses the ZAR (South African rands) cents per US dollar from SARB series 5339 (monthly) and end of quarter data (that is for March, June,

September and December) from 1960 to 2016 was extracted from this data series to make it quarterly. For the income proxy, the paper uses the expenditure on GDP in real terms from SARB series 6045C (quarterly) from 1960 to 2016. The rate of GDP growth percentage change is drawn from SARB series 6006J (yearly) (from 1960 to 2016) to get the actual average growth rate (Ga) per decade 1960.

The software package eviews was used to estimate the growth rate of output per decade as predicted by Thirwall's law (y_{Bt}) for each of the five decades from 1960 to 2009 and then for part of the sixth decade from 2010 to 2016. Even though quarterly data is used, the paper finds estimates per decade. This means that for the growth of exports and income proxy the paper uses ten years (for example 1960 – 1969) and forty quarters for other variables (for example 1960 quarter one – 1969 quarter four).

5. Discussion of results

Figure 1 shows that from 1960 to 2016, the real exchange growth rate for South Africa lies between 4.00 and 7.50, indicating that there is an upward trend in the real exchange rate over time. The upward trend is inconsistent with the assumption that the real exchange rate is constant in the long-run (Cruz, 2000). Additionally, we note in Figure 2 that in the long-run the growth rate of output and the real exchange rate move together. We log the real exchange and GDP to find the real exchange growth rate (LRER) and output growth rate (LGDP). Since we are working with time-series data of a large sample (56 years) there may be structural breaks in the model.

Figure 1: Growth Rate of the Real Exchange Rate

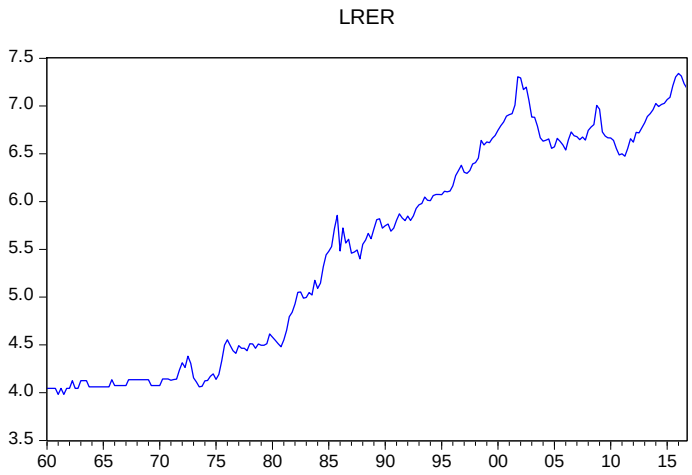
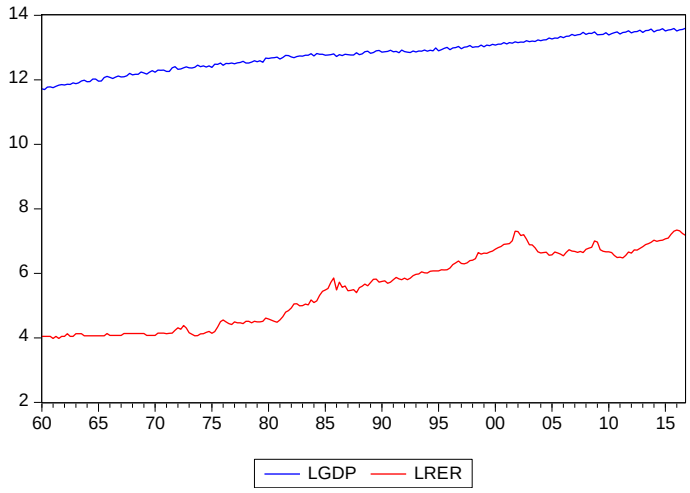


Figure 2: Real Exchange rate and Output movements



Structural breaks are likely because the South African economy has experienced several business cycles of varying durations (Gujarati, 2009). We use the scatter plot approach to evaluate the impact of structural breaks on the income elasticity of demand for imports. The paper put forward that the South African economy must have had at least three significant structural breaks since 1960 to 2016. Of course, there may be other factors that might have contributed to the differences in the income elasticity of demand for imports during all these varying periods.

Figure 3 illustrates the relationship between the growth rate of income and imports from 1960 to 1969, Figure 4 shows the same relationship from 1970 to 1991, and Figure 5 illustrates the relationship from 1992 to 2007 and Figure 6 shows the relationship between 2008 and 2016. Looking at the correlation coefficients, we can deduce that all these periods indicate that South Africa must have experienced some structural breaks.

Figure 3

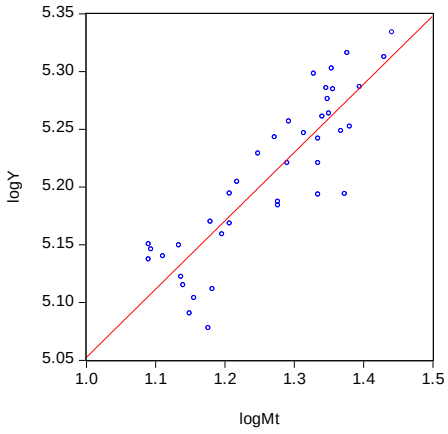


Figure 4

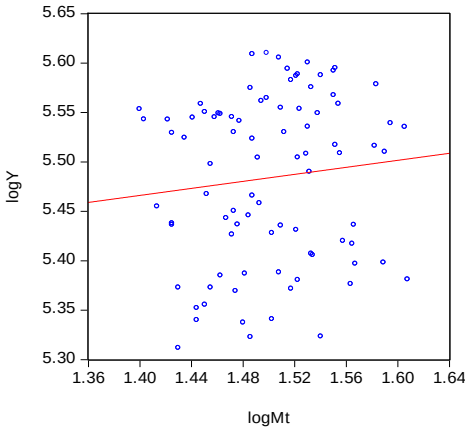
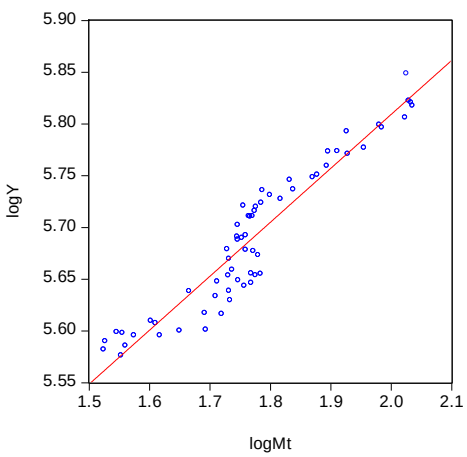
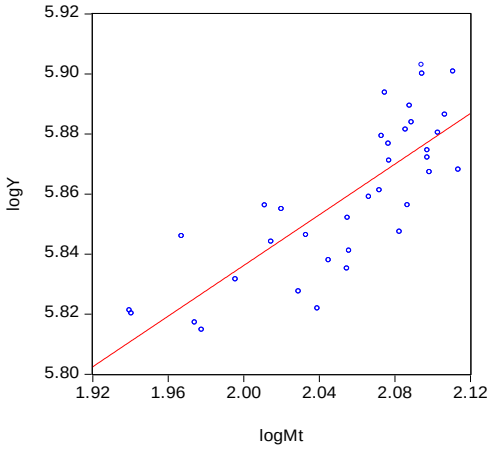


Figure 5

Figure 6





The first structural break may be predominately attributed to the oil price volatility, Soweto uprising and sanctions during the 1970s (Cassim, 2004). The second structural break can be explained by the wave of democracy in South Africa from 1994 and the trade liberalization policies and the opening of the financial account which was previously frozen that were undertaken to stimulate export growth. The third structural break may have come as a result of the 2008 global financial crisis. We can expect that there will be structural breaks that can be witnessed in the real price elasticity of demand for imports during the same periods.

The paper also tests for stationarity in the long-run variables; growth rate of imports, growth rate of real exchange rate as well as the growth rate of income. Using the correlogram we find that the growth rates of imports as well as the growth rate of real exchange rate are stationary after first differencing generally. However, the paper uses the augmented Dickey-Fuller test to test for stationarity in the growth rate of income and finds that after first differencing it is stationary. For about two decades 1980 to 1989 and 2011 to 2016 we difference six and five times respectively before stationarity is observed in the data.

Since the paper uses a traditional model to estimate the income elasticity of demand for imports (Hussain, 1999), we do not check for model specification. Taking from literature that the model is correctly specified, we estimate equation (10)* for each decade from 1960 to 2016. Table 1.1 below illustrates a comparison for each decade of the actual growth rates (Ga) with the growth rates estimated by Thirlwall's law (the balance of payments equilibrium growth rate, y_{Bt}) without adjusting for the years the economy experienced structural breaks. The regression results for Table 1.1 are presented in the appendix 1 at the back of this paper. The calculation of y_{Bt} is shown in Appendix 3.1, we find the average of the growth rate of exports per decade and divide by the estimated income elasticity of demand for imports.

Table 1.1: South Africa - Calculations of the growth rate consistent with the growth rate of the balance of payments equilibrium.

Years	Actual Average Growth Rate (Ga)	Estimated Growth of balance of payment equilibrium ($\mathbf{y_{Bt}}$)
1960 – 1969	5.49	3.31
1970 – 1979	3.25	2.30
1980 – 1989	2.24	1.39
1990 – 1999	1.39	4.88
2000 – 2009	3.61	1.23
2010 – 2016	2.04	1.99

For robustness Table 1.2 below illustrates a comparison for each decade of the actual growth rates (Ga) with the growth rates estimated by Thirlwall's law (y_{Bt}) once the data has been adjusted to deal with the impact of structural breaks and outliers. Firstly, informed by the structural break analysis, the data was adjusted to remove a single year of outlying data from the 1970 to 1979 period, that is, 1973 which saw a sharp contraction in exports as a result of the global oil shock.

Secondly, the paper adjusted for 1990 to 1999 period by removing data for 1995 which saw a surge of exports as SA re-entered the global market. From the 2000 to 2009 period, the data for 2009 was excluded as this year that saw a sharp fall of exports in the aftermath of the Great Recession. Finally, for the period 2010 to 2016, data from the year 2010 was excluded as this year saw a strong resurgence in exports following a recovery from the global recession. Full regression results which underlie Table 1.2 are presented in Appendix 2 at the back of the paper and the calculation of y_{Bt} for Table 1.2 are shown in Appendix 3.2.[3]

[3] It is noteworthy that while as would be expected in both Table 1.1 and Table 1.2 the estimates for the period 1960 to 1969 are identical, the estimates for the period 1980 to 1989 are markedly different even though no strucutrual breaks have been identified in that period. This is presumably a result of the impact of removing the outlying data from the decade from 1970 to 1979 which has impacted on the underlying trend data applicable to the 1980's period.

Table 1.2: South Africa - Calculations of the growth rate consistent with the growth rate of the balance of payments equilibrium adjusted for structural breaks

Years	Adjusted Actual Average Growth Rate (Ga)	Adjusted Estimated Growth of balance of payment equilibrium (y_{Bt})
1960 – 1969	5.49	3.31
1970 – 1979	3.10	0.90
1980 – 1989	2.24	0.93
1990 – 1999	1.20	1.47
2000 – 2008	4.18	2.65
2011 – 2016	1.88	1.09

To test for the predictive power of the Thirlwall's model, firstly, we look at the movements between actual growth (Ga) and the model's predicted growth rate (y_{Bt}) illustrated in Figure 7 (in which data from all years is included) and Figure 8 (adjusted for structural breaks) and we see that the there is some degree of visual correlation between Ga and y_{Bt}.

Secondly, use is made of (Swales, 1985) method which requires the regression of the actual growth rate (Ga) on the predicted growth rate (y_{Bt}). According to this method, if the regression coefficient equals one and the constant term equals zero, then statistically the predicted growth rate (y_{Bt}) is to be considered a good estimate of the actual growth rate (Ga).

Figure 7: Movements between estimated and actual growth rate (y_{Bt}) and (Ga)

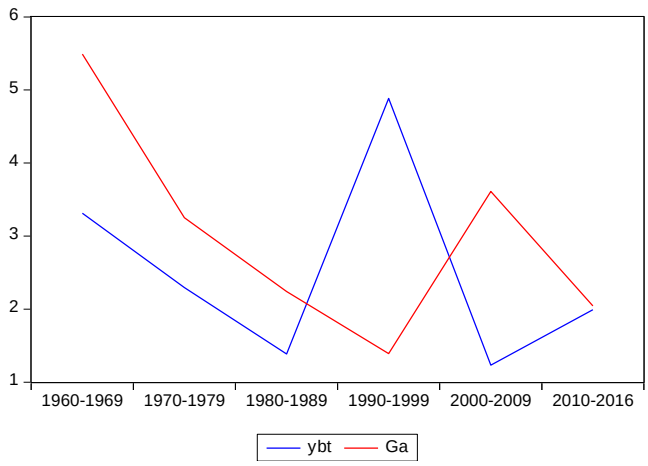
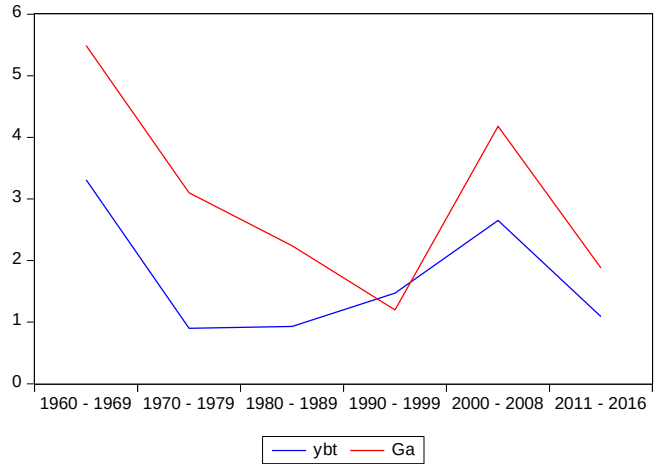


Figure 8: Movements between estimated and actual growth rate (y_{Bt}) and (Ga) adjusted for structural breaks



Without adjusting for structural breaks in Table 2.1, Thirlwall's law's predicted growth rate is found to be statistically significant at the 5 percent level as the regression coefficient does not deviate statistically from unity nor does the constant deviate statistically from zero (see regression results at Appendix 1.2).

Table 2.1: Estimated coefficient of regressing the prediction of the basic model (y_{Bt}) against the actual growth rate (Ga).

Dependent Variable	Constant	y_{Bt}	R^2	|t-value|
Ga	-0.296484	1.697262	0.966717	5.389393
	(0.774808)	(0.314926)*		

*Significant at 5%

Once structural breaks are taken into account, then the predictive power of Thirlwall's law can be shown to have increased in that the model's predicted growth rate (y_{Bt}) has a stronger

correlation with South Africa's actual growth rate (Ga). As can be seen in Table 2.2, the growth rate predicted by Thirlwall's law is found to be statistically significant at the 5 percent level with a regression coefficient that is closer to unity than in Table 2.1 and with a constant that does not deviate statistically from zero (see regression results on Appendix 2.2). This result shows that the growth rate of the South African economy can be explained by the growth rate of the balance of payments equilibrium. Furthermore, the South African economy is balance of payments constrained. This paper develops further on the policy implications of these results in the following section.

Table 2.2: Estimated coefficient of regressing the prediction of the basic model (y_{Bt}) against the actual growth rate (Ga) adjusted for structural breaks

Dependent Variable	Constant	y_{Bt}	R^2	|t-value|
Ga	0.760213	1.307123	0.694145	3.012987
	(0.849437)	(0.433830)*		

*Significant at 5%

Looking at Appendix 1.1 above for period 1960 – 1969, using the full data set, r-squared is 78.24%. This means that the growth in imports during this period could be explained by the growth in income. The income elasticity of demand for imports is significant at 5% level of significance. However, there is negative autocorrelation with the Durbin-Watson d stat of 0.70.

For the period 1970 – 1979, r-squared is 21% illustrating a low degree of goodness of fit. The sign shows the expected relationship between imports and income even though the income elasticity of demand for imports is insignificant at 5% level of significance and significant at 10%. Imports can be explained by other factors other than income. During this period, the world experienced an oil price crisis. Furthermore, South Africa experienced sanctions. These can explain the negative relationship between imports and income, and the insignificance of income in import determination during this period.

Similarly, between 1980 and 1989 South Africa continued to experience sanctions and increase political turmoil. There was a substantial decrease in gold exports and aggregate growth was constrained (Lawrence, 2006). Even though the sign of the income elasticity of demand for imports was expected, it is significant but the r-squared is low. The period 1990 –

1999 has r-squared equal 87.83% which is high, an indication that there might be autocorrelation.

Furthermore, the income elasticity of demand for imports is significant after differencing five times. During this period, South Africa embarked on a lot of trade liberalization policies, and fiscal stabilization under the government of national unity (Cassim, 2004). These liberalization policies boosted exports due to decrease in input costs and profitability of domestic sales (Lawrence, 2006). For the period 2000 – 2008 r-squared is too high, however, the income elasticity of demand for imports is significant at 5% and surprisingly between 2011 and 2016; the income elasticity of demand for imports is significant at 5% after sixth differencing.

6. Discussion of international trade policy implications

A powerful implication of Thirlwall's law is that a country's economic growth rate will be enhanced if it promotes exports and if it income elasticity of imports is constrained.

The South African economy suffered from the apartheid era sanctions and protectionist policies. Those policies negatively affected both imports and exports and it was only favourable international prices that could help the country not run into external constraints (Lawrence, 2006).

There is no doubt that trade liberalization and dismantling of sanctions has greatly assisted restructuring of the economy since the 1990s. In the 1990s there was a clear focus on liberalizing and simplifying the tariff structure but it seems that such attempts have since slowed down (Flatters, 2007). The focus was to liberalize input tariffs so that tariffs on final products could also be reduced. Furthermore, it was to create a globally competitive base and stimulate exports.

Moreover, South Africa introduced export subsidies in the 1970s which were designed to counter the anti-export bias of import protectionism (Cassim, 2004). They further replaced quantitative restrictions with equivalent tariff and other duties. Tariffs have decreased from 23% in the 1990s to around 7.7% in 2004 (Flatters, 2007).

Unsurprisingly, the basket of export goods has remained relatively unchanged. South Africa has a comparative advantage in capital intensive primary commodities (Lawrence, 2006). An

additional tendency is that labour-intensive production has contracted due to imports and production that is biased towards capital and high-skill-intensive growth.

On the other hand, South Africa has paved a way for trade negotiations for itself in the recent past. Currently, South Africa has trade agreements with the Southern African Development Community (SADC), European Uunion, BRICS countries, to name a few, as well as preferential trade acces under the United States' AGOA arrangement. It has also by itself formulated policies that support trade and export-oriented growth approach such as ASGI-SA, National Industrial Policy Framework (NIPF) and the National Development Plan (NDP). As (Lawrence, 2006) puts it, policymakers are cognisant that an export-led approach would be instrumental at stimulating economic growth.

However, there has factors that negatively influence trade and export-led growth. Issues such as exchange rate volatility, barriers to entry and surcharges play a significant role as constraints to growth. Even though tariffs do not affect exports directly, they do impact them indirectly through input costs and relative prices. Therefore, trade policy must be positioned such that it captures the continuation of commodity cycles, exploits rapid growth in emerging markets and encourages growth (Robert, 2012).

First, authorities must begin to answer the fundamental question; to what extent is the current export behaviour explained by competitiveness and to what extent is competitiveness the result of macroeconomic policies? The exchange rate is the most import instrument in any export promotion (Cassim, 2004). The main interest lies on the level that the real exchange rate ought to be at in order to sustain a viable export-led growth strategy.

Most economies undertake a flexible exchange rate policy since it is argued that exchange rates are balanced and stable in the long-run. Effectively, what must be done to reduce exchange rate volatilities and raise price competitiveness? It was (Lawrence, 2006) that argued that developing economics are likely to experience negative external shocks from a flexible exchange rate regime. However, the choice of exchange rate regime has recently emerged as a key element of policy strategies to control for inflation and cope with chronic externalities (Perrotini, 2006).

Despite the fact that a flexible exchange rate works better as a shock absorber, the problem to diversify and develop in the presence of rising prices remains with this regime. This is why (Thirlwall A. , The balance of payments constraint as an explanation of the international

growth rate differences, 1979) advocates for a fixed exchange rate and gaining control of capital movements as a country. The advantage of a fixed exchange rate or managed excahnge rate, which is more likely given the relative openness of South Africa's economy, is that a country can devalue the currency and currency devaluation can be used to stabilize effective demand (Perrotini, 2006).

In light of the results of testing Thirlwall's law, South Africa should consider managing its real exchange rate (despite the assumption that in the long-run the exchange rate is constant) in order to assist in sustainably promoting exports and rendering imports less competitive. There is asymmetry in managing the exchange rate in that keeping the currency relatively competitive requires the building up of foreign reserves, whereas attempts to maintain currency strength through purchasing the local currency with foreign reserves is limited by the finite holdings of such reserve holdings.

It is also noteworthy that a competitive real exchange rate can be achieved by nominal exchange rate depreciation if domestic inflation is kept in check. In fact a competitive real exchange rate can also be achieved through a low domestic infaltion rate, even where there is no depreciation of nominal exchange rate. As such, inflation-targeting framework can be viewed with the requirement of real exchange rate competitiveness as supported by Thirlwall's law.

Beyond the realm of macroeconomic policy, government can undertake other interventions to increase the competitiveness of domestic goods (Cassim, 2004). The government can promote local technological innovation to boost local capital and labour intensive exportable commodities.

The government ought to act expeditiously against both unfair trade and surges in imports that threaten injury to local industries. Trade and trade agreements must be simplified to avoid administrative costs and unfair gains. Importantly, the government must have a direct policy to promote export-led growth and avoid policy reversals as that is important for investment. Local producers must be subsidized to boost their trade competitiveness in line with the World Trade Organisation rules (WTO) on subsidies and countervailing measures (WTO, 2018).

Third, there must be strengthening of law enforcement. There must be a formulation of anti-dumping measures to promote local producers. Recently, developing economies find

themselves as dumping sites of 'bad' goods from the rest of the world, eroding their competitiveness in the global market. Additionally, there must be a clear intention to deal with illegal imports, customs, fraud, transhipment and abuse of industrial support programmes.

7. Conclusion

Effectively, the application of Thirwall's law in South Africa, show both theoretically and empirically how that rate of economic growth could be improved for the South African economy. Policy formulation directed to promote exports must move to the forefront of economic growth in the country.

South Africa must induce comparative advantage in certain sectors to foster competitiveness of our goods in the global market. Moreover, trade negotiations must be simplified and aimed at deriving gains from trade. Furthermore, at a macroeconomic policy level, it is important for the country to work toward achieving a competitive real exchange rate – through a possible combination of inflation control and interventions to weaken the nominal exchange rate.

Indeed, the results of this paper support Thirlwall's law that the growth rate of an economy can be explained by the growth rate of the balance of payments. This illustrates how powerful are the results of Thirlwall's law and the durability of the law.

Economists must formalize the role of exchange rate on trade as future research prospects. The point of departure is the effect of different exchange rate policies on international trade and subsequently on economic growth. Additionally, Thirlwall's balance of payments theory only focuses on the exportable commodities and does not account for movements in the financial accounts. It would provide a conclusive position on the theory of balance of payments constrained growth to uncover the effect of financial flows on the growth rate of balance of payments equilibrium used to predict the actual growth rate of an economy.

Appendix

1.1 Regression results with no Adjustment for structural breaks

Dependent Variable: LMT(1)				
Method: Least Squares				
Date: 03/18/18 Time: 21:46				
Sample: 1960Q1 1969Q4				
Included observations: 40				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-11.78257888	1.852296792	-6.361064237	2.04044E-07
LRER(1)	-0.615249273	0.544984407	-1.128930048	0.266193976
LGDP(1)	1.434269099	0.143917899	9.965884075	5.03566E-12
R-squared	0.78239318	Mean dependent var		2.930113577
Adjusted R-squared	0.770630649	S.D. dependent var		0.240422497
S.E. of regression	0.115144393	Akaike info criterion		-1.413221161
Sum squared resid	0.490554559	Schwarz criterion		-1.286555202
Log likelihood	31.26442323	Hannan-Quinn criter.		-1.36742275
F-statistic	66.51571767	Durbin-Watson stat		0.69787296
Prob(F-statistic)	5.58395E-13			

Dependent Variable: LMT(1)				
Method: Least Squares				
Date: 03/18/18 Time: 21:47				
Sample: 1970Q1 1979Q4				
Included observations: 40				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.731104	2.700181	-0.270761	0.7881
LRER(1)	-0.476626	0.157619	-3.023908	0.0045
LGDP(1)	0.500898	0.258734	1.935957	0.0605
R-squared	0.2109	Mean dependent var		3.443699
Adjusted R-squared	0.168246	S.D. dependent var		0.11059
S.E. of regression	0.100859	Akaike info criterion		-1.678155
Sum squared resid	0.376381	Schwarz criterion		-1.551489
Log likelihood	36.56309	Hannan-Quinn criter.		-1.632356
F-statistic	4.944428	Durbin-Watson stat		0.589991
Prob(F-statistic)	0.012501			

Dependent Variable: LMT(-5)				
Method: Least Squares				
Date: 03/21/18 Time: 18:28				
Sample: 1980Q1 1989Q4				
Included observations: 40				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-9.056531	4.953949	-1.828144	0.0756
LRER(-5)	-0.215855	0.06955	-3.103603	0.0037
LGDP(-5)	1.068111	0.411153	2.597845	0.0134
R-squared	0.207109	Mean dependent var		3.438953
Adjusted R-squared	0.16425	S.D. dependent var		0.123767
S.E. of regression	0.113147	Akaike info criterion		-1.448217
Sum squared resid	0.473684	Schwarz criterion		-1.321551
Log likelihood	31.96435	Hannan-Quinn criter.		-1.402419
F-statistic	4.832339	Durbin-Watson stat		0.923189
Prob(F-statistic)	0.01366			

Dependent Variable: LMT(-5)				
Method: Least Squares				
Date: 03/21/18 Time: 18:30				
Sample: 1990Q1 1999Q4				
Included observations: 40				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-11.88894	4.580961	-2.595293	0.0135
LRER(-5)	0.644436	0.100563	6.408274	0
LGDP(-5)	0.908971	0.393744	2.308531	0.0267
R-squared	0.878372	Mean dependent var		3.738862
Adjusted R-squared	0.871798	S.D. dependent var		0.229876
S.E. of regression	0.082308	Akaike info criterion		-2.084659
Sum squared resid	0.25066	Schwarz criterion		-1.957993
Log likelihood	44.69319	Hannan-Quinn criter.		-2.038861
F-statistic	133.6033	Durbin-Watson stat		1.03726
Prob(F-statistic)	0			

Dependent Variable: LMT(1)				
Method: Least Squares				
Date: 03/23/18 Time: 02:00				
Sample: 2000Q1 2009Q4				
Included observations: 40				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-19.22663	1.597478	-12.0356	0
LRER(1)	-0.173625	0.060429	-2.87318	0.0067
LGDP(1)	1.864331	0.102797	18.13602	0
R-squared	0.929743	Mean dependent var		4.36265
Adjusted R-squared	0.925945	S.D. dependent var		0.246232
S.E. of regression	0.067007	Akaike info criterion		-2.495995
Sum squared resid	0.166129	Schwarz criterion		-2.369329
Log likelihood	52.91989	Hannan-Quinn criter.		-2.450196
F-statistic	244.8187	Durbin-Watson stat		1.133028
Prob(F-statistic)	0			

Dependent Variable: LMT(-6)				
Method: Least Squares				
Date: 03/23/18 Time: 02:02				
Sample: 2010Q1 2016Q4				
Included observations: 28				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-17.5536	3.800094	-4.619254	0.0001
LRER(-6)	0.060279	0.083649	0.720627	0.4778
LGDP(-6)	1.621095	0.301744	5.372428	0
R-squared	0.649044	Mean dependent var		4.709389
Adjusted R-squared	0.620967	S.D. dependent var		0.116522
S.E. of regression	0.071737	Akaike info criterion		-2.33065
Sum squared resid	0.128657	Schwarz criterion		-2.187914
Log likelihood	35.6291	Hannan-Quinn criter.		-2.287014
F-statistic	23.11698	Durbin-Watson stat		1.588104
Prob(F-statistic)	0.000002			

1.2 Prediction Results with no adjustments for structural breaks following McGregor and Swales (1985)

Dependent Variable: GA(-3)				
Method: Least Squares				
Date: 03/23/18 Time: 02:30				
Sample (adjusted): 4 6				
Included observations: 3 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.296484	0.774808	-0.382654	0.7673
GT(-3)	1.697262	0.314926	5.389393	0.1168
R-squared	0.966717	Mean dependent var		3.66
Adjusted R-squared	0.933434	S.D. dependent var		1.66334
S.E. of regression	0.429147	Akaike info criterion		1.380686
Sum squared resid	0.184167	Schwarz criterion		0.779761
Log likelihood	-0.071029	Hannan-Quinn criter.		0.172749
F-statistic	29.04556	Durbin-Watson stat		2.997996
Prob(F-statistic)	0.116796			

2.1 Regression adjusted for structural breaks

Dependent Variable: LMT(-1)				
Method: Least Squares				
Date: 03/23/18 Time: 03:42				
Sample (adjusted): 1961 1969				
Included observations: 9 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-13.37304	3.98921	-3.352303	0.0154
LRER(-1)	-0.304672	1.688871	-0.1804	0.8628
LEXPGDP(-1)	1.46148	0.441501	3.310257	0.0162
R-squared	0.833638	Mean dependent var		2.878216
Adjusted R-squared	0.778184	S.D. dependent var		0.221075
S.E. of regression	0.104121	Akaike info criterion		-1.425333
Sum squared resid	0.065047	Schwarz criterion		-1.359592
Log likelihood	9.414001	Hannan-Quinn criter.		-1.567203
F-statistic	15.03296	Durbin-Watson stat		1.660361
Prob(F-statistic)	0.004604			

Dependent Variable: LMT(-1)				
Method: Least Squares				
Date: 03/23/18 Time: 03:29				
Sample: 1970 1979				
Included observations: 9				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-16.79853	5.669487	-2.962972	0.0252
LRER(-1)	-1.272372	0.405943	-3.134359	0.0202
LEXPGDP(-1)	2.070562	0.579515	3.572922	0.0117
R-squared	0.680965	Mean dependent var		3.431058
Adjusted R-squared	0.57462	S.D. dependent var		0.123075
S.E. of regression	0.080271	Akaike info criterion		-1.945611
Sum squared resid	0.038661	Schwarz criterion		-1.879869
Log likelihood	11.75525	Hannan-Quinn criter.		-2.087481
F-statistic	6.403367	Durbin-Watson stat		1.680918
Prob(F-statistic)	0.032472			

Dependent Variable: LMT(3)				
Method: Least Squares				
Date: 03/23/18 Time: 03:22				
Sample: 1980 1989				
Included observations: 10				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-16.90115	7.190578	-2.350457	0.0511
LRER(3)	-0.008886	0.115732	-0.076779	0.9409
LEXPGDP(3)	1.591616	0.597043	2.665832	0.0322
R-squared	0.680694	Mean dependent var		3.45258
Adjusted R-squared	0.589464	S.D. dependent var		0.093475
S.E. of regression	0.059892	Akaike info criterion		-2.549207
Sum squared resid	0.02511	Schwarz criterion		-2.458431
Log likelihood	15.74603	Hannan-Quinn criter.		-2.648787
F-statistic	7.461283	Durbin-Watson stat		2.370778
Prob(F-statistic)	0.018396			

Dependent Variable: LMT(-1)				
Method: Least Squares				
Date: 03/23/18 Time: 03:30				
Sample: 1990 1999				
Included observations: 9				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-30.74531	10.90805	-2.818589	0.0304
LRER(-1)	0.271516	0.22298	1.217669	0.2691
LEXPGDP(-1)	2.540666	0.9441	2.691098	0.036
R-squared	0.973342	Mean dependent var		3.73403
Adjusted R-squared	0.964456	S.D. dependent var		0.246861
S.E. of regression	0.046541	Akaike info criterion		-3.035769
Sum squared resid	0.012996	Schwarz criterion		-2.970027
Log likelihood	16.66096	Hannan-Quinn criter.		-3.177639
F-statistic	109.5367	Durbin-Watson stat		1.651183
Prob(F-statistic)	0.000019			

Dependent Variable: LMT(-2)				
Method: Least Squares				
Date: 03/23/18 Time: 03:36				
Sample: 2000 2008				
Included observations: 9				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-15.95421	2.352009	-6.78323	0.0005
LRER(-2)	-0.290571	0.082871	-3.50628	0.0127
LEXPGDP(-2)	1.677794	0.170217	9.856824	0.0001
R-squared	0.950474	Mean dependent var		4.189692
Adjusted R-squared	0.933965	S.D. dependent var		0.19956
S.E. of regression	0.051281	Akaike info criterion		-2.841775
Sum squared resid	0.015779	Schwarz criterion		-2.776033
Log likelihood	15.78799	Hannan-Quinn criter.		-2.983645
F-statistic	57.57412	Durbin-Watson stat		1.723918
Prob(F-statistic)	0.000121			

Dependent Variable: LMT(-8)				
Method: Least Squares				
Date: 03/23/18 Time: 03:44				
Sample: 2011 2016				
Included observations: 6				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-24.17518	1.564955	-15.44785	0.0006
LRER(-8)	-0.24138	0.107995	-2.235093	0.1115
LEXPGDP(-8)	2.271279	0.112011	20.27733	0.0003
R-squared	0.992763	Mean dependent var		4.471046
Adjusted R-squared	0.987938	S.D. dependent var		0.213066
S.E. of regression	0.0234	Akaike info criterion		-4.365302
Sum squared resid	0.001643	Schwarz criterion		-4.469422
Log likelihood	16.09591	Hannan-Quinn criter.		-4.782104
F-statistic	205.7693	Durbin-Watson stat		2.875474
Prob(F-statistic)	0.000616			

2.2 Predictions after adjusting for structural breaks following McGregor and Swales (1985)

Dependent Variable: GA				
Method: Least Squares				
Date: 03/23/18 Time: 19:26				
Sample: 1 6				
Included observations: 6				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.760213	0.849437	0.894961	0.4214
GT	1.307123	0.43383	3.012987	0.0394
R-squared	0.694145	Mean dependent var		3.015
Adjusted R-squared	0.617681	S.D. dependent var		1.592052
S.E. of regression	0.984397	Akaike info criterion		3.067626
Sum squared resid	3.876146	Schwarz criterion		2.998212
Log likelihood	-7.202877	Hannan-Quinn criter.		2.789758
F-statistic	9.078093	Durbin-Watson stat		1.694766
Prob(F-statistic)	0.039434			

3.1 Calculations of the estimated growth rate y_{Bt} with no adjustment for structural breaks

Reg1						Reg2					Reg3				Reg4				Reg5				Reg6			
μ	1.434269		Xt	%gdp		μ	0.500898	Xt	%gdp		μ	1.068111	Xt	%gdp	μ	0.908971	Xt	%gdp	μ	2.017349	Xt	%gdp	μ	1.269352	Xt	%gdp
Ave	4.75		5.1	3		Av	1.15	2.7	5.2		Av	1.48	0	6.6	Av	4.44	-0.4	-0.3	Av	4.444444	8.3	4.2	Av	2.483333	3.5	3.3
			7.1	3.8				3.1	4.3				-5.4	5.4			-1.5	-1			2.4	2.7			0.8	2.2
			8.5	6.2				3	1.7				-2.6	-0.4			5.5	-2.1			1	3.7			3.6	2.5
y_{Bt}	**3.311792**		7.6	7.4	y_{Bt}	**2.295877**	-5.2	4.6	y_{Bt}	**1.385624**	-1.3	-1.8	y_{Bt}	**4.8846443**	10.4	1.2	y_{Bt}	**2.203111**	0.1	2.9	y_{Bt}	**1.956379**	3.2	1.7
Ga	5.49		4.9	7.9	Ga	3.25	-4.9	6.1	Ga	2.24	2.7	5.1	Ga	1.39	2.5	3.2	Ga	4.177778	2.8	4.6	Ga	1.883333	3.9	1.3
			3.1	6.1				-1.2	1.7				10.1	-1.2			10.9	3.1			8.6	5.3			-0.1	0.3
			1.4	4.4				4.3	2.2				-3.7	0			7.2	4.3			7.5	5.6				
			4.8	7.2				4.6	-0.1				4.6	2.1			5.3	2.6			7.8	5.4				
			4.2	4.2				3.3	3				8.2	4.2			3.2	0.5			1.5	3.2				
			0.8	4.7				1.8	3.8				2.2	2.4			1.3	2.4								

3.2 Calculations of the estimated growth rate y_{Bt} after adjusting for structural breaks

	Reg1			Reg2			Reg3			Reg4			Reg5			Reg6
μ	1.46148		μ	2.070562		μ	1.591616		μ	2.540666		μ	1.677794		μ	2.271279
Ave	4.75		Ave	1.855556		Ave	1.48		Ave	3.722222		Ave	4.444444		Ave	2.483333
y_{Bt}	3.25013		y_{Bt}	0.89616		y_{Bt}	0.929873		y_{Bt}	1.465058		y_{Bt}	2.648981		y_{Bt}	1.093363
Ga	5.49		Ga	3.1		Ga	2.24		Ga	1.2		Ga	4.177778		Ga	1.883333

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