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Alternative Closures for an Open Economy Model in a Stock and Flow Consistent Framework: The Case of Central America

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Alternative Closures for an Open Economy Model in a Stock and Flow Consistent Framework: The Case of Central America [1]

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Abstract

The main aim of this paper is to test in Central American countries if output adjustments are supply or demand-driven and to provide theoretical insights on the relationship between low productivity and persistent external deficits. At this purpose, a fully-demand-led Stock and Flow Consistent model of an open economy is combined with a supply-driven and/or a demand-driven closure. In a second stage, the empirical evidence using Time Varying Parameter technique and Granger Causality test suggests a supply driven closure for long-run movements and a joint closure demand-supply in the short-run in the period 1992-2014.

Keywords : external-demand, growth, Granger causality, Central America, Bayesian estimation, time-varying parameters

JEL Classification : E12, E16, F43, O47.

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Contents

List of Tables

List of Figures

1 Introduction

In the current integrated and interdependent international context, the relationship between external sector and economic performance remains a controversial topic (Krugman & Obstfeld, 2009). Whether in terms of capital flows and its instability effect on exchange rates and financial markets, or in terms of the persistent deficits in developing and even developed countries (e.g. US) and its effect on inequality and employment, mainstream theory predictions of market forces adjustment seem to hold, at best, weakly.

In particularly, countries from Central America have experienced persistent external deficits and low productivity during periods of high and low growth. These fluctuations have resulted in an important policy discussion on the role of the external sector for achieving an appropriate economic performance. While high deficits could be associated with low external demand, deficiencies in terms of capital formation and productivity could be considered as supply limitations to achieve sustainable and higher economic outcomes.

In this sense, few models after the traditional Mundell-Fleming (Fleming, 1962; Mundell, 1963) and its extensions integrate external and internal sectors of the economy to infer policy implications. In fact, the micro-foundation of modern macroeconomics, normally represented in the use of an aggregate production function, restricts the role of external sector on growth and, more importantly, assumes an implicit supply-driven adjustment after shocks originated on the demand side or even coming from supply itself (e.g. productivity shocks). Given the criticism to this approach and its strong assumptions, specially after the last economic crisis in 2007, models have tried to incorporate market rigidities based on the argument of limited rationality of agents and availability of information, among others.

Nevertheless, these mainstreams models with market rigidities or information issues cannot account for the policy issue of supply and demand constrains in Central America and other developing countries. The current work is developed under an alternative theoretical framework commonly known as heterodox theory, which considers that market rigidities are not the main cause of the limited applicability of mainstream theory on the persistent disequilibrium situations, but on the role of prices as the adjustment mechanism of markets and the less importance given to the demand side of the economy.

The present work integrates a basic Stock and Flow model with an open economy with two closures. The first closure is a demand-driven adjustment, where productivity reacts positively to market size and demand shocks; and the second approach is a supply-driven one, where the propensity to import reflects structural problems that makes expansionary demand unsustainable with respect to the balance of payment. In this sense, prices do not lead to equilibrium and neither rigidities nor market imperfections play the main role leading to persistent disequilibriums. Moreover, the two closures provide a solid base to discuss the relative importance of productivity and balance of payment issues. Is low productivity (competitiveness in international trade terminology) causing trade deficits or it is trade deficits that is affecting the productivity of the economies?

Once the Stock and Flow model is combined with the different closures endogenizing productivity and/or propensity to import, a reduced form equation is derived in order to empirically test which closure is more likely to fit Central American data: supply-driven, demand-driven or a joint closure. In order to give more flexibility to the econometric model the two-step Engle-Granger cointegration is complemented with a Time Varying Parameter Model estimated through Bayesian Methods and Kalman Filter. Using the estimates of the Time Varying Parameters model, Granger Causality Test gives some evidence in favor of a supply-driven closure in the long-run and a joint closure for short-run periods. These results reinforce the relevance of the theoretical model derived and suggest that the economic policy in Central America cannot concentrate in just one of the issues, specially measures that promotes higher productivity.

Given that the theoretical framework used here is less known in the literature, Section 2 explains the main characteristics of heterodox and Section 3 describes a basic Stock and Flow Consistent model with open economy of Lavoie et al. (2007) complemented in Section 4, where the two closure are introduced: supply-driven and demand-driven, in the spirit of Palley (2002) and Setterfield (2012), respectively. In a second stage, in Section 5 the case of Central America is presented in detail. The last section summarizes the conclusions relating the empirical evidence with the theoretical model.

2 Heterodox Theory

The heterodox economic school constitutes an alternative theoretical framework not only in ideas, but also in terms of methodological issues to the mainstream tradition of optimization behavior and its use of prices as a key variable for market clearing conditions. Although heterogeneous in its composition, this alternative school could be characterized by three main features: the relevance of income distribution, the importance of demand over supply, and the study of interest rates as a monetary phenomenon (Vernengo, 1999).

First, in terms of distribution, while the Neoclassical school assumes a strong correspondence between productivity and distribution, for heterodox thinking, distribution deals more with bargaining power of firms and workers and institutions, which at the same time affect prices, growth and cycles. [1]

The second characteristic is centered on the role of demand. In this sense, Keynes has caused some confusion on the distinction between orthodox and heterodox theory given its close connection with his professor Marshall and his influence on the work of Hicks, Samuelson, Modigliani and Solow—referred as main representatives of Keynesian Synthesis (Lavoie, 2009). Based on Keynes, for heterodox theory demand is relevant even in the long-run.

A third theoretical divergence is an illustration of the function of prices and market clearing conditions. In the determination of interest rate, contrary to heterodox school, orthodox theory believes in the existence of a capital market that sets a natural rate of interest beyond the monetary phenomena. However, the latter are crucial in the heterodox models, which includes concepts such as liquidity preferences, fundamental uncertainty and animal spirit together with mark-up processes, separating the determination of interest rate from the capital market.

Finally, price flexibility is normally supposed to be a positive scenario given that reduces the number of frictions in a given market. However, price movements caused by distributional conflict can have negative impact on the economy. Keynes (1936) pointed out the inefficacy of reducing money wages to restore full-employments taking into consideration a potential contraction in aggregate demand and firms' sales. All the previous results, concepts, and methodological disparities explained lead to the three main features of heterodox theory mentioned in the beginning: the importance of distribution, the relevance of demand and the study of interest rate as a monetary phenomenon (not as a clearing price).

3 A Stock and Flow Consistent Model

3.1 General Characteristics

Inspired by the heterodox theory, it is relevant to review the methodology used to integrate the ideas of a particular school into mathematical consistent systems—in this case Stock and Flow Consistent (SFC) frame-

[1]To simplify the exposition, orthodox mainstream and Neoclassical school is used interchangeable, even if they have differences in certain topics.

work.[2] The SFC model emphasizes the accounting coherence of transactions and accumulation processes (Caverzasi & Godin, 2013). Its initial motivation was to have a comprehensive system to study the flow of money and its movements, extending the traditional social accounting approach (Copeland, 1949). The concern on money transformation, movements and uses was complemented with Tobin's (1982) attention on stock evolution and the interdependencies between financial and real sectors. Godley achieved the integration of stock and flow issues and wrote a modern methodology used mostly by heterodox theory (see for example Godley & Cripps, 1983).

The SFC model is composed by two elements: an accounting framework and a set behavioral equations (Caverzasi & Godin, 2013). The accounting scheme is expressed in two balance sheet matrices at least, which fulfill the double-entry principle. A first matrix includes stocks per agent such as bills, capital, loans and net worth (Balance Sheet). A second matrix comprises all transactions among agents incorporating the usual exchange of good and services (i.e. consumption, investment), but also "spending" on asset holding (e.g. change in money, bills, etc.). This accounting framework interconnects all matrices and avoids "black holes" (Godley, 1996). From here, a set of identities is combined with behavioral equations that represent agents' decisions in a context of bounded rationality and expressed as aggregated variables. After substituting, the model gets to a system of difference equations which lead to stationary states and stability analysis.[3] Moreover, SFC is very flexible and it admits different closures. In fact its precursor, Tobin developed behavioral equations more in line with Neoclassical synthesis (Caverzasi & Godin, 2013). Nevertheless, it is important to mention that Godley and Lavoie (2007) modern SFC models provide an explicit mechanism towards the correspondent steady state due to its fully consistent accounting, and are normally demand-led; at the same time, the latter feature is a limitation because they do not include any supply restrictions integrated.

3.2 A Stock and Flow Consistent Model with Open Economy

3.2.1 Formal Model

In this section, a basic SFC model with open economy developed by Godley and Lavoie (2007) is described before introducing a closure that allows for the interaction between supply and demand. Although it is

[2] Other prevailing frameworks are: Dynamic Stochastic General Equilibrium models (DSGE) and Agent-Based (AB) models.

[3] Although mathematically this is similar to DSGE solutions and more to the AB model, SFC models do not have a system of prices that assure convergence and market clearing conditions (except for some part of the financial sector).

an open economy model, its main objective is centered on growth and external balance. Exchange rate considerations and prices in general are assumed to be fixed—resulting in no inflation.[4]

Table 1: Balance Sheet of Stocks

	North			South			$\sum$
	Households	Gvt.	Central Bank	Households	Gvt.	Central Bank	
Cash Money	$+H_h^N$		$-H_h^N$	$+H_h^S$		$-H_h^S$	0
Bills	$+B_h^N$	$-B^N$	$+B_{cb}^N$	$+B_h^S$	$-B^S$	$+B_{cb}^S$	0
Gold Reserve			$+or^N \cdot p_g^N \cdot xr$			$+or^S \cdot p_g^S$	$\sum OR$
Wealth	$-V_h^N$	-V_g^N	0	$-V_h^S$	$-V_g^S$	0	$-(\sum OR)$
$\sum$	0	0	0	0	0	0	0

Note: From Godley et al. (2007).

It is assumed that the world economy is composed of two countries: North and South, which are trading goods, but not capital. Each country has its own government, central bank, and currency. From here, as it was explained in the previous section, the starting point of SFC is the accounting consistency. In Table 1, the Balance Sheet of Stocks shows the main accumulation variables: bills (B_j^i), money (H_j^i) and physical gold (or^i), for $i = N, S$ and $j = h, cb$ (households and Central Bank). The bills are issued by each government and bought by their households and central banks, respectively. It is not possible for households or central banks to buy foreign bonds. Then, government's wealth (V_g^i) is equivalent to its public debt, while in the case of households (V_h^i) is the sum of its money stock and bonds. Central banks' net wealth is zero because they are transferring all the profits coming from bonds interest to their respective government, so its liabilities, money, is equal to its assets, bills and gold.

[4]As a consequence, arguments based on the law of one price and uncovered interest parity from the orthodox theory, as well as arguments related with distributional issues and its effect on effective demand of heterodox school are both set aside to focus on external demand. Moreover, investment is not included in order to simplify and avoid the inclusion of a banking sector, the interaction of inside and outside money, retained profits and inventories.

Given that gold (or^i) does not have a national counterpart, both countries should take part of the sum: $\sum OR = p_g^N \cdot xr + or^S \cdot p_g^S$ (the only non-zero row), where physical quantity of gold is or^i and p_g^i price of gold for each country, and xr the exchange rate, defined as units of south's currency per unit of north's currency. In Table 1, the sums by row of the other stocks, bills and money, are zero within each country, since both assets are only held by nationals. As a consequence, gold is the only stock that uses the exchange rate (xr) to sum up rows. [5] Regarding columns, there is no exception, they must sum up to zero. For instance, in households' column, once total wealth (V_h) is subtracted from the sum of money and bills, there should not be any positive or negative residual, because this would mean an omission of third asset in the accounting system. Conversely, as previously mentioned central banks do not have any wealth, this is transferred indirectly to government or to households through bills and money. Then the sum of government and households' wealth is equal to reserves: $\sum_i (V_h^i + V_g^i) = \sum OR$, $i = N, S$, and all the columns sum up to zero (Godley & Lavoie, 2007).

Changes in stocks per agent and a detail of their transactions comes from Table 2 Transactions-Flow Matrix. Elements with a minus sign represents a spending and those with a positive sign denote income. In this sense, households' spendings are: consumption ($-C^i$), which it is translated into a income for the production sector ($+C^i$); taxes, which are paid to government ($-T^i$); and the rest is used to buy bonds ($-\Delta B_h^i$) or to keep high powered money ($-\Delta H_h^i$). Households' incomes ($+Y^i$) come from the production sector in terms of wages and profits, and from the government that pays interest on their bonds($+r_{-1} \cdot B_{h-1}^i$). On the other hand, producers do not only supply goods for consumption, but also for government spending ($+G^i$) and exports ($+X^i$). In this sense, imports (IM^i) are assumed to be used solely in the production process (e.g. machinery and intermediate good) and exports together with imports are the only transactions among the two countries, besides gold.

[5] In SFC models, rows of stock and flow matrices should sum up zero, except for tangible goods that are not financial assets (e.g. capital, inventories), meaning goods with no counterpart in terms of liability (Godley & Lavoie, 2007). Such is the case of gold (or^i) which is used as reserves for international transactions.

Table 2: Transaction-Flow Matrix

	North Country					South Country				
	Households	Producers	Gvt.	Central Bank		Households	Producers	Gvt.	Central Bank	$\sum$
Consumption	$-C^N$	$+C^N$				$-C^S$	$+C^S$			0
Govt. Exp		$+G^N$	$-G^N$				$+G^S$	$-G^S$		0
North Exports		$+X^N$			$\cdot xr$		$+IM^S$			0
South Exports		$-IM^N$			$\cdot xr$		$-X^S$			0
GDP	$+Y^N$	$-Y^N$				$+Y^S$	$-Y^S$			0
Interest Payments	$+r_{-1}B^N_{h-1}$		$-r_{-1}B^N_{-1}$	$+r_{-1}B^N_{cb-1}$		$+r_{-1}B^S_{h-1}$		$-r_{-1}B^S_{-1}$	$+r_{-1}B^S_{cb-1}$	0
Profits Central Bank			$+r_{-1}B^N_{cb-1}$	$-r_{-1}B^N_{cb-1}$				$+r_{-1}B^S_{cb-1}$	$-r_{-1}B^S_{cb-1}$	0
Taxes	$-T^N$		$+T^N$			$-T^S$		$+T^S$		0
Change in cash	$-\Delta H^N_h$			$+\Delta H^N_h$		$-\Delta H^S_h$			$+\Delta H^S_h$	0
Change in bills	$-\Delta B^N_h$		$+\Delta B^N$	$-\Delta B^N_{cb}$		$-\Delta B^S_h$		$+\Delta B^S$	$-\Delta B^S_{cb}$	0
Change in reserves				$-\Delta or^N \cdot p^N_g \cdot xr$					$-\Delta or^S \cdot p^S_g$	0
$\sum$	0	0	0	0		0	0	0	0	0

Note: From Godley et al. (2007).

Governments get resources from taxes ($+T^i$) and selling bonds ($+\Delta B^i_{-1}$) and pay for goods ($-G^i$) and interests on public debt to households and central banks ($-r_{-1} \cdot B^i_{-1}$, where B_{-1} stands for total bonds in period $t-1$). Interests of bills held by Central Banks ($+r_{-1} \cdot B^i_{cb-1}$) are given back to government through the transfer of profits ($-r_{-1} \cdot B^i_{cb-1}$, from central perspective). Moreover, each central bank provides the change in money holding desired by households ($+\Delta H^i_h$) and acquires bills from government as a residual buyer ($-\Delta B^i_{cb}$). At the same time, the reserves of gold are used by the two monetary institutions in case of external unbalance. The spendings and incomes of each agent (columns) and the transactions among agents (row) should sum up to zero with no exception.

After having these two matrices: stocks and transactions (flows), there is no "black hole" in stocks' evolution thanks to the double entry principle. All relationships and trade between agents and its feedbacks to stock are explicit. Based on this consistency a set of identities are derived and combined with behavioral equations in order to construct the system. From the production sector in column 2 of the transaction matrix, the macroeconomic identity equivalent to National Income and Products Accounts (NIPA) is derived:

$$Y^i = C^i + G^i + X^i - IM^i, \tag{1}$$

where $i = N, S$. Each of this demand components should respond to a behavioral rule. In the case of imports, they are assumed to depend on their level of economic activity, given that they are used to produce:

$$IM^i = \mu^i \cdot Y^i, \tag{2}$$

where μ^i is the propensity to import of each country. This parameter will be really important for the steady state and for the closures in Section 4. The exports are inferred from row 3 and 4 of the transaction matrix:

$$X^N = IM^S / xr \tag{3}$$

$$X^S = IM^N \cdot xr, \tag{4}$$

The propensity to export of country i is the the propensity to import of country $-i$ and vice versa. Another component of demand is consumption. It is assumed that households behave in a myopic way and base their decision on their disposable income YD^i and in a lesser extent on previous wealth (V^i_{h-1}), analogous to Modigliani consumption function (Modigliani, 1986):

$$C^i = \alpha^i_1 \cdot YD^i + \alpha^i_2 \cdot V^i_{h-1},\ 0 < \alpha^i_2 < \alpha^i_1 < 1 \tag{5}$$

$$YD^i = Y^i + r^i_{-1} \cdot B^i_{h-1} \cdot -T^i, \tag{6}$$

where the same propensity to consume α^i_1 is applied to wages, profits (summed up in Y^i) and interest gains to set aside the relation effective demand-distribution of income. Similarly, tax rates are applied equally to all sources of income:

$$T^i = \theta^i (Y^i + r^i_{-1} \cdot B^i_{h-1}),\ 0 < \theta^i < 1 \tag{7}$$

On the other hand, financial asset decisions are integrated in a two stage process following Keynes (1936) approach. First, the level of consumption and savings is determined (5), and then the proportion of wealth (including new savings) held in each asset is assessed (Godley & Lavoie, 2007):

$$V^i_h = V^i_{h-1} + (YD^i - C^i) \tag{8}$$

$$B^i_h / V^i_h = \lambda^i_0 + \lambda^i_1 \cdot r^i - \lambda^i_2 \cdot (YD^i / V^i_h) \tag{9}$$

$$H^i_h / V^i_h = (1 - \lambda^i_0) - \lambda^i_1 \cdot r^i + \lambda^i_2 \cdot (YD^i / V^i_h) \tag{10}$$

In particular, (8) updates wealth from previous period by adding savings and (9) and (10) define the proportion of wealth held in bills and in money. Brainard and Tobin (1968), share the same two-stage structure decision making and they added some formal restrictions to (9) and (10): a)intercepts of both equations should sum up to one and b) the effect of interest (r^i) and the ratio disposable income-wealth (YD^i/V) should be symmetric among equations. These conditions allow to maintain proportions between zero and one, and any increase (decrease) is compensated by a decrease (increase) induced by symmetry. In fact, (10) could be substituted by: $H^i_h = V^i_h - B^i_h$, leaving money as a residual asset, coherent with the special functions of money and fundamental uncertainty (see for example Dequech, 2000).

With respect to supply, governments issue bonds to cover their deficits. These deficits incorporate interest payments and profits transferred from the Central Bank. The difference between the supply of bonds of the government and the demand of bonds of households is bought buy the Central Bank (residual buyer):

$$\Delta B^i_s = (G^i + r^i_{-1} \cdot B^i_{s-1}) - (T^i + r^i_{-1} \cdot B^i_{cb-1}) \tag{11}$$

$$B^i_{cb} = B^i_s - B^i_h, \tag{12}$$

where B^i_s is the amount of bills supplied by the government. At the same time, given that financial and money market is demand-led (13)—endogenous money —, the Central Bank must provide a supply of money according to (9). From Central Bank balance, the difference between changes in money supply (ΔH_s^i), responding to households demand, and changes in bills (ΔB_{cb}^i), responding to government supply, is counterbalanced by changes in reserves:

$$H_s^i = H_h^i \tag{13}$$

$$\Delta(or^i \cdot p_g^i) = \Delta H_s^i - \Delta B_{cb}^i \tag{14}$$

In order to complete the system, some additional equations are needed. The price of gold is assumed to be in the north's currency and fixed (15). Consequently, the price of gold on the South should be converted using the exchange rate xr. Moreover, government spending, exchange rate and interest rate are assumed to be given and fixed:[6]

$$p_g^N = \bar{p}_g^N \tag{15}$$

$$p_g^S = p_g^N \cdot xr \tag{16}$$

$$xr = \bar{xr} \tag{17}$$

$$r^i = \bar{r}^i \tag{18}$$

$$G^i = \bar{G}^i \tag{19}$$

$$\Delta or^S = -\Delta or^N \tag{20}$$

The last equation (20) reflects the last row of Table 2, changes in reserves from one country are absorbed by the second country. This equation over-determines the system, then it is called redundant equation, since it is already implicit in all the other equations (1-19), so it can be omitted. This is similar to the "Walrasian principle" and it is a consequence of the accounting consistency combined with equality of behavioral supply and demand equations.

3.2.2 Steady States and Simulations

Given the evolution of stocks: household wealth, gold and government public debt, a first steady state called "quasi-steady state equilibrium" is proposed by Godley et. al (2007). The quasi-steady state is achieved when

[6] However, it is important to clarify that fixed exchange regime and interest rate is not the source of money endogeneity in the model. In the orthodox theory, Central Bank keeps the interest rate fixed, thus money endogeneity is supply-caused and induced by monetary policy decision. In this model, endogeneity is demand-caused based on households portfolio decisions (Lavoie, 2014).

households reach a constant wealth, $\Delta V_h = 0$. Substituting in (8), the basic macroeconomic identity (1) and the definition of disposable income in (6):

$$\begin{aligned} V_h^i &= V_{h-1}^i + (YD_h^i - C_h^i) \\ \Delta V_h^i &= C^i + G^i + X^i - IM^i + r_{-1}^i \cdot B_{h-1}^i - T^i - C^i \\ \Delta V_h^i &= (G^i + r_{-1}^i \cdot B_{h-1}^i - T^i) + (X^i - IM^i), \end{aligned} \tag{21}$$

which shows that in order for wealth to be constant, there should be an equality between external and fiscal position $IM^i - X^i = G^i + r_{-1}^i \cdot B_{h-1}^i - T^i$. Taking into account that taxes and imports depend on economic activity, the quasi-steady state is given by:

$$Y^{i*} = \frac{G_{NT}^i + X^i}{\theta^i + \mu^i}, \tag{22}$$

where $G_{NT}^i = G^i + (1 - \theta^i) \cdot r_{-1} \cdot B_{h-1}^i$, is the net government spending. Basically, it subtracts taxes paid for interests gains on government debt, from total spending $G^i + r_{-1} \cdot B_{h-1}^i$. However, this quasi-steady state leaves public and external deficit (surplus) constant over time, causing a continuous deterioration (amelioration) of public debt and reserves. This is due to the absence of the automatic mechanism of orthodox theory which uses prices and market clearing condition to achieve a consistent steady state. For example, the adjustment through interest rates, which is also a price, in a traditional Mundell-Fleming model.

In this context of persistent deficits (surpluses), Godley and Lavoie (2007) suggest some alternatives: adjustment through interest rate, exchange rate, borrowing (lending) of reserves, control on imports or deflate (re-activate) economic activity. Taking into account that: this model does not account for all the effects of exchange rate (e.g. capital movements), the relevance of fiscal rules (e.g. Maastricht rule, Washington Consensus) and recent studies suggesting a policy biased towards fiscal austerity (see for example Dosi, Napoletano, Roventini, & Treibich, 2014), the last adjustment is chosen, meaning deflating (re-activating) economic activity through a government spending rule for both countries:

$$G^i = G_{-1}^i + \varphi^i (\Delta or_{-1}^i \cdot p_{g-1}^i) \tag{23}$$

In other words, this equation replaces a constant spending (19), for a policy equation which deflates or stimulates the economic activity based on signals provided by changes reserves, reducing the twin deficit (surplus) to zero. If $X^i = M^i$ is added to $\Delta V_h^i = 0$ condition, the super-steady stead is:

$$Y^{i**} = \frac{X^i}{\mu^i} = \frac{\mu^{-i} Y^{-i}}{\mu^i} \tag{24}$$

In this respect, the super steady-state is not achieved by market forces, but by a policy decision.[7] Furthermore, it is important to mention that even if only spending is chosen as short-run adjustment, under SFC context, the choice of adjustment (e.g. exchange rate, interest rate) not only affects the route to the super-steady state, but also the super-steady state itself will be different for each option (this is consistent with the path dependent and accumulative causation presented in Section 2). An example will be presented in the simulations below.

This spending adjustment could be associated with a Neoclassical closures where the limits come from a fixed quantity of labor or capital (Taylor, 2004). However, there is an important distinction. The constraint in this SFC model is given by the demand of the second country. Then, production limits are set by external demand and not by supply factors. This external constraint was first proposed by Harrod (1949) and in a modern version by Thirlwall (2002).

Particularly, two simulations can exemplify the features of this fiscal adjustment following (Godley & Lavoie, 2007). A base scenario (Base) and two alternatives scenarios (Scenario 1 and 2) are set, starting from two very similar countries in terms of initial conditions and parameters (see Appendix B.1 for details on parameters). In all scenarios there is an increase of μ^S, propensity to import of the South, in the period 16 to make the South resemble a developing country (e.g. a Central American country) and the North to a developed country (e.g. US). In the Base, the spending is assumed to be exogenous and constant for both countries (19) and there will be no response to persistent twin deficits (surplus). In Scenario 1, spending of both countries will follow the short-run adjustment (23), then the country will decrease (increase) spending to eliminate the deficit (surplus) and achieve the super-steady state (24). The last scenario, Scenario 2, leaves the spending of the South (developing country) constant ($G^S = \bar{G}^S$) and the North increases the level spending permanently ($G^N = \bar{G}^N + Constant$) starting also in period 16, which at first seems that it moves the cost of the adjustment from the South to the North and could affect the developed country.[8]

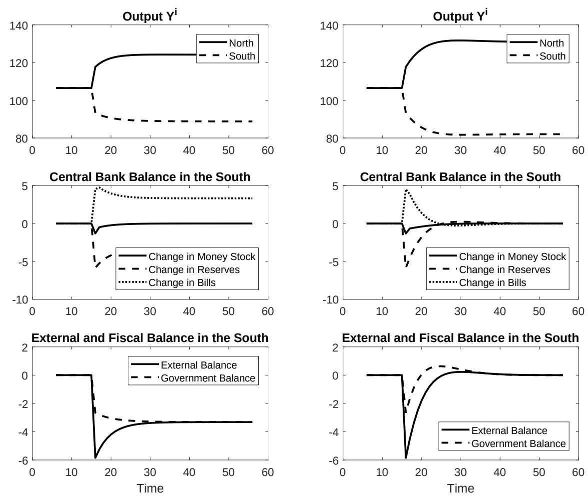
In the first column of Figure 1, the Base scenario is presented, as previously mentioned there is no spending adjustment, as a result, economic activity of South and North move in opposite direction. The South has a lower quasi-steady state and the North has an important increase on its quasi-steady state. Nevertheless,

[7]Although the quasi-steady state (22) is the inertial situation, it is not sustainable; the spending adjustment (23) or some other is strictly needed to have a stock consistent equilibrium.

[8]Scenario 2 is a proposal of the present work in the spirit of Godley et al. (2007) and Central American Experience (60's).

Central Bank balance in the South is in a risky situation, changes in reserves get to a point of continuous drops and bills are translated into an unsustainable growth of debt. Both stocks' dynamic are due to the twin deficit in row 3 column 1 of the Figure 1 corresponding to (22).[9]

Figure 1: Effect of an increase of μ^S, with exogenous (left) and endogenous (right) government spending



In the second column of Figure 1, the reaction fiscal policy function (23) is added for both countries (Scenario 1). Specifically, a higher μ^S in period 16 provokes an external deficit for the South, which impacts the balance of the South's Central Bank in terms of loss of reserves and it increases bills purchases to finance fiscal deficit.[10] Therefore, the government of the South responds by decreasing spending by an amount equals to a factor of $\varphi^S = 0.25$ times the drop in reserves, resulting in a decrease of economic activity and imports together with a reduction of fiscal deficit. In fact, in period 20, South achieves a fiscal surplus and it manages to stabilize bills and gold stocks.[11] Similar adjustments have been applied by the International Monetary Fund for developing countries (e.g. Central America during the 80's and 90's) and other fiscal

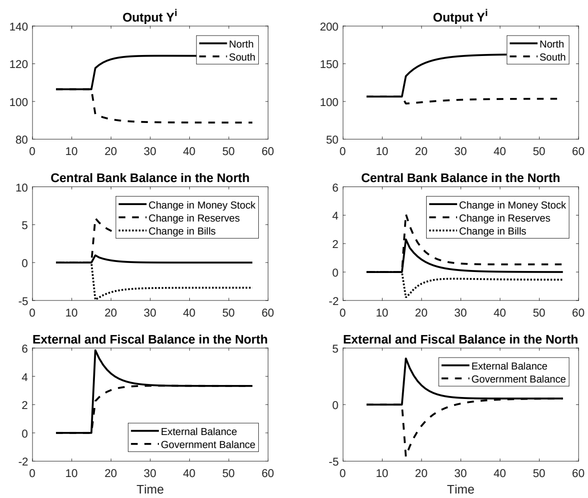
[9] Even if the initial movement of money and reserves can be thought as the compensation hypothesis of the traditional Mundell-Fleming with fixed exchange-rate, this is not the case because it is not a policy decision, but a consequence of endogenous money. Indeed, in medium to long run this relation reserves-money supply disappears even if reserves continue falling, because households' portfolio is already adjusted (Godley & Lavoie, 2007).

[10] This fiscal deficit is a consequence of the initial fall of output and taxes.

[11] It is important to mention that North applies the same reaction function and it increase its government spending, expanding its output and reaching the higher super-steady state.

rules follow an analogous mechanism (e.g. Maastricht Treaty).

Figure 2: Effect of an increase of μ^S, with $\Delta G^N = 0$ (left) and with $\Delta G^N > 0$ (right)



On Figure 2, Base scenario (left) and Scenario 2 (right) are simulated. On the left, the Base Scenario is again presented, but from the North's perspective.[12]. On the second column, in Scenario 2, government spending is exogenous in both countries, but the North increases it by 10 $\Delta G^N_{t=16} = 10$ just in period 16, translated into a permanent higher level of spending thereafter. Then, it can be noticed that North increases its output level beyond the level on the Base Scenario and Scenario 1, and the South experienced almost no change in economic activity. In this context, the increment on G^N stimulates Y^N and IM^N goes up. Consequently, South's exports grow and close the external deficit, Y^S and T^S do not fall significantly and fiscal deficit in the South ends close to zero.

Therefore, for the North, the increase in government spending is translated into a higher growth, deficits close to zero (a small surplus) and the accumulation of reserves and debt reduction are slower than in the Base Scenario, close to the super-steady state. In this sense, Scenario 2 proves that there could be an approximated G^N that impacts positively both countries in terms of adjustment (route) and with a higher super-steady. In other words, North's fiscal policy can counterbalance the negative shock of μ^S and, as mentioned before, the choice among adjustment policies affects not only the route but also leads to a different super-steady

[12]After the negative shock on μ^S, the North has a persistent twin surplus that is translated into a continuous debt (bills) reduction and a persistent increase in gold reserves

state. Compared to Scenario 1, which proposes an austerity agreement for both countries, in Scenario 2 the expansive fiscal policy of the North leaves both countries in a better situation (Lavoie, 2014). Moreover, it is relevant to notice that even without a shock in propensities to import, both countries can achieve a higher super-steady state by jointly increasing their spendings, demonstrating the lack of a supply constraint that interacts with demand side.

Nevertheless, Scenario 2 has some drawbacks. First, its feasibility is really limited, given that it requires a high coordination among countries.[13] Second, in this model both countries are only constrained by external demand, once they agree on expansive policies, they do not have any supply constraint in terms of productive resources because the model is fully demand-led. In the next section, supply considerations are added to address this latter disadvantage.

4 Closures: Demand and Supply Driven

The simple SFC model with open economy in the previous section showed the pertinence of demand factors in policy decisions, specially the consequences of fiscal austerity. However, there is usually an implicitly prevalence of supply or demand in orthodox and heterodox model, respectively. In the case of SFC with open economy, there is a fully demand-led structure, the only constraint faced by each country is external demand. In this section two closures are added to SFC model as a proposal in order to include supply factors into the analysis: a supply-driven adjustment, suggested by Palley (2002), and a demand-driven adjustment suggested by Setterfield (2012).

First of all, it is important to restate that for the simplification of the closures analysis, SFC model reaches the super steady-steady equilibrium (24) through spending adjustment (23). From here, one way to introduce supply factors is to incorporate a maximum capacity of production. This can be similar to the limiting full-employment level of economic activity in the context of a Neoclassical closure. In this sense, this task was addressed more in detail by Harrod in a closed economy (1972, 1939). Harrod proposed three concepts: warranted growth, natural rate of growth, and effective growth.

[13]However, policies on Scenario 2 could still be a potential policy for integration processes (i.e. European Union, Central America) and it could be discussed in International institutions in charge of countries' external balances and growth. In fact, Keynes' proposal on this matter, during the discussions of the creation of the International Monetary Funds, was more in line with Scenario 2 (Lavoie, 2014).

First, warranted growth is defined as the rate of growth needed to induce a level of investment that could absorb all savings in the economy. Then, an equivalent concept to warranted growth could be the super-steady state of SFC (24), which is the level of output coherent with a level of imports that absorbs no more than the exports reached (Thirlwall, 2002).

Second, natural rate of growth in Harrod's theory is the sum of productivity and population growth. While warranted growth is interpreted as a full-utilization of capital, natural rate of growth represents a full employment of labor. As suggested by Palley (2002) this second concept is absent in external constrained growth models. The third concept is straightforward, effective growth is comparable to the observable growth of SFC.

On the other hand, Harrod emphasizes the difficulty of arriving to an equality of the three growths, given that savings depend on distribution and economic activity (Kaleckian closure), warranted growth depends on firms' expectation, and natural growth is exogenously determined, so there is no mechanism of adjustment ("knife edge"). Analogously, SFC with open economy does not have any mechanism to close external and fiscal unbalances. However, through a policy rule which endogenizes spending, SFC reaches the super-steady state equilibrium, an equivalent equality between effective and warranted growth (Thirlwall, 2002). Nevertheless, the problem continues to be the absence of a natural rate growth rate or level. In this sense, a limiting supply could be:[14]

$$Y_n^i = \lambda^i \bar{N}^i, \tag{25}$$

where Y_n^i is the natural level of output given by labor productivity (λ^i) and a fixed level of labor. This equation is added to the system of SFC model with open economy, but still both processes, the super steady-state (Y_{ss}^i, from now on) and the natural level of output (Y_n^i), are independent. Following Palley (2002), a first closure to connect these two elements can be supply-driven by endogenizing propensities to imports:

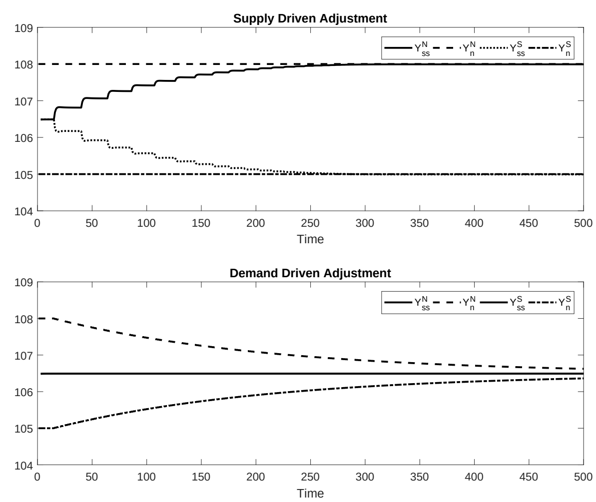
$$\Delta\mu^i = -\xi^i(Y_{n-1}^i - Y_{ss-1}^i),\ \xi^i > 0, \tag{26}$$

The main argument is that propensity to import tends to increase after an excess of demand, $Y_{ss-1}^i > Y_{n-1}$, because an expanding economy faces labor market bottlenecks (White & Thirlwall, 1974; Hughes & Thirlwall, 1979). Specifically, once all labor is employed ($\bar{N}^i$), demand is covered by competitive imports. Regarding non-competitive imports, the argument can be extended if the increases on medium to long-run

[14]Simplifying the steps of Harrod, expectations are left out.

investments are associated with imported machinery and inputs (Arestis & Milberg, 1993). As a consequence, in SFC model, taking into account that $Y^i_{ss-1} = \frac{X^i}{\mu^i}$, reductions on μ^i allow the convergence of Y^i_{ss-1} to Y^i_{n-1} (see Figure 3), in case of excess of demand.

Figure 3: Supply and Demand driven closures



However, the supply-driven closure in a SFC model has other restrictions. First, if both countries are identical and $\xi^N = \xi^S$, one country should be in excess of demand while the other one should be in excess of supply, which seems to be not consistent with the correlation among countries' cycles (see for example Matesanz, Ferrari, Torgler, & Ortega, 2017; Basnet & Sharma, 2013). Second, even if both countries have different excesses, the magnitudes should be consistent with the volume of stocks (i.e. gold reserves and government bills) in order to be able to achieve the equilibrium before a "default".

This stock requirements are also relevant when $\xi^N \neq \xi^S$.[15] reserves and low debt to face these periods. A potential option is to increase the reaction function sensitivity (φ^i) to reduce initial stocks requirements, revealing an induced relationship between the speed of adjustment and the fiscal policy reaction function that can be tested in future studies.

In order to perform an analysis of stability conditions of the supply adjustment, inter-country interaction is simplified by considering only one country. This could be interpreted as special case in which one of the

[15]The difference in adjustment speeds allows to drop the first restriction. Despite both countries being able to be below (over) the full-employment, there should be enough

countries has low influence on the other, applicable for small open economies such as Central America. In this sense, assuming exogenous exports ($\bar{X}$) and substituting super-steady state of SFC model (24) in the adjustment equation (26):

$$\mu_t = \mu_{t-1} - \xi \left(\bar{Y}_n - \frac{\bar{X}}{\mu_{t-1}} \right), \tag{27}$$

where $\bar{Y}_n$ is the natural level of economic activity which is fixed given that λ and $\bar{N}$ are constant. This is coherent with exogeneity of productivity on Neoclassical model, such as total productivity of factors in the production function. Solving this first order nonlinear equation, the new steady state is:

$$\mu^* = \frac{\bar{X}}{\bar{Y}} \tag{28}$$

More importantly, out of equilibrium dynamics (27) can be linearized using a first degree Taylor approximation around its steady state:

$$\mu_t - \mu^* \approx \frac{\bar{X} - \xi \bar{Y}^2}{\bar{X}} (\mu_{t-1} - \mu^*)$$

Then, the stability condition will be given by:

$$0 < \xi < 2\bar{X}/\bar{Y}^2 \tag{29}$$

As a consequence, the steady state is equivalent to the ratio export to natural level of economic activity. Its convergence, taking into account the square terms in the denominator of (29), seems to be less likely given that the range of stability is small. Also, its empirical estimation could be sensible to small samples and short periods.

The second closure is a demand-driven adjustment in the spirit of Setterfield (2012). Starting from the natural level of output (25), productivity can be endogenized under Verdoorn's Law argument. Verdoorn's Law (2002) establishes a direct positive relationship between labor productivity and output, in terms of demand:

$$\Delta\lambda^i = \chi^i (Y^i_{ss-1} - Y^i_{n-1}), \ \chi^i > 0 \tag{30}$$

In general, this relationship is a result of labor specialization coming with the increase of market size, and it is usually applied to the case of manufacturing given its increasing returns to scale that allow to endogenize the aggregate natural level of output. Thus, supply capacity is sensible to movements in demand shocks even in the long-run, coherent with heterodox theory. In the SFC model, the demand side is represented by the super-steady Y^i_{ss-1}, then in (30) productivity reacts to the excess of demand by increasing the natural level of output (see Figure 3). In this case, stock consistency requirements are less binding compared with the previous supply-driven closure because the movement in productivity do not affect the external sector directly as in the case of the propensity to import.

Analogous to supply closure, if exports are held constant ($\bar{X}$) and substituting the super-steady state:

$$\lambda_t = \lambda_{t-1} + \chi\left(\frac{\bar{X}_n}{\bar{\mu}} - \lambda_{t-1}\bar{N}\right) \tag{31}$$

The procedures to get the steady state and the stability condition of this second closure are similar to the supply-driven case, but with no approximation given that is a linear difference equation:

$$\lambda^* = \frac{\bar{X}_n}{\bar{\mu}\bar{N}}, \tag{32}$$

$$0 < \chi < 2/\bar{N} \tag{33}$$

A potential third alternative is to combine both adjustments at the same time, allowing for a joint supply-demand-driven adjustment:

$$\begin{cases} \mu_t &= \mu_{t-1} - \xi(\lambda_{t-1}\bar{N} - \frac{\bar{X}}{\mu_{t-1}}) \\ \lambda_t &= \lambda_{t-1} + \chi(\frac{\bar{X}}{\mu_{t-1}} - \lambda_{t-1}\bar{N}) \end{cases} \tag{34}$$

Solving the steady state for productivity and propensity to imports gives a multiple equilibria situation with infinite solution for $\lambda > 0$ and $\mu > 0$:

$$\begin{cases} \mu^* &= \frac{\bar{X}}{\bar{N}\lambda^*} \\ \lambda^* &= \frac{\bar{X}}{\bar{N}\mu^*} \end{cases} \tag{35}$$

In terms of the dynamics out of the equilibrium using a first degree Taylor approximation again, (34) is equivalent to:

$$\begin{pmatrix} \mu_t - \mu^* \\ \lambda_t - \lambda^* \end{pmatrix} \approx \begin{pmatrix} 1 - \frac{\xi\lambda^{*2}\bar{N}^2}{\bar{X}} & -\xi\bar{N} \\ \frac{-\chi\lambda^{*2}\bar{N}^2}{\bar{X}} & 1 - \chi\bar{N} \end{pmatrix} \begin{pmatrix} \mu_{t-1} - \mu^* \\ \lambda_{t-1} - \lambda^* \end{pmatrix} \tag{36}$$

Taking into account the infinite equilibria, it can be checked that one of the eigenvalues of the system is $r_1 = 1$. Then, its second eigenvalue (r_2) can be derived using the fact that the product of eigenvalues is equal to the determinant of the jacobian, $r_1 \cdot r_2 = |J|$. Finally, decomposing the Jacobian a new representation is obtained :

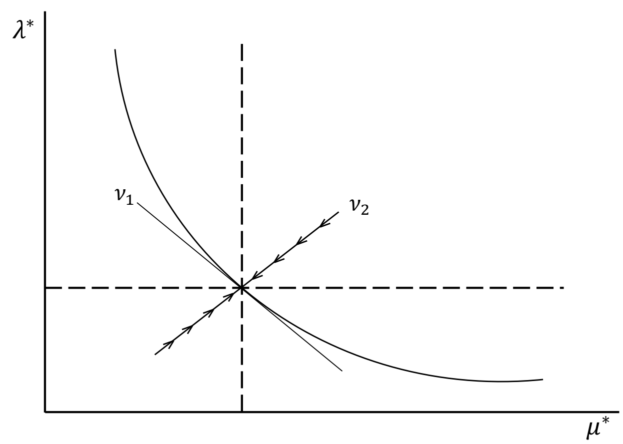
$$\begin{pmatrix} \mu_t - \mu^* \\ \lambda_t - \lambda^* \end{pmatrix} \approx \begin{pmatrix} 1 & -\xi \\ \frac{-\lambda^{*2}\bar{N}}{\bar{X}} & -\chi \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & 1 - \chi\bar{N} - \frac{\xi\lambda^{*2}\bar{N}}{\bar{X}} \end{pmatrix} \begin{pmatrix} 1 & -\xi \\ \frac{-\lambda^{*2}\bar{N}}{\bar{X}} & -\chi \end{pmatrix}^{-1} \begin{pmatrix} \mu_{t-1} - \mu^* \\ \lambda_{t-1} - \lambda^* \end{pmatrix}$$

From here the stability condition for r_2 is:

$$0 < \chi < \frac{2}{\bar{N}} - \frac{\xi\lambda^{*2}\bar{N}}{\bar{X}}, \tag{37}$$

From this derivation in Figure 4, the curve with infinity equilibria is shown with the two eigenvectors. For the first vector (v_1) corresponding to $r_1 = 1$ its stability is not defined for first order conditions. This indeterminacy in local analysis is because small shocks around the equilibrium do not tend to get back to their previous position given the multiplicity of equilibria. In the case of v_2 under (37), shocks on this line return to the previous steady state.

Figure 4: Stability using a joint closure



Therefore, three different closures have been added to the SFC model with open economy to account for supply constraints. From the demand and supply-driven closures individually it seems at first that the latter has a smaller range of stability given the square term in (29). When both closures are combined, stability is not straightforward, because of the presence of multiple equilibria. In order to have more insights on the application of these closures: demand, supply and joint closure, next section provides an empirical analysis to infer which of them is more likely for the case of Central America.

5 Evidence on Central America

An interesting case of study is that of developing countries. Among different schools of thought, the majority of arguments suggests a supply-driven adjustment given their scarcity of capital (25). Kalecki (1976) argues that developing countries have both problems: demand and supply deficiencies, and thus Keynesian policies are less effective. Nevertheless, some other authors dissent and claim that usually excess of capacity is the norm more than the exception (see for example Taylor, 1979).

Even if authors of different theories agree on the supply difficulties in developing countries, they can differ greatly on the causes and policy recommendations. For instance, Prebisch's theory addresses the constraints faced by third world countries to industrialize and recommends a process of Import Substitution Industrialization (ISI) with policies that protect internal market (Caldentey & Vernengo, 2016). On the contrary, other authors from the orthodox school, argue in favor of market liberalization strategies and free mobility of capital with foreign direct investments benefits.

For this reason, a group of developing countries such as Central America can be used to test the two closures derived in the previous section, in the context of a public policy debate: either by solving balance of the payments constrained growth would also solve supply deficiencies (demand-driven closure) or addressing supply problems would automatically improve external balance issues (supply-driven closure). Since the SFC model involves only two countries, each Central American country will be analyzed with respect United States (US) as the main trade partner of the region.

5.1 Empirical Strategy

Based on the two alternative closures of SFC model with open economy in Section 4, it can be noticed that they induce an ordering dynamic in the model. In the supply-driven closure, starting from an equilibrium $Y^i_{n-1} = Y^i_{ss-1}$, after a exogenous shock in Y_{n-1}, μ^i reacts and it produces an adjustment in Y^i_{ss}. As a result, it could be argue that Y^i_n tends to precede Y^i_{ss}. The contrary can be observed for the demand-driven closure, a shock in Y^i_{ss-1} influences productivity λ^i and Y^i_n, then Y^i_{ss} precedes Y^i_n.

In this sense, following Granger (1969) and Sims (1972) a variable X causes Y if the set $\{X_{t-1}, ...X_{t-p}\}$ improves the forecasting of Y, conditionally on $\{Y_{t-1}, ...Y_{t-p}\}$. Particularly, from the two closures with

$p = 1$:

$$\begin{pmatrix} g_{ss} \\ g_n \end{pmatrix} = \begin{pmatrix} \beta_{1,0} \\ \beta_{2,0} \end{pmatrix} + \begin{pmatrix} \beta_{1,1} & \beta_{1,2} \\ \beta_{2,1} & \beta_{2,2} \end{pmatrix} \begin{pmatrix} g_{ss-1} \\ g_{n-1} \end{pmatrix} + \begin{pmatrix} u_1 \\ u_2 \end{pmatrix}, \tag{38}$$

where g_j for $j = ss, n$ is the growth rate of Y_j^i, and i refers to Central America countries. If $\beta_{1,2}$ is significantly different from zero and $\beta_{2,1}$ is not, supply-driven closure is more likely; the contrary would imply the same for the demand closure. In case of joint significance of $\beta_{1,2}$ and $\beta_{2,1}$, there would be evidence of a joint closure of (34). A fourth outcome could be that both parameters are not significantly different from zero and both constraints are independent. In the last two circumstances policies would need to be focused on both demand and supply.

However, there is an important issue, neither Y_{ss}^i nor g_{ss} is observable. While g_n can be approximated by the sum of the growth of labor productivity and labor force, g_{ss} refers to the maximum growth allowed by the external constraint.

A feasible solution was proposed by Thirlwall (2002) in a modern version of Harrod multiplier (24). Starting from a balanced external account, equivalent to the super-steady state conditions in SFC model of previous section:

$$P^i \cdot x^i = P^{-i} \cdot m^i \cdot xr, \tag{39}$$

where P^i and P^{-i} stands for internal and external prices, and x^i and m^i for real exports and imports. In a second step, Thirlwall uses Cobb-Douglas demand functions for exports and imports in log terms:

$$\log(x_t^i) = \log(A_x^i) + \eta^i \cdot [\log(P_t^i) - \log(P_t^{-i}) - \log(xr_t)] + \mu^{-i} \cdot \log(Y_t^{-i}) + u_t, \tag{40}$$

$$\log(m_t^i) = \log(A_m^i) + \Psi^i \cdot [\log(P_t^{-i}) + \log(xr_t) - \log(P_t^i)] + \mu^i \cdot \log(Y_t^i) + \varepsilon_t \tag{41}$$

Combining (39) in log-terms with (40) and (41) and deriving with respect to time:[16]

$$g_{ss}^i = \frac{[(1 + \eta + \Psi) \cdot (g_{P^i} - g_{P^{-i}} - g_{xr}) + \mu^{-i} \cdot g_{ss}^{-i}]}{\mu^i}, \tag{42}$$

the subindex ss is added to the growth rates of outputs given that (39) holds. If real exchange rate growth is stationary around zero (Relative Purchasing Power Parity, PPP), $E(g_{P^i} - g_{P^{-i}} - g_{xr}) = 0$, or if the sum of price elasticities are close to one $\eta^i + \Psi^i \approx 1$ (rejecting Marshal-Lerner condition):

$$g_{ss}^i = \frac{\mu^{-i} \cdot g_{ss}^{-i}}{\mu^i} = \frac{g_x}{\mu^i}, \tag{43}$$

[16] The $\log(A_x)$ and $\log(A_m)$ terms are constant and they becomes zero.

which is coherent with (24), but in growth terms, it is usually called "Thirlwall's Law". Then, the estimation of (40) and (41) can be used to get μ^i and μ^{-i}, and in a second step g_{ss} can be approximated with (43). At the same time, (40) and (41) isolate the effects of output and prices, consistent with the assumption of SFC model with open economy of keeping prices fixed. Once g_{ss}^i is observable, a Granger causality test can be performed in (38) to make inference on the four hypothesis explained before: Supply-Driven Closure, Demand-Driven Closure, Joint Closure or independent processes.

Thirlwall's Law has received many theoretical and empirical criticism. Theoretically, the main assumptions are still debated: the role of internal demand is omitted, the omission of price dynamics and its influence on external constraint, the lack of distinction between small and large countries and the omission of supply considerations, which was addressed in the previous section (see for a review on criticisms Blecker, 2016).

Empirically, even when many studies have been done for developing and developed countries, there are still some concerns on: biases coming from using only two countries instead of including all the trade partners, simultaneity and changes in export and import compositions (in terms of goods and destination or origin). More importantly, empirical studies have been reproached of trying to prove a tautology given the the usual objective in this literature is to test if the observed long run growth of output g^i is close to g_{ss}^i of (43), which can be proven to be equivalent to test a near- identity $g_x^i = g_m^i$ (see for a example Cortes & Bosch, 2015).

Despite these criticisms, the use of the Thirlwall's Law here is only to approximate g_{ss}^i and make it observable.[17] Also, in the process of estimating g_{ss}, a point raised in the criticisms is particularly relevant to the case of Central America, the problem of parameters stability. The region has experienced structural changes in the external sector that could have affected exports and imports composition. In fact, previous studies at a regional level and country specific allude to this difficulty.

For instance, at a regional level, Moreno-Brid and Pérez (1999) include 5 out of the 7 countries for the period 1950-1996 in a multivariate cointegration analysis (Johansen, 1991) following the two equations (40) and (41). The authors obtain a high association between the observed growth (g^i) and Thirlwall's Law

[17]The empirical strategy used here could also be considered a different method for testing the endogeneity of natural rate of growth giving that in the demand-driven closure Verdoorn's Law is used which it is the same basis for the existent literature on natural rate of growth (see for example Thirlwall, 2002; Senay & Mert, 2015).

prediction (g_{ss}^i) for all the cases, which as previously mentioned is the main aim of this literature. Also, they commented the problems of social instability, civil wars, changes in general policy framework, etc.

At country level, Saballos (2009) tests the same hypothesis for Nicaragua in the period 1937-2009 using two-step Engle Granger Cointegration (Engle & Granger, 1987). The results are consistent with Thirlwall model, and as commonly found in the literature, the inclusion of capital flow considerations in the balance of payments does not alter these results.[18] In addition, Seballos includes dummy variables to control for structural changes in the Nicaraguan economy. Both studies, at regional and country level, include among their regressors the terms of trade (prices of exports over prices of imports) given the importance of Presbich-Signer hypothesis of historical decline of terms of trade for exporters of primary goods (Pérez Caldentey & Vernengo, 2011). This inclusion is coherent with SFC open economy model because it partials-out prices effect from income elasticities (propensities to import and exports).

Therefore, in order to account for potential structural changes, a Time Varying Parameter (TVP) extension is employed to improved the measurement of g_{ss}^i using Kalman Filter (Kalman, 1960). Equation (40) and (41), with the inclusion of terms of trade, becomes the observation equations:

$$\begin{aligned} \log(x_t^i) &= \log(A_{x,t}) + \eta_t^i \cdot [\log(P_t^i) - \log(P_t^{-i}) - \log(xr_t)] \\ &+ \mu_t^{-i} \cdot \log(Y_t^{-i}) + \alpha_t^i \cdot \log(ToT^i) + u_t \end{aligned} \tag{44}$$

$$\begin{aligned} \log(m_t^i) &= \log(A_{m,t}) + \Psi_t^i \cdot [\log(P_t^{-i}) + \log(xr_t) - \log(P_t^i)] \\ &+ \mu_t^i \cdot \log(Y_t^i) + \delta_t^i \cdot \log(ToT^i) + \varepsilon_t \end{aligned} \tag{45}$$

Regarding the state equations three options are estimated: a) a random coefficient model first suggested by Hildreth et al.(1968), b) an autoregressive process of degree one (AR(1)) in the spirit of Harvey et al. (1982) and c) a robustness check with an AR(2). Then, if $\beta_t^i = [\log(A_{x,t}^i), \eta_t^i, \mu_t^{-i}, \alpha_t^i]'$, the export equation becomes:

$$\begin{pmatrix} \beta_t^i \\ \beta_{t-1}^i \end{pmatrix} = \begin{pmatrix} c^i \\ 0 \end{pmatrix} + \begin{pmatrix} \phi_{1,1}^i & \phi_{1,2}^i \\ 1 & 0 \end{pmatrix} \begin{pmatrix} \beta_{t-1}^i \\ \beta_{t-2}^i \end{pmatrix} + \begin{pmatrix} \nu_t^i \\ 0 \end{pmatrix}, \tag{46}$$

from where, in case a) it is assumed $\phi_{1,j}^i = 0$ for $j = 1, 2$ and i stands for different each Central American country, in case b) $c^i = 0$ and $\phi_{1,2}^i = 0$ and in case c) only $c^i = 0$. For the import equation, the state-space

[18] For the extension of Thirlwall model with capital flow and its small impact in empirical results see Thirlwall (2002).

representation and cases are the same.[19] Once β_t^i, c^i and $\phi_{j,j}^i$ are estimated, in line with Thirlwall, a more flexible super-steady state approximation would become observable given TVP:

$$\hat{g_{ss}}^i = \frac{\hat{\mu}_t^{-i} \cdot g_{ss}^{-i}}{\hat{\mu}_t^i} = \frac{g_x^i}{\hat{\mu}_t^i}, \tag{47}$$

where $\hat{g_{ss}}^i$ would be the growth consistent with the external demand for each i, each Central American country and $\hat{\mu}_t^i$ and $\hat{\mu}_t^{-i}$ are the estimates obtained from (46) propensity to import and export, respectively. On the other hand, g_{ss}^{-i} in the first equality is still not observable. Then, estimating g_{ss}^i would require to assume that $g_{ss}^{-i} \approx g^{-i}$ (for $-i = US$), which given identity (39) should be true; also, if it is considered that all Central American economies are open and small, there should not be any feed-back between from their super-steady state equilibrium to US equilibrium, then g^{-i} is exogenous and $g_{ss}^{-i} \approx g^{-i}$ is a plausible assumption from Central America perspective. [20]

As a last step, Granger causality test (38) can be implemented substituting $\hat{g_{ss}}^i$ by g_{ss}^i and in a panel setting (see for example Wooldridge, 2001) with the Central American countries, to compensate the problems of small sample.

5.2 Context and Data

Central America is a sub-region consisting on seven countries: Belize, Guatemala (GTM), Honduras (HON), El Salvador (SVD), Nicaragua (NIC), Costa Rica (CR) and Panama (PAN), but only the last six will be considered because of limited data availability for Belize. Although the six countries share the same region they can be divided into two groups given their Gross National Product (GDP) per capita: NIC, SVD, HON and GTM are considered lower middle-income countries and CR and PAN upper-middle countries (*World Bank Analytical Classifications*, 2017). For 2015, CR's GDP (per capita) reached the amount of USD 11,260.09, the biggest country in the region and NIC with USD 2,086.90, the smallest one (see Table 3). For 2010-2015, the real growth has been led by PAN with 7.90% and NIC with 5.17%, achieving in this way a relative quick recovery after the 2009 crisis, yet below the growth experienced during the 60's.

[19] In Appendix A a more detailed methodology on the Bayesian Estimation and Kalman Filter applied here is included.

[20] A second option would be to use the second equality of (47), but because of data restriction only aggregate exports are available for Central American countries, then it would be required to assume that all exports growth g_x^i is absorbed by US. Both options will be estimated, although the former using $g_{ss}^{-i} \approx g^{-i}$ seems more theoretically coherent.

Table 3: Central America Indicators

Country	GDP p. cap.	GDPg	Agr. GDP	E. Agr.	Inf.Empl.	Trade	EB	REM	FDI	Int. K.	Food exp.
CR	$11,260.09	3.58	5.81	13.10	36.06	66.92	-2.81	1.21	5.94	81.08	36.35
GTM	$3,903.48	3.83	11.37	33.57	68.11	58.95	-10.46	9.99	2.21	64.26	42.66
HON	$2,528.89	3.50	14.10	29.94	73.31	114.87	-19.01	16.78	5.63	36.82	59.52
NIC	$2,086.90	5.17	19.15	32.19	74.98	102.64	-19.60	9.60	7.51	57.10	63.92
PAN	$13,268.11	7.90	3.21	16.18	40.50	138.58	-9.03	1.19	10.08	32.00	57.94
SVD	$4,219.35	1.97	11.60	20.45	65.74	70.44	-17.86	16.28	1.15	66.55	20.47

Note: World Development Indicators (WDI). GDP p. cap.: GDP per capita (USD) 2015; average 2010-2015 of GDPg: Mean GDP growth (annual %), Agr. GDP: Agriculture, value added (% of GDP), E. Agr.: Employment in agriculture (% of total employment), Inf.Empl.:Informal employment (% of total non-agricultural employment), Trade: Trade (% of GDP), EB: External balance on goods and services (% of GDP), REM: Personal remittances, received (% of GDP), FDI:Foreign direct investment, net inflows (% of GDP), Intermediate and capital goods (% Imports of goods) from CEPALSTAT and Food exports (% of merchandise exports).

The structure of some economies continues to be based on the primary sector. The value added of agricultural sector in NIC, for instance, represents 19.15% of GDP, while in the case of PAN is only 3.21%.[21] The primary sector is a set of activities associated with low productivity and technology, whereas manufacturing is characterized by a high product per worker (Verdoorn's Law).[22] Demand- driven closure highly depends on Verdoorn's Law implications and having a dual market structure can limit its functioning.

Another important feature of these economies is their relationship with the world, and in most of them a persistent external deficit covered by remittances and complemented with Foreign Direct Investment (FDI). The exports are centered on primary goods; on average Central American countries export 50% on goods associate with food, such as coffee, beans and livestock, also semi-manufactured goods related with food industry. On the other hand, the imports of intermediate goods and capital goods stand for the 56.30% of the total imports suggesting a high inter-dependence of the production process, specially for those countries with high external deficit (e.g. NIC and SVD).

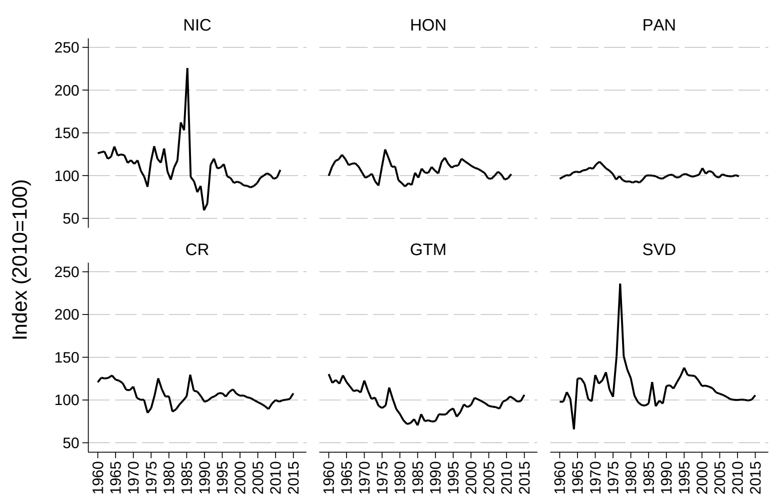
[21]In this sense, these economic activities incorporate an important part of the employed population for the lower-middle income countries, close to 30.00%

[22]This low productivity is also common in informal sectors, for the period 2010-2015, low-middle income countries concentrate around 70.54% of the workers on informal activities, and even for CR and PAN, this proportion is high (38.28%).

These problems has been structural. During the 60's, NIC, CR, HON, GTM and SVD formalized a process of regional integration, called Central American Common Market (CACM) to overcome this historical situation. Based on the contributions of Prebisch (1981), who pointed out the lack of convergence between developed and developing countries, together with the persistent external deficits and the declining historical trend of terms of trade (see Figure 5), the Economic Commission for Latin America and the Caribbean (ECLAC) guided the CACM process under the argument of Prebisch that free trade could be counterproductive for small economies.[23]

As a consequence, the economic integration looked for the creation of a common market which consisted in treating products from the rest of countries of the CACM as national products, and the intensive investment of governments in industrialization of specific sectors—vertical policies (Zapata & Perez, 2001). Although other steps such as the monetary union and the coordination of central to compensate balance of payments issues never were completed, the growth during this period is still one the highest in Central America history (see Figure 6).

Figure 5: Terms of trade for Central American countries



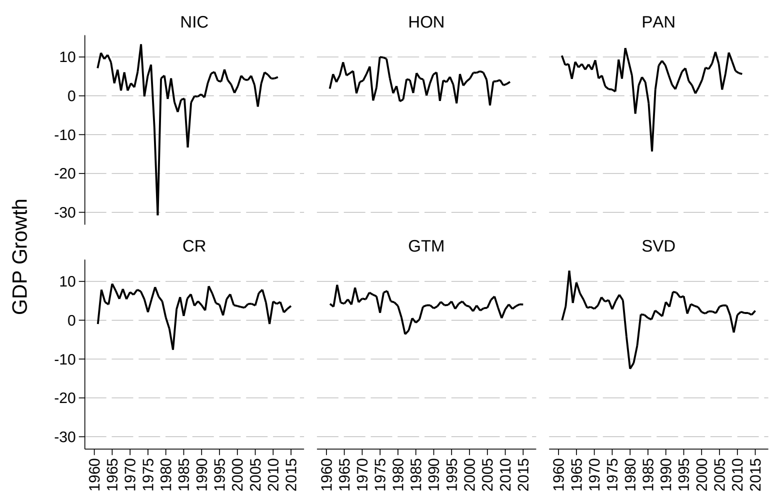
Note: Author's calculations based on WDI

[23]Although Figure 5 does not seem to provide evidence of the negative trend of Central America's terms of trade, but for some periods (e.g. SVD after 1995), Prebisch proved this hypothesis using a larger sample to capture a long-run dynamics, an updated version of this test has confirmed Prebisch results with a sample that starts 1650 to 2000 and allowing for structural brakes (Arezki, Hadri, Loungani, & Rao, 2014).

This set of policies is better known as Import Substitution Industrialization (ISI) and its operative objective can be seen as a change of μ^{-i} and μ^{i} (propensities to imports) through industrialization and an increase internal demand provided by the CACM—implicitly using a potentially joint adjustment supply and demand-driven. [24] These strategies let them also coordinate their spendings to achieve a higher growth for every country (in line with Scenario 2 of Section 3.2.2), allowing using a demand-driven approach, meaning an increase in productivity by the increase of internal demand.

Following Zapata and Perez (2001), the regional initiative was theoretically consistent and it had a positive impact on Central America, but the internal and external conflicts caused its collapse. [25] In Figure 6, it shown how these events were translated into significant drops of output during the 70's, particularly a drop of 30.00% in NIC during the last year of their civil war. Other authors underlined the inconsistency of ISI given that it reduced competition and created inefficient small industries that could not resist the falls in trade barriers (see for example Medal, 1988).

Figure 6: Output Growth for Central American countries



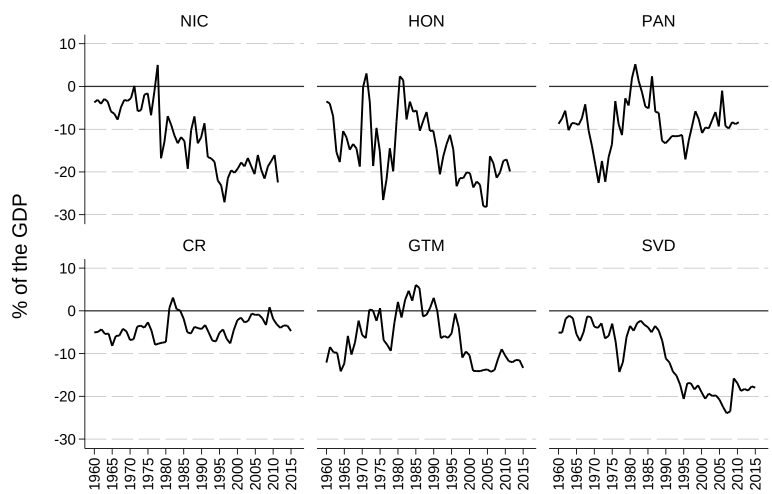
Note: Author's calculations based on WDI

[24]Another explanation in the SFC open economy framework could be that with higher tariffs, Central American countries become more in line with SFC assumption of having only few countries with similar characteristics in the world

[25]Internally, civil wars (e.g. GTM), dictatorships (e.g. NIC) and coups d'État(e.g. Arbenz in GTM). Externally, disagreements on the distribution of benefits from the common markets that even caused armed conflicts (e.g. HN and SVD), combined with price oil shocks and energy crisis.

The collapse of CACM was followed by the "Lost Decade" in Latin-America characterized by unpayable debts, external disequilibriums and high inflation. In Figure 7, it can seen the downward trend of the net exports, specially in the case of HON, SVD and NIC. Specifically, the latter experienced a commercial embargo from US from 1986 to 1989. As a consequence, Central American countries abandoned their fixed exchange rate regimes in order to protect reserves and adjust their economies to the new scenario.[26]. At the same time, this dynamics affected the real exchange rates causing relevant appreciations (see Figure 8), meaning a decrease of real exchange rate.[27] In fact, NIC had the highest appreciation explained by a hyperinflation that reached an annual increase of 33,547.93% in 1989 (Rodriguez, 2002).

Figure 7: Net Exports of Goods and Services as GDP percentage for Central American countries



Note: Author's calculations based on WDI

During the 90's, the region received support in terms of capital transfers translated into reserves and structural reforms through the Washington Consensus (Williamson, 2000).[28] In this sense, the experience of

[26]The movements of exchange rates were closely related to inflation pressures given the high pass-through of imported goods and expectation of lack of reserves—nominal exchange rate-inflation spirals (Camara & Vernengo, 2001)

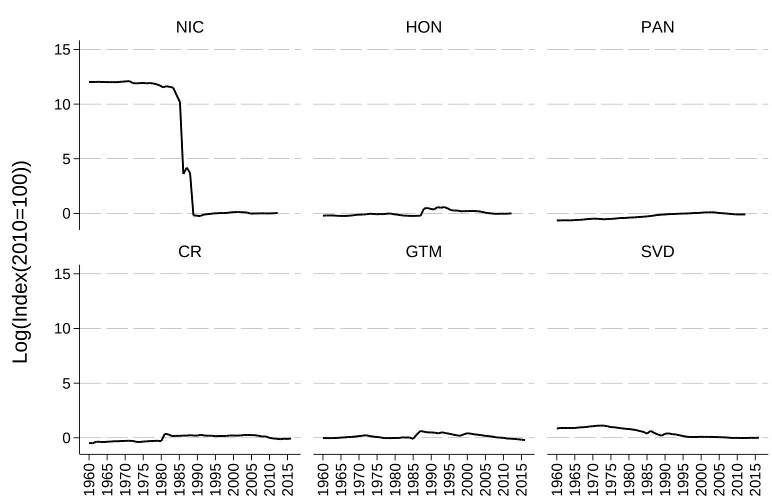
[27]The real exchange rate was approximated by $RER = \frac{xr \cdot P^{-i}}{P^i}$, where xr was measured by an index of the official nominal exchange rate, given data limitation on the effective nominal exchange rate; P^i and P^{-i} are measured by the consumer price index (CPI) of each Central American country and US CPI.

[28]The structural reforms implemented focused on market liberalization: free trade, privatization, Foreign Direct Investment (FDI), fiscal discipline, financial liberalization, property rights, deregulation.

Central America seems similar to the quasi-steady state of the SFC model, after an exogenous shock (e.g. war, collapse of CACM) there is an important change in the propensities to import (μ^i, μ^{-i}) and there was not any automatic mechanism to reduce the twin deficit, then reserves went down dramatically. The adjustment process implemented to reach the super-steady state, led by the International Fund and the World Bank, emphasized the reduction of spending and increase of taxes, analogous to the spending rule of SFC model (23).

Regarding supply constraints, the structural reform argued that liberalization can increase productivity and the natural growth (Y_n^i). While spending adjustment allows to reduce the excess of demand, the super-steady state is restored through market forces and its advantages of allocation—a supply–driven closure (Rodriguez, 2002). This argument is not in line with the supply closure provided in Section 4, but again using Medal's (1988) argument CACM could have been hiding the true propensities to import given that there was not any qualitative change in the economic structure and industrial efficiency because of limited competition. As a result, market liberalization restores the proper propensities, for example some sectors prefer to import machinery and intermediate good. This would be coherent with the supply-driven closure of 4, but still it is difficult to control for the different exogenous events (e.g.: commercial embargo, civil wars).

Figure 8: Real Exchange Rate for Central American countries



Note: Author's calculations based on WDI and MoxLAD Database (University of Oxford)

The different periods experienced by Central American countries affect importantly the characteristics of the variables discussed throughout this section. These variable are used to estimate the propensities to import of (44) and (45), and the demand constrained growth (g^i_{ss}). Specifically, in Table B.2, the log of real GDP, real imports, real export, terms of trade and an approximation to real exchange rates are tested to study the degree of persistence of each series. Two tests are performed, the Augmented Dickey Fuller (ADF) and a unit root test with structural brakes, Clemente, Montañez and Reyes (1998), CMR, in order to account for marked changes during the different periods (i.e. CACM, "Lost Decade", adjustment).

It can be concluded from Table B.2 that almost all variables are $I(1)$ across countries and the inclusion of structural change reinforces this statement with few exceptions. Also, Central America offers an interesting policy debate on the two adjustment derived in Section 4: supply-driven and demand-driven, with strategies such as CACM and liberalization process of the 90's as examples of the application of SFC model. In the next section, results of unobservable g^i_{ss} and Granger causality test will be discussed.

5.3 Results

5.3.1 Propensities to Import and Export for Central American Countries

The estimation of μ^i and μ^{-i} using (40) and (41) and the approximation to μ^i_t and μ^{-i}_t using (44) and (45) and Kalman Filter should take into account the high persistence of the main variables: exports, imports and GDP.[29] The TVP has the advantage to improve fitting by letting coefficients become stochastic variables and identifying cointegration in line with structural changes. Considering that CMR reinforces the $I(1)$ behavior of most of the series: first, a two-stage Engle-Granger Cointegration procedure is implemented with fixed coefficients and a dummy variable to control for the CACM period. In a second step, TVP model will be used to estimate the long-run relationship of export and import equations. As a last step, using ADF, the residuals of each observation equation will be tested to provide some evidence of cointegration. The short-run equation will not be presented, given that it requires the use of other econometric methods (see for example Koop, Leon-Gonzalez, & Strachan, 2011), besides the fact that theoretically the SFC model is more focused on the long-run relationship of the estimation. [30]

[29]The frequency of the data used in this sub-section is yearly from 1960-2014.

[30]Koop et al. (2011) argue that the generalization of cointegration in a context of varying parameter needs to account for the evolution of the cointegration space through time different from the traditional approach used here.

In Tables B.3, B.4, B.5 and B.6, as a first step the two-stage Engle-Granger cointegration is reported. For export and import equations, this process is replicated in two scenarios: including and excluding the RER (columns numbered as 1 and 2 in these Tables). This is because as mentioned before, the RER used in the present analysis is only a proxy variable, given the limitation on data of effective nominal exchange rate and its substitution by official nominal exchange rate. Some studies have preferred to omit this variable (see for example Moreno-Brid & Pérez, 1999), however as it can be confirmed from this robustness check it affects not only long-run parameters, but also the cointegration itself—significance of the lagged residuals. Another interpretation on this sensitivity to RER could be that the measurement error of the RER included in the regressions are affecting the results; particularly, when Central American countries, during the "Lost Decade", ran multiplicity of exchange rates and faced black market problems (e.g. CR and NIC see for example Ramirez, 1992). Despite this possibility, RER will be included at least to control to some extent for high inflation periods and assuming that the official exchange rates after some years were obliged to get closer to the effective rates by the pressure of black markets.

Another variable added to both import and export equations is an event dummy that stands for the period of CACM as a change of intercept ($CACM$) together with an interaction variable with GDP ($CACM \cdot \log(Y)$) to allow some variation on the propensities to import. As expected, in the case of PAN, neither $CACM$ nor $CACM \cdot \log(Y)$ are significant given this country did not participate on the Central American Initiative. Nonetheless, it is surprising that CR exports and imports are not affected by these event variables, meaning that there is no exogenous increase on imports or exports and that CR's propensities were not modified with respect to the rest of the period. As discussed in Section 5.2, both countries are structurally different from the rest of Central America (HN, NIC, SVD, GTM) in terms of main economic sectors and external constraint, they have a more balanced trade account and depend less on remittances.

On the other hand, the event dummy has an heterogeneous effect on the group of Central America lower-middle income countries. For NIC and SVD, there is an autonomous increase in export but a decrease in the propensity to export (equal to the propensity to import of US μ^{-i}). For HON and GTM, it is the propensity to export that increases and the autonomous component that decreases. The same pattern holds for the import equation, HON and GTM had an exogenous decrease on imports, while an increase on propensity to import, and NIC and SVD experienced the opposite. This could be a signal of the distributional problems of the benefits of CACM dynamics that conditioned the sustainability of the economic integration during the 70's and 80's. Still, in all the equations, even for PAN and CR, the propensities to import (μ^i) and to export (μ^{-i}) are significantly different from zero.

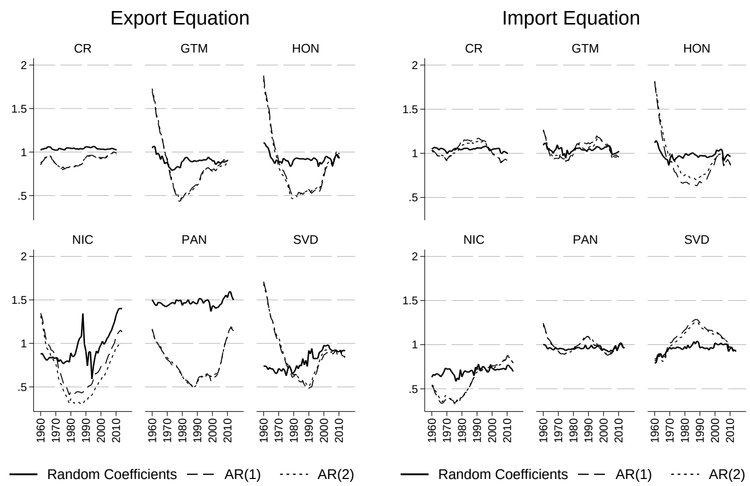
In the case of variables related to prices (RER and terms of trade), RER is significant in all the regressions of exports and in the case of the import equations it is relevant only for NIC. In this sense, in general, the effect of RER is negative on exports. This means a real depreciation decreases exports, except for the case of NIC for which the effect is positive. The terms of trade in general have a unexpected negative effect on exports and positive of imports. For PAN, neither exports nor imports are affected by terms of trade.

If GDP growth of US is assumed to be constant around 2.69% during the period, g^i_{ss} can be estimated for each Central American Country. The highest external constrained growth are for the high-middle income countries, PAN and CR with 6.37% and 4.02%, respectively, but also NIC gets a 4.74% rate of growth even higher than CR and explained mainly by its high propensity to export. The lowest growth are for GTM with 1.90% and HON, 2.49%.

The second step, would be to replicate the same procedure but allowing for more flexibility on the propensities to imports with a TVP model. Using Kalman Filter, as mentioned in Section 5.1, three state equations are proposed: Random Coefficient (i.e. $\mu^i_t = c^i + \varepsilon^i$), AR(1) (i.e. $\mu^i_t = \phi^i_{1,1}\mu^i_{t-1} + \varepsilon^i$) and AR(2) (i.e. $\mu^i_t = \phi^i_{1,1}\mu^i_{t-1} + \phi^i_{1,2}\mu^i_{t-2} + \varepsilon^i$). These regressions include the same regressors of the first step but with no dummy variables given that the parameters, including the intercept can change period by period.

In the estimation of the state equation, the first alternative, random coefficient (see Figure C.2 and C.1 for the case of the propensities to import), has only one parameter c^i, a mean value. The posterior distribution of this parameter is highly spread for the propensity to export of NIC and SVD and concentrated for the rest of cases, specially for CR, HON and GTM. For the two former cases, the draws from the Gibbs sampling are correlated even after applying a thinning (retaining one value every hundred draws). However, this does not affect the validity of the results, it only reduces efficiency translated into a larger range in the credible intervals.

Figure 9: Propensities to import: $\hat{\mu}^i$ and $\hat{\mu}^{-i}$ for Central American countries



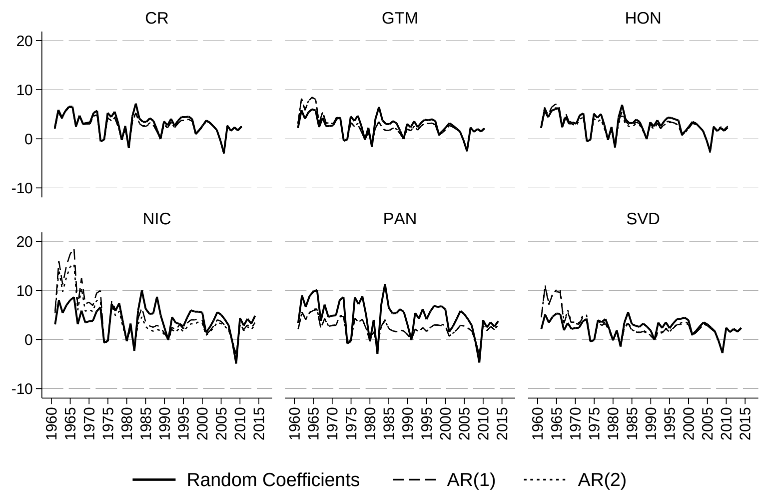
Note: Author's calculations based on WDI and MoxLAD Database

The second alternative, AR(1) seems to be more stable in convergence and a thinning procedure was not required (see Figure C.4 and C.3 for the case of the propensities to import). For all countries' propensities $\phi^i_{1,1}$ is close to one, approximating a random walk, and the same holds true for other parameters. For example, in Table B.7, RER effect on exports for SVD seems to be persistent given that its credible intervals are in a range from 0.625 and 0.990. However, credible intervals for the corresponding $\phi^i_{1,1}$ of the propensities to export are tighter compared with other coefficients. The same applies to the effects on imports (see Table B.8).

The third option is the AR(2) process, which seems to have similar characteristics to the AR(1) in terms of sampling convergence and unimodal posterior distribution (see Figure C.6 and C.5 for the case of the propensities to import). Adding the second lag increases the significance of $\phi^i_{1,1}$ for RER and increases the range of values for the $\phi^i_{1,1}$ of the propensities to import, now centered at one (with no truncation) and confirming a random walk process.

Nevertheless, none of the parameters of the second lag, $\phi^i_{1,2}$, are significant (see Figure C.6 and C.5). In this respect, Figure 9 shows the latent processes, meaning the parameters of import and export regressions. Specifically, the propensities to import and export do not differ by much when AR(1) and AR(2) cases are compared, except in the case of NIC and HON for the propensity to export and import, respectively. This similarity on the latent process reinforces the fact of getting $\phi^i_{1,1}$ close to a random walk in both cases and the non-significance of $\phi^i_{1,2}$. Regarding the random coefficient alternative, it contrasts significantly, since it has little variation even during the 80's and 90's, except for an important jump in NIC during the hyperinflation period in the 80's.

Figure 10: Growth constrained by external demand $\hat{g}^i_{ss}$ for Central American countries



Note: Author's calculations based on WDI and MoxLAD Database

From the dynamics of the propensities, the externally constrained growth g^i_{ss} is showed in Figure 10. There are cases in which few variation is added by allowing an AR(1) and AR(2) compare with random coefficients, such as HON and CR. On the other hand, PAN and NIC propensities change significantly in the 90's with the liberalization policies. In this latter country, an important negative trend lead to reduce in growth from over 10% during the 60's to values below 5% in the last years. Across countries the last financial crisis had a sharply declined on constrained growth, particularly PAN, SVD and NIC.

5.3.2 Granger Causality Test

Taking into account that g^i_{ss} has been approximated, using US growth and the propensity to import ($\hat{\mu}^i_t$) and the propensity to export ($\hat{\mu}^{-i}_t$) it is possible to perform the Granger causality test. The natural rate of growth g^i_n is measured as the sum of the labor productivity growth and labor force growth, but these variables are available only after 1992, which reduces dramatically the sample per country.[31] Thus, an option is to use a panel structure to get larger sample. In Table 4, the Granger Test is applied on two possibilities: a) g_{ss}^i and g_n^i in levels and b) their trends are subtracted using Hodrick-Prescott Filter (Hodrick & Prescott, 1981) to concentrate on a set of more regular movements of the cycle, similar to the other frameworks where the natural rate is not observable and is estimated on the basis of a regular cycle, a "mean" cycle (short-run dynamics) (see for example Senay & Mert, 2015; Thirlwall, 2002). [32]

It is important to mention that the standard errors used in the Granger Test are robust (Newey-West for autocorrelation and heteroskedasticity) for two reasons. First, one of the variables was not observable (g_{ss}^i) and its approximation using Kalman Filter and the super-steady state result (24) or (43)—Thirlwall's Law, has still a measurement error that at least increases the variance of the variable (Wooldridge, 2001).[33] Second, using Hodrick-Prescott Filter on series and then applying Granger causality test has potential drawbacks (see for example Florin, Gross, Pfeifer, Fink, & Timmermann, 2010).[34] Then, given that solving explicitly this problem is beyond the scope of the study, robust standard errors at least attenuate such potential disadvantage.

In the context of panel data, regressions are presented with and without fixed effects. In the first column, Granger tests are performed with the propensities to import and export coming from the Random Coefficient dynamics. Without considering fixed effects, the natural rate of growth is not Granger-causing the demand constrained growth in levels and vice-versa. In contrast, in the short-run using both gaps, they caused each other. Once fixed effect dummies are added to the test, the natural rate of growth causes g_{ss}^i in levels but its gap do not affect g_{ss}^i gap.

[31] The frequency of the data used in this sub-section is yearly from 1992-2014.

[32] Many studies use a process of filtering and Granger causality in network analysis and economic cycle synchronization (see for example Matesanz et al., 2017), or in the analysis of macroeconomic variables such as prices, industrial production and stock prices (see for example Gokmenoglu, Azin, & Taspinar, 2015)

[33] In the worst case scenario, the measurement error could be not random and generate a biased not only an increase in variance.

[34] Other authors has argued about the validity of using Filtering and Granger causality (see for example Barnett & Seth, 2011).

Table 4: Granger Causality Test using μ^i and μ^{-i}

	TVP	Random Coefficients				AR(1)				AR(2)			
	Dep. Var.	g_{ss}	g_n	g_{ss}	g_n	g_{ss}	g_n	g_{ss}	g_n	g_{ss}	g_n	g_{ss}	g_n
Level	g_{ss-1}	0.5385***	0.0603	0.4881***	0.0314	0.4188***	0.0925	0.4041***	0.1361	0.3985***	0.1146	0.3958**	0.1487
		0.14	0.1	0.16	0.1	0.15	0.16	0.15	0.15	0.15	0.16	0.15	0.15
	g_{n-1}	-0.1038	0.2510***	-0.1260*	0.1528	-0.0752	0.2485**	-0.0812	0.1368	-0.0645	0.2448**	-0.0764	0.135
		0.07	0.1	0.07	0.1	0.05	0.1	0.05	0.1	0.05	0.1	0.05	0.1
	R^2	0.2821	0.0741	0.3126	0.1575	0.1669	0.0745	0.1784	0.1628	0.1487	0.0757	0.1556	0.1636
	AIC	523.4951	605.1637	527.7694	602.7108	453.5378	605.1069	461.7086	601.8762	448.1872	604.9332	457.1181	601.7474
	BIC	532.1435	613.8121	550.8318	625.7732	462.1862	613.7553	484.771	624.9387	456.8356	613.5816	480.1805	624.8098
HP gap	g_{ss-1}	0.3433**	0.1695*	0.3435**	0.1704	0.3320**	0.2551*	0.3320**	0.2563*	0.3264**	0.2563*	0.3265**	0.2574*
		0.16	0.1	0.16	0.1	0.15	0.14	0.15	0.14	0.15	0.14	0.15	0.14
	g_{n-1}	-0.1217*	-0.0399	-0.1223	-0.0416	-0.0981*	-0.0524	-0.0982*	-0.0542	-0.0959*	-0.0508	-0.0960*	-0.0525
		0.07	0.09	0.07	0.09	0.06	0.09	0.06	0.1	0.05	0.09	0.05	0.1
	R^2	0.1114	0.0175	0.1116	0.0201	0.1017	0.0241	0.1017	0.0268	0.0993	0.0236	0.0993	0.0262
	AIC	505.6122	571.2774	515.5864	580.9257	443.8759	570.389	453.869	580.0283	439.2582	570.4642	449.2512	580.1078
	BIC	514.2606	579.9258	538.6488	603.9881	452.5243	579.0374	476.9315	603.0908	447.9066	579.1126	472.3136	603.1702
FE		No		Yes		No		Yes		No		Yes	

Note: Author's calculations based on WDI. Significance level: *** 1%, ** al 5%, * 10%. Coeff./ Robust Standard Errors.

Using AR(1) dynamic drops the Granger causality of natural growth to external constrained growth, but in the short-run a double bidirectional causality holds, before and after fixed effects. In case of using AR(2) in the latent process (coefficients), only the natural growth causes g_{ss}^i. It is important to consider that AR(2) may be creating over-fitting problems. In Table B.9, these results are replicated by using the growth of exports and only one of the propensities (μ^i) following equation (47) to approximate g_{ss}^i, but none of the causalities are significant. However, given the limitation of data, these exports correspond to the total amount sold by each Central American country to all their trade patterns, then it is difficult to control for the dynamics of all the other countries and may be causing important biases.

In Table B.10, the ADF is used to test for the presence of unit root in the errors of the observation equation. It is observed that with few exceptions (NIC and SVD exports) the persistence of errors is low, giving some evidence of cointegration.

In conclusion, throughout the period 1992-2015, it can be said that the supply-driven closure is more likely to explain the behavior of Central American countries. Also, the importance of the balance of payments are reflected in a short-run double bidirectional causality from the constrained demand growth and the natural rate of growth, supporting the relevance of a joint closure like the one derived in Section 4. From the cointegration with static parameters, gives some evidence of the distributional issues during the CACM, but this is not clear from the Kalman Filter results. In terms of economic policy, supply seems to be more important in the long-run, equivalent to a weak evidence of Verdoorn's Law, which is coherent with the low weight of manufacturing in Central American economic sectors. In this sense, low productivity seems to be causing the external unbalances during 1992-2014.

6 Conclusion

The implication of mainstream theories on growth and external sector leads to an implicit supply-driven closure where demands plays a limited role in economic dynamics. An alternative theoretical framework, known as heterodox theory, is described based on three principles: distribution of income, preponderance of demand over supply and the determination of interest rate as a monetary phenomenon, contradicting the role of prices as a key variable for market clearing.

Setting aside the distributional conflict issues, a fully-demand SFC model with open economy is presented where prices do not work as market clearing mechanism, its quasi-steady state for small countries

(South) implies an unsustainable twin deficit, an increasing debt and a continuous fall of international reserves. A recurrent short-run policy reaction is to set a fiscal rule and make spending depend on changes in reserves. In this way, the fall in government spending deflates the economy and induces an import reduction. This allows to reach a super-steady state equilibrium with constant stock levels. This implies that market forces alone would have not led to an equilibrium.

This result seems to differ from orthodox models only in terms of adjusting variables—price and spending, but an important difference is that in SFC, the choice of a specific short-run closure affects not only the route to the super-steady state, but also its level. Simulations showed that an austerity fiscal policy rule, related to changes on international reserves, converge to a lower super-steady state compared with a second scenario where the developed country shares the cost of adjustment by using expansive fiscal policies. Indeed, this second scenario results in a better and still sustainable level of economic activities for both countries (North an South).

To complement the fully-demand led SFC model, supply factors are incorporated. Two closure are added: a demand-driven closure, based on the interaction of productivity and aggregate demand; and a supply closure, centered on the changes in the propensity to import caused by labor market bottlenecks and country dependence on imported inputs for production. The stability of the supply–driven closure depends, depend on the ratio of exports and the square of the natural level of output. In the case of demand-driven closure, this range is associated with labor force size. The latter seems at first more likely given the square term in the supply-driven case.

Moreover, a joint supply-and-demand-driven closure is proposed. This joint closure results in a situation of multiple equilibria with an inverse relationship between productivity and propensity to import. In terms of the dynamics, the decomposition of its Jacobian matrix shows a converging eigenvector with a small range of stability and a second one with an eigenvalue equal to one. In addition, some simulations with SFC and the two closures show the importance of the level of stock on the choice of short-run adjustment policy given the risk of a "default". The policy implications of these two closures are exemplified with a debate on whether the persistent external deficits are due to a lack of productivity or if it is the structural deficits create an insufficient demand and generate a negative influence on productivity.

In the case of Central American was taken as a study case. In this sense, Central America is a convenient study case since it allows to interpret different historical periods through the lens of SFC model and the added closures (e.g. CACM and liberalization process).

The 90's characterized by liberalization policies and strong fiscal adjustment similar to the austerity fiscal measures in SFC open economy model. In terms of closures, it could be argued that international competition during this period of liberalization reveals the true propensities to import hidden by protectionist measures. From a supply drive perspective, the results of the TVP model show important variation of propensities to import during this period, specially in NIC and SVD, potentially caused by the excess of demand adjustment and low productivity.

For this second period the data allow to approximate the natural rate of growth, and the externally constrained growth. Then, a Granger causality test was run in a panel framework, obtaining significant results at 10% in favor of a supply closure for long run movements and a joint closure during business cycles. Although the evidence is still weak, probably due to sample size and the short period considered, the results reinforce the importance of joint closures and the study of the combination of orthodox and heterodox adjustment, such as in SFC framework.

On the other hand, to the extent of the literature reviewed, the empirical strategy used for testing the causality of the unobservable growth constrained by external demand, and the natural rate of growth is an innovative way for the current purpose of evaluating two closures in a heterodox framework, but also it can be used to inspect natural rate of growth endogeneity. Therefore, the addition of supply and demand closures to SFC models seems important from a theoretical and empirical perspective. More research is suggested to extend the econometric results for developed countries and for multi-country theoretical SFC models.

References

Arestis, P., & Milberg, W. (1993). Degree of monopoly, pricing, and flexible exchange rates. *Journal of Post Keynesian Economics*, *16*(2), 167-188.

Arezki, R., Hadri, K., Loungani, P., & Rao, Y. (2014). *Testing the prebisch-Singer Hypothesis Since 1650: Evidence from panel techniques that allow for multiple breaks* (Tech. Rep.).

Barnett, L., & Seth, A. K. (2011). Behaviour of granger causality under filtering: Theoretical invariance and practical application. *Journal of Neuroscience Methods*, *201*(2), 404 - 419. doi: https://doi.org/10.1016/j.jneumeth.2011.08.010

Basnet, H. C., & Sharma, S. C. (2013). Economic integration in latin america. *Journal of Economic Integration*, *28*, 551-579.

Blake, A., & Mumtaz, H. (2012). *Technical Handbook – No. 4 Applied Bayesian Econometrics for central bankers*. Bank of England.

Blecker, R. A. (2016, December). The debate over "Thirlwall's law": balance-of-payments-constrained growth reconsidered. *European Journal of Economics and Economic Policies: Intervention*, *13*(3), 275-290.

Brainard, W. C., & Tobin, J. (1968). *Pitfalls in financial model-building* (Cowles Foundation Discussion Papers No. 244). Cowles Foundation for Research in Economics, Yale University.

Caldentey, E. P., & Vernengo, M. (2016). Reading Keynes in Buenos Aires: Prebisch and the Dynamics of Capitalism. *Cambridge Journal of Economics*, *40*(6), 1725-1741.

Camara, A., & Vernengo, M. (2001). The german balance of payments school and the latin american neo-structuralists. In L. Rochon & M. Vernengo (Eds.), *Credit, interest rates and the open economy: Essays on horizontalism.* Edward Elgar Publishing Limited.

Carter, C. K., & Kohn, R. (1994). On gibbs sampling for state space models. *Biometrika*, *81*(3), 541-553.

Caverzasi, E., & Godin, A. (2013). *Stock-flow consistent modeling through the ages* (Economics Working Paper Archive). Levy Economics Institute.

Clemente Lopez, J., Montañés, A., & Reyes, M. (1998). Testing for a unit root in variables with a double change in the mean. *Economics Letters*, *59*(2), 175-182.

Copeland, M. A. (1949). Social accounting for moneyflows. *The Accounting Review*, *24*(3), 254-264.

Cortes, P. H. C., & Bosch, J. R. (2015). La ley de thirlwall: una lectura crítica. *Investigación Económica*, *74*(292), 11 - 40.

Dequech, D. (2000). Fundamental uncertainty and ambiguity. *Eastern Economic Journal*, *26*(1), 41-60.

Dosi, G., Napoletano, M., Roventini, A., & Treibich, T. (2014, 11). *The Short- and Long-Run Damages of Fiscal Austerity: Keynes beyond Schumpeter* (LEM Papers Series No. 2014/22). Laboratory of Economics and Management (LEM), Sant'Anna School of Advanced Studies, Pisa, Italy.

Engle, R. F., & Granger, C. W. J. (1987, March). Co-integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, *55*(2), 251-276.

Fleming, J. M. (1962). Domestic financial policies under fixed and under floating exchange rates. *Staff Papers (International Monetary Fund)*, *9*(3), 369-380.

Florin, E., Gross, J., Pfeifer, J., Fink, G. R., & Timmermann, L. (2010). The effect of filtering on granger causality based multivariate causality measures. *NeuroImage*, *50*(2), 577 - 588. doi: https://doi.org/10.1016/j.neuroimage.2009.12.050

Godley, W. (1996). *Money, finance and national income determination: An integrated approach* (Economics Working Paper Archive). Levy Economics Institute.

Godley, W., & Cripps, F. (1983). *Macroeconomics* [Book]. Oxford University Press.

Godley, W., & Lavoie, M. (2007). *Monetary economics : an integrated approach to credit, money, income, production and wealth / wynne godley and marc lavoie* [Book]. Palgrave Macmillan Basingstoke.

Gokmenoglu, K., Azin, V., & Taspinar, N. (2015). The relationship between industrial production, gdp, inflation and oil price: The case of turkey. *Procedia Economics and Finance*, *25*, 497 - 503. (16th Annual Conference on Finance and Accounting, ACFA Prague 2015, 29th May 2015) doi: http://dx.doi.org/10.1016/S2212-5671(15)00762-5

Granger, C. W. J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica*, *37*(3), 424-438.

Hamilton, J. D. (1994). *Time Series Analysis*. Princeton University Press.

Harrod, R. (1939). An essay in dynamic theory. *Economic Journal*, *49*, 14-33.

Harrod, R. (1949). *International economics*. Nisbet.

Harrod, R. (1972). An essay in dynamic theory. In *Economic essays* (pp. 254–277). London: Palgrave Macmillan UK.

Harvey, A. C., & Phillips, G. D. A. (1982). The estimation of regression models with time-varying parameters. In M. Deistler, E. Fürst, & G. Schwödiauer (Eds.), *Games, economic dynamics, and time series analysis: A symposium in memoriam oskar morgenstern organized at the institute for advanced studies, vienna* (pp. 306–321). Heidelberg: Physica-Verlag HD. doi: 10.1007/978-3-662-41533-7_18

Hildreth, C., & Houck, J. P. (1968). Some estimators for a linear model with random coefficients. *Journal of the American Statistical Association*, *63*(322), 584-595.

Hodrick, R. J., & Prescott, E. (1981, May). *Post-War U.S. Business Cycles: An Empirical Investigation* (Discussion Papers No. 451). Northwestern University, Center for Mathematical Studies in Economics and Management Science.

Hughes, J., & Thirlwall, A. P. (1979). Imports and labour market bottlenecks: a disaggregated study for the u.k. *Applied Economics*, *11*(1), 77-94.

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models. *Econometrica*, *59*(6), 1551-1580.

Kalecki, M. (1976). *Essays on developing economies*. Harvester Press.

Kalman, R. E. (1960). A new approach to linear filtering and prediction problems. *Transactions of the ASME–Journal of Basic Engineering*, *82*(Series D), 35–45.

Keynes, J. M. (1936). *The general theory of employment, interest and money*. London: Macmillan and Co.

Kim, C.-J., & Nelson, C. R. (1999). *State-Space Models with Regime Switching*. MIT Press.

Koop, G., Leon-Gonzalez, R., & Strachan, R. W. (2011). Bayesian inference in a time varying cointegration model. *Journal of Econometrics*, *165*(2), 210 - 220. doi: http://dx.doi.org/10.1016/j.jeconom.2011.07.007

Krugman, P., & Obstfeld, M. (2009). *International economics: Theory and policy*. Pearson Addison-Wesley.

Lancaster, T. (2004). *Introduction to modern bayesian econometrics*. Wiley.

Lavoie, M. (2009). *Introduction to post-keynesian economics*. Palgrave Macmillan UK.

Lavoie, M. (2014). *Post-keynesian economics: New foundations*. Edward Elgar Publishing Limited.

Matesanz, D., Ferrari, H. J., Torgler, B., & Ortega, G. J. (2017). Synchronization and diversity in business cycles: a network analysis of the european union. *Applied Economics*, *49*(10), 972-986. doi: 10.1080/00036846.2016.1210765

Medal, J. (1988). *Nicaragua: política económica, crisis y cambio social*. Managua (Nicaragua).

Modigliani, F. (1986). Life cycle, individual thrift, and the wealth of nations. *American Economic Review*, *76*(3), 297-313.

Moreno-Brid, J. C., & Pérez, E. (1999). Balance-of-payments-constrained growth in central america: 1950–96. *Journal of Post Keynesian Economics*, *22*(1), 131-147. doi: 10.1080/01603477.1999.11490231

Mundell, R. A. (1963). Capital mobility and stabilization policy under fixed and flexible exchange rates. *The Canadian Journal of Economics and Political Science / Revue canadienne d'Economique et de Science politique*, *29*(4), 475-485.

Palley, T. I. (2002). Pitfalls in the theory of growth: An application to the balance-of-payments-constrained growth model. In *The economics of demand-led growth* (chap. 7). Edward Elgar Publishing.

Prebisch, R. (1981). *Capitalismo periferico: crisis y transformación*. Fondo de Cultura Económica.

Pérez Caldentey, E., & Vernengo, M. (2011, May). *Understanding the business cycle in Latin America: Prebisch's contributions* (Estudios y Perspectivas – Sede Subregional de la CEPAL en México No. 127). Naciones Unidas Comisión Económica para América Latina y el Caribe (CEPAL).

Ramirez, N. (1992). *Las causas de la inflacion en economias pequeñas en vias de desarrollo con tasas fijas de cambio: un analisis comparativo de costa rica y nicaragua*. Banco Central de Nicaragua.

Rodriguez, T. (2002). *Ajuste estructural y desarrollo rural en nicaragua*. Nitlapán.

Saballos, F. A. (2009). Crecimiento económico restringido por la balanza de pagos: Evidencia empirica para nicaragua 1937-2008. *Banco Central de Nicaragua*.

Senay, A., & Mert, M. (2015). *The endogeneity of the natural rate of growth: An alternative approach* (Economics Discussion Papers No. 2015-2). Kiel.

Setterfield, M. (2012). The remarkable durability of thirlwall's law. In E. Soukiazis & P. A. Cerqueira (Eds.), *Models of balance of payments constrained growth: History, theory and empirical evidence* (pp. 83–110). London: Palgrave Macmillan UK.

Sims, C. (1972). Money, income, and causality. *American Economic Review*, *62*(4), 540-52.

Taylor, L. (1979). *Macro models for developing countries*. Mc Graw-Hill book Company.

Taylor, L. (2004). *Reconstructing macroeconomics*. Harvard University Press.

Thirlwall, A. P. (2002). *The nature of economic growth*. Edward Elgar Publishing.

Tobin, J. (1982, March). *Money and Finance in the Macro-Economic Process* (Cowles Foundation Discussion Papers No. 613R). Cowles Foundation for Research in Economics, Yale University.

Turvi. (2017). *Alternative closures for an open economy model in a stock and flow consistent framework: The case* *of central america* (Unpublished master's thesis). Université Paris 1 Panthéon-Sorbonne/Universitat Autònoma de Barcelona/Università Ca'Foscari Venezia.

Verdoorn, P. J. (2002). Factors that determine the growth of labour productivity. In J. McCombie, M. Pugno, & B. Soro (Eds.), *Productivity growth and economic performance: Essays on verdoorn's law* (pp. 28–36). London: Palgrave Macmillan UK.

Vernengo, M. (1999). *Foreign exchange, interest and prices: An essay on international finance and income distribution* (Unpublished doctoral dissertation). New School University.

White, H., & Thirlwall, A. P. (1974). U.s. merchandise imports and the dispersion of demand. *Applied Economics*, *6*(4), 275-292.

Williamson, J. (2000). What should the world bank think about the washington consensus? *World Bank Research Observer*, *15*(2), 251-264. doi: 10.1093/wbro/15.2.251

Wooldridge, J. M. (2001). *Econometric Analysis of Cross Section and Panel Data* (Vol. 1) (No. 0262232197). The MIT Press.

World bank analytical classifications. (2017). Retrieved from http://siteresources.worldbank.org/DATASTATISTICS/Resources/OGHIST.xls

Zapata, R., & Perez, E. (2001). *Pasado, presente y futuro del proceso de integracion centroamericano* (CEPAL-Serie Estudios y Perspectivas No. 11).

Appendix A Bayesian Estimation and Kalman Filter

A.1 Basic Kalman Filter

Following Kim and Nelson (1999), Kalman Filter relates two main equations:

$$\begin{aligned} Y_t &= H_t B_t + A_t \cdot z_t + e_t,\ \operatorname{var}(e_t) = R_t \\ B_t &= m_t + F_t B_{t-1} + \upsilon_t,\ \operatorname{var}(\upsilon_t) = Q_t, \end{aligned} \tag{48}$$

where the first one is called observation equation and the second one is the transition equation or state equation. The Filter establishes a relationship between observable variables (i.e Y_t and X_t), a not observable variable (i.e B_t) and a set of parameter that relates these variables (F_t, m_t and H_t). This connection is achieved based on an algorithm that sequentially update a linear projection (Hamilton, 1994). It is important to mention that these equations are not correlated given that $\operatorname{cov}(e_t, \upsilon_t) = 0$.

For this specific work, Kalman Filter is used to estimate a Time Varying Parameter (TVP) Model. Following the same notation of Section 5.1, the export equation to estimate for a country i is:

$$\begin{aligned} \log(x_t^i) = \log(A_{x,t}) + \eta_t^i \cdot [\log(P_t^i) - \log(P_t^{-i}) - \log(xr_t)] \\ + \mu_t^{-i} \cdot \log(Y_t^{-i}) + \alpha_t^i \cdot \log(ToT^i) + u \end{aligned} \tag{49}$$

For a state-space representation that takes into account three alternatives of state equation: Random parameters, AR(1) and AR(2), if $\beta_t^i = [\log(A_{x,t}^i), \eta_t^i, \mu_t^{-i}, \alpha_t^i]'$, $Y_t = \log(x_t^i)$, $H_t = [1, \log(P_t^i) - \log(P_t^{-i}) - \log(xr_t), \log(Y_t^{-i}), \log(ToT^i), 0, 0, 0, 0]$, (49) becomes:

$$Y_t = H_t \begin{pmatrix} \beta_t^i \\ \beta_{t-1}^i \end{pmatrix} + e_t,\ \operatorname{var}(e_t) = R_t \tag{50}$$

$$\begin{pmatrix} \beta_t^i \\ \beta_{t-1}^i \end{pmatrix} = \begin{pmatrix} c^i \\ 0 \end{pmatrix} + \begin{pmatrix} \phi_{1,1}^i & \phi_{1,2}^i \\ 1 & 0 \end{pmatrix} \begin{pmatrix} \beta_{t-1}^i \\ \beta_{t-2}^i \end{pmatrix} + \begin{pmatrix} \nu_t^i \\ 0 \end{pmatrix},\ \begin{pmatrix} \operatorname{var}(\nu_t^i) & 0 \\ 0 & 0 \end{pmatrix}, \tag{51}$$

where compare with 48, $B_t = [\beta_t^i, \beta_{t-1}^i]'$, $m = [c^i, 0]'$, $\operatorname{vec}(F) = [\phi_{1,1}^i, 1, \phi_{1,2}^i, 0]'$, $\upsilon = [\nu_t^i, 0]'$ and $\operatorname{vec}(Q) = [\operatorname{var}(\nu_t^i), 0, 0, 0]'$, which can be simplified again to:[35]

[35] The same representation and estimation process is applied to the import equation (45).

$$
\begin{aligned}
Y_t &= H_t B_t + e_t,\ \text{var}(e_t) = R \\
B_t &= m + F B_{t-1} + \nu_t,\ \text{var}(\nu_t) = Q
\end{aligned} \tag{52}
$$

Based on this representation, the set of equations for update the linear projection are presented by Hamilton (1994):

$$
\begin{aligned}
B_{t|t-1} &= m + B_{t-1|t-1} \\
P_{t|t-1} &= F P_{t-1|t-1} F' + Q \\
\eta_{t|t-1} &= Y_t - H B_{t|t-1} \\
f_{t|t-1} &= H P_{t|t-1} H' + R \\
B_{t|t} &= B_{t|t-1} + K \eta_{t|t-1} \\
P_{t|t} &= P_{t|t-1} - K H P_{t|t-1},
\end{aligned} \tag{53}
$$

where $K_t = P_{t\ t-1} H' f_{t\ t-1}^{-1}$. In general, $B_{t|t-1}$ is the linear projection of the unobservable element, and $P_{t|t-1}$ its Mean Square Error (MSE). After observing the forecasting error in the projection $\eta_{t|t-1}$ (and its variance $f_{t|t-1}$), $B_{t|t}$ and $P_{t|t}$ update the initial projection and MSE. To start the filtering, the initial point should be specified $B_{0|0}$ and $P_{0|0}$. This could be the mean and variance of the series, but in case of non-stationarity series, it is better to establish any initial $B_{0|0}$ with high variance $P_{0|0}$, for expressing the higher uncertainty (Blake & Mumtaz, 2012).

A.2 Bayesian Estimation

Bayesian estimation is based on a subjective concept of probability. Contrary to maximum likelihood estimator, its main components are not only the likelihood but a prior distribution that represents a prior belief on the parameters to estimate. Combined through Bayes theorem, these components produce a posterior distribution of the parameters, meaning a modification of prior beliefs based on the evidence of data (likelihood). In this sense, differing from frequentist approach where there is a population parameter that is approximated through a sample model, Bayesian Estimation is a continuous update of beliefs (Lancaster, 2004). For instance, Blake and Mumtaz (2012) provide an example for a linear regression with a dependent variable Y_t and a set of independent variables X_t:

$$Y_t = \beta X_t + \nu_t;\ \nu_t \sim \mathcal{N}(0, \sigma^2) \tag{54}$$

From Bayes' theorem, the posterior distribution of the parameters $H(\beta,\ \sigma^2|Y_t)$ would be given by:

$$H(\beta,\ \sigma^2|Y_t) = \frac{F(Y_t) \times P(\beta_0, \sigma_0^2)}{F(Y)} \propto F(Y_t) \times P(\beta_0, \sigma_0^2), \tag{55}$$

where $F(Y_t)$ is the likelihood function, $P(\beta_0, \sigma_0^2)$ is the joint prior distribution. In the denominator, $F(Y)$ is constant fo secondary importance for calculating moments of the posterior distribution.

However, the interest should be centered on $H(\beta|Y_t)$ and $H(\sigma^2|Y_t)$. Instead of integrating $H(\beta,\ \sigma^2|Y_t)$ to obtain these results, Gibbs sampling could be a method to obtain the marginal posteriors, conditional just in the data(Y_t). The inputs for the Gibbs sampling are:

1. The Posterior distribution of β assuming σ^2 is known:

$$\begin{aligned} &H(\beta|\sigma^2,\ Y_t) \sim \mathcal{N}(M^*, V^*) \\ &M^* = (\Sigma_0^{-1} + \frac{1}{\sigma^2} X_t^T X_t)^{-1} (\Sigma_0^{-1}\beta_0 + \frac{1}{\sigma^2} X_t^T Y_t) \\ &V^* = (\Sigma_0^{-1} + \frac{1}{\sigma^2} X_t^T X_t)^{-1}, \end{aligned} \tag{56}$$

   Using a normal prior of the parameters, β_0 is the mean prior and Σ_0 its prior variance covariance matrix.

2. The Posterior distribution of σ^2 assuming β is known.

$$\begin{aligned} &H(\frac{1}{\sigma^2}|\beta,\ Y_t) \sim Ga(T_1, \theta_1) \\ &T_1 = \frac{T_0 + T}{2} \\ &\theta_1 = \frac{\theta_0 + (Y_t - \beta_t X_t)^T (Y_t - \beta_t X_t)}{2} \end{aligned} \tag{57}$$

   In this case, a gamma prior ($Ga(T_0, \theta_0)$) is specified for the inverse of the variance and T_1 and θ_1 are the shape and scale parameter of the posterior gamma distribution, respectively, .

A.3 Gibbs Sampling

As it was stated before, Gibbs sampling supposes an initial joint distribution:

$$f(x_1, x_2),$$

x_1 and x_2 and the objective is to get the marginal distributions:

$$f(x_i),\ i = 1, 2.$$

Following Blake and Mumtaz (2012), the algorithm would be:

1. Specify starting values, where the superindex is represents a draw:

$$x_1^0, x_2^0$$

2. Sample x_1^1 from $f(x_1|x_2^0)$:

$$f(x_1^1|x_2^0)$$

3. Sample x_2^1 from $f(x_2^1|x_1^1)$:

$$f(x_2^1|x_1^1)$$

4. Repeat steps 1-3 until convergence.

In this way, marginal distributions are obtained $f(x_i)$ for $i = 1, 2$, $H(\beta|Y_t)$ and $H(\sigma^2|Y_t)$ for the specific case of Bayesian estimation.

A.4 Basic Algorithm

In this work Mumtaz and Blake's (2012) code was modified to estimate F, since they assumed a random walk for all parameters, and for the estimation of $AR(2)$ more steps were added given the non-invertibility of Q, both changes following Kim and Nelson (Kim & Nelson, 1999) description of the steps. In general, the main objective of the algorithm is to combine Kalman Filter, Bayesian Estimation and Gibbs Sampling meaning that: now the Bayesian method is applied on an unobservable variable (B_t) that is generated by the Kalman Filter and at the same time the Kalman filter will use parameters (m and F) estimated by the Bayesian method, iterated using Gibbs sampling.

However, there are other assumptions and details needed before presenting the steps:

1. e_t and υ_t are independent and normally distributed, with zero mean and variance R and Q, respectively.

2. To be able to sample from the unobservable variable β_t of the Kalman Filter, its joint distribution is needed. Assuming an AR(1) β_t as an example, but its is similar for the rest of cases (i.e. Random Coefficients and AR(2)), and following Kim and Nelson (1999):

$$H(\beta_1, \ ..., \beta_T|Y_1, ..., Y_T) = H(\beta_T|Y_1, ..., Y_T) \prod_{t=1}^{T-1} H(\beta_t|\beta_{t+1}, Y_1, ..., Y_T) \tag{58}$$

3. Given that e_t and ν_t are independent and normally distributed:

$$\begin{aligned} H(\beta_T|Y_1, ..., Y_T) &\sim \mathcal{N}(\beta_{T|T}, P_{T|T}) \\ H(\beta_t|\beta_{t+1}, Y_1, ..., Y_T) &\sim \mathcal{N}(\beta_{t|t,\beta_{t+1}}, P_{t|t,\beta_{t+1}}) \end{aligned} \tag{59}$$

4. The mean and variance of the second distribution is hard to find, but using Carter and Kohn's (1994) argument, Kalman Filter can be applied backward as in a smoothing process, updating with β_{t+1}:

$$\begin{aligned} \beta_{t|t,\beta_{t+1}} &= \beta_{t|t} + P_{t|t}F^T(FP_{t|t}F^T + Q)^{-1}(\beta_{t+1} - \mu - F\beta_{t|t}) \\ P_{t|t,\beta_{t+1}} &= P_{t|t} - P_{t|t}F^T(FP_{t|t}F^T + Q)^{-1}FP_{t|t} \end{aligned} \tag{60}$$

Based on these assumptions the general steps followed by the algorithm used are:

1. All variables are standardized to avoid potential problems of scaling.

2. Set priors for the parameters of interest: F, μ, R and Q. In the case of μ and F, the first one is assumed to be zero in AR(1) case and for F prior distribution is a normal distribution with mean zero and variance one for all parameters. For R and Q, their priors are based on an Ordinary Least Square regression with a dummy sample of 15 observations including the regressors of H_t, and recovering the variance of the residuals and the variance-covariance matrix, this last one scaled by a factor $\tau = 3.510E-4$ as signal of imprecision.

3. Set output matrices for the results.

4. Set initial values for the Kalman filter ($\beta_{0|0}$ and $P_{0|0}$), which are going to remain fix through the iterations, corresponding in the both cases to the regression of the dummy sample of step 2.

5. Set initial parameters for μ, F, Q and R. Those are equal to the prior distributions chosen. Also, the number of iterations is set at 110,000 with a burning sample of 109,000.

6. Given the initial points $\beta_{0|0}$ and $P_{0|0}$, and initial values for the parameters, the Kalman filter is run and saved, following equation 53.

7. Once $\beta_{T|T}$ and $P_{T|T}$ are obtained through the Kalman Filter, it is possible to sample the last observation from:

$$H(\beta_T|Y_1, ..., Y_T) \sim \mathcal{N}(\beta_{T|T}, P_{T|T}) \tag{61}$$

8. Then, the backward procedure of Carter and Khon (see equation 60) is applied to get $\beta_{T-1|T-1,\beta_T}$ and $P_{T-1|T-1,\beta_T}$, where β_T has been randomly generated and $\beta_{T-1|T-1}$ and $P_{T-1|T-1}$ are taken from the Kalman Filter results of Step 6. Now, it is possible to sample from:

$$H(\beta_{T-1}|\beta_T, Y_1, ..., Y_T) \sim \mathcal{N}(\beta_{T-1|T-1,\beta_T}, P_{T-1|T-1,\beta_T}) \tag{62}$$

   This procedure continues until it arrives to $t = 1$ in order to generate a complete random draw of β_t from its joint normal distribution.

9. Next, with β_t generated randomly from its joint distribution, Gibbs sampling can be applied. For the case of F, it is sampled from:

$$H(F|Q,\ \beta_t) \sim \mathcal{N}(M^*, V^*), \tag{63}$$

   During this sampling a control for the stability condition of AR(1) is set, if not the invertibility of Q or P can be affected.

10. Similarly R and Q are sampled from an inverse gamma using residuals e_t and υ_t generated with the output of Step 8 and Step 9, respectively, and shape parameter $T + T_0$, where $T_0 = 0$, given that the dummy sample is included into the estimation due to the small sample size.

11. Iterating step 6-10, replacing the parameters and the filter results and saving them just after the burning repetitions, allows to obtain the posterior distribution of F, Q, R and β_t for $t = 1, ..., T$.

Appendix B Tables

Table B.1: Simulations in a SFC Model with Open Economy

Parameters	Base	Scenario 1	Scenario 2
α_1^N	0.60	0.60	0.60
α_1^S	0.70	0.70	0.70
α_2^N	0.40	0.40	0.40
α_2^S	0.30	0.30	0.30
λ_0^N	0.64	0.64	0.64
λ_0^S	0.67	0.67	0.67
λ_1^N	5.00	5.00	5.00
λ_1^S	6.00	6.00	6.00
λ_2^N	0.01	0.01	0.01
λ_2^S	0.07	0.07	0.07
μ^N	0.19	0.19	0.19
μ^S	0.19	0.30	0.30
θ^N	0.20	0.20	0.20
θ^S	0.20	0.20	0.20
$\bar{G}^N$	20.00	20.00	30.00
$\bar{G}^S$	20.00	20.00	20.00
φ^N	-	0.25	-
φ^S	-	0.25	-

Table B.2: Unit Root Test: Augmented Dickey Fuller (ADF) and Clemente-Montañez-Reyes (CMR)

Var	Country	ADF Levels		ADF First Diff.	CMR Levels		CMR First Diff.		CMR Levels			CMR First Diff.			Result
		C	$C\&T$	C	t_{stat}	$date$	t_{stat}	$date$	t_{stat}	$date1$	$date2$	t_{stat}	$date1$	$date2$	
$\log(Y)$	NIC	0.589	0.611	0.000	-3.214	2007***	-2.980	1977***	-1.909	1975***	2001***	-9.298	1977***	1991***	$I(1)$
	HON	0.575	0.168	0.000	-2.130	1997***	-6.620	1980**	-2.669	1979***	1999***	-6.601	1976	1980*	$I(1)$
	PAN	0.940	0.519	0.000	-2.293	2007***	-6.248	1986	-2.878	1983***	2009***	-7.091	1978	1986	$I(1)$
	CR	0.361	0.146	0.000	-2.181	1994***	-6.732	1980**	-2.559	1980***	1999***	-8.010	1980***	1984***	$I(1)$
	GTM	0.612	0.301	0.041	-2.262	1998***	-4.024	1980***	-2.782	1975***	1999***	-8.063	1979***	1986***	$I(1)$
	SVD	0.356	0.056	0.015	-2.744	1996***	-5.274	1978***	-3.661	1973***	1996***	-4.917	1976***	1984***	$I(2)$
$log(m)$	NIC	0.823	0.412	0.000	-2.692	1998***	-4.117	1965	-3.737	1995***	2007***	-9.601	1993*	1997	$I(1)$
	HON	0.290	0.019	0.000	-2.861	1998***	-7.431	1980*	-3.398	1974***	1999***	-8.726	1969	1980	$I(1)$
	PAN	0.735	0.030	0.000	-2.243	1992***	-7.170	1989	-3.090	1986***	2006***	-7.566	1989	2001	$I(1)$
	CR	0.672	0.118	0.000	-2.356	1994***	-5.951	1979	-2.881	1973***	1994***	-7.610	1979***	1984***	$I(1)$
	GTM	0.785	0.613	0.000	-2.899	1994***	-4.152	1980	-3.088	1994***	2008**	-4.408	1979***	1984***	$I(1)$
	SVD	0.732	0.526	0.000	-3.482	1996***	-5.967	1980	-3.184	1974***	1994***	-5.723	1978***	1980***	$I(1)$
$\log(x)$	NIC	0.933	0.941	0.000	-2.976	2001***	-4.938	1978	-3.487	1997***	2007***	-5.768	1977***	1987***	$I(1)$
	HON	0.216	0.108	0.000	-2.735	2003***	-6.408	1968**	-3.107	1975***	2002***	-5.635	1967**	2007	$I(1)$
	PAN	0.749	0.040	0.000	-2.655	2004***	-7.375	1989	-3.068	1981***	2006***	-8.100	1989	2001	$I(1)$
	CR	0.235	0.782	0.006	-2.340	1992***	-4.347	1966	-2.841	1973***	1994***	-8.173	1972**	1987	$I(1)$
	GTM	0.266	0.237	0.000	-2.839	1996***	-2.922	1975**	-3.242	1970***	1996***	-4.461	1978***	1986***	$I(2)$
	SVD	0.718	0.710	0.000	-3.440	1996***	-6.407	1980	-3.682	1994***	2001***	-2.994	1977	1989**	
$\log(ToT)$	NIC	0.019	0.024	0.000	-3.483	1985***	-5.468	1985	-3.013	1985	1990***	-3.808	1985*	1990*	$I(1)$
	HON	0.012	0.051	0.000	-2.896	1972*	-6.879	1975	-3.544	1982***	1985***	-4.345	1979	1984	$I(1)$
	PAN	0.268	0.496	0.000	-3.357	1977***	-8.473	1975	-4.105	1976***	1982***	-9.139	1973***	1979**	$I(1)$
	CR	0.016	0.045	0.000	-4.603	1972***	-4.672	1975	-4.892	1972***	2003**	-4.834	1975	1984	$I(1)$
	GTM	0.353	0.859	0.000	-2.886	1968***	-6.646	1984	-4.478	1975***	1994***	-4.823	1975	1982	$I(1)$
	SVD	0.004	0.021	0.000	-4.762	1975	-9.220	1975	-4.994	1975	2005**	-9.712	1975	1984	$I(0)$
$\log(RER)$	NIC	0.852	0.853	0.000	-3.917	1989***	-3.236	1986	-6.203	1985***	1989***	-0.094	1986***	1992***	$I(0)$
	HON	0.332	0.648	0.000	-3.343	1992***	-2.632	1988	-5.273	1991***	1999***	-2.582	1977	1988	$I(1)$
	PAN	0.487	0.981	0.091	-2.053	1992***	-4.986	2004***	-3.498	1980***	1992***	-3.675	1972	2004***	$I(1)$
	CR	0.283	0.850	0.000	-0.696	1978***	-4.173	1979	-9.079	1978***	2009***	-17.286	1979	2008	$I(0)$
	GTM	0.379	0.782	0.000	-2.065	2012***	-6.130	1984	-2.035	1983***	2005***	-3.977	1983**	1988***	$I(1)$
	SVD	0.902	0.667	0.000	-3.404	1984***	-8.698	1973**	-4.098	1984***	1997***	-8.535	1973***	1987	$I(1)$
Critical Value (5%)					-3.560		-3.560		-5.490			-5.490			

Note: Author's calculations based on WDI and MoxLAD Database. Significance level: *** 1%, ** al 5%, * 10%. C: Constant ADF, $C\&T$: Constant and Trend ADF (p-values reported for ADF) and CMR tests are all with a constant and with one or two dummies for structural breaks (t-stat reported).

Table B.3: Cointegration of Exports Equation Two-Step Engle-Granger 1

Variables	Nicaragua				Honduras				Panama			
	1		2		1		2		1		2	
$\log(Y)$	3.4827***		2.2670***		0.9844***		0.9672***		2.2943***		1.4527***	
	0.2		0.27		0.06		0.07		0.16		0.14	
$CACM \cdot \log(Y)$	-1.8032***		-0.4765*		0.8131***		0.7762***		-0.1639		0.1656	
	0.23		0.27		0.09		0.09		0.13		0.19	
$\log(ToT)$	-0.6548***		0.0021		-0.4926***		-0.6581***		-0.1407		-0.9294	
	0.2		0.24		0.17		0.16		0.45		0.6	
$\log(RER)$	0.1057***				-0.1608***				-1.9030***			
	0.02				0.06				0.3			
$\Delta\log(Y)$		1.4175		1.0712		1.8570***		1.9413***		-0.7746		-1.2202*
		1.06		1.13		0.59		0.58		0.84		0.66
$\Delta\log(ToT)$		-0.3938***		-0.1571		-0.5440***		-0.5521***		-0.1867		-0.4527
		0.08		0.13		0.12		0.13		0.54		0.51
$\Delta\log(RER)$		0.0708***				-0.0467				-1.1826		
		0.01				0.04				0.73		
$Resid_{-1}$		-0.1762**		-0.1098		-0.3572***		-0.3008***		-0.4243***		-0.2907***
		0.08		0.07		0.1		0.11		0.11		0.08
$CACM$	54.0321***	-0.0025	15.1606*	0.0265	-23.7527***	0.0284	-22.6406***	0.027	4.7644	0.0364	-4.6729	0.0445*
	6.86	0.03	8.15	0.03	2.68	0.02	2.79	0.02	3.72	0.03	5.58	0.03
Constant	-80.9191***	0.0227	-47.1490***	0.0084	-4.8806***	-0.0283	-3.6144*	-0.0306*	-45.3620***	0.0754**	-16.2872***	0.0726***
	5.86	0.04	8.49	0.04	1.78	0.02	1.85	0.02	5.15	0.03	3.97	0.03
N	56	55	56	55	56	55	56	55	55	54	55	54
R^2	0.9345	0.3112	0.8664	0.1611	0.9755	0.4512	0.9729	0.4204	0.9655	0.2756	0.9404	0.2632
AIC	-17.1383	-77.013	20.8162	-68.1708	-104.627	-140.773	-100.97	-139.769	-57.476	-91.1232	-29.3719	-92.203
BIC	-4.9862	-64.969	30.943	-58.1342	-92.4748	-128.729	-90.8433	-129.732	-45.432	-79.1892	-19.3352	-82.2581

Note: Author's calculations based on WDI and MoxLAD Database. Significance level: *** 1%, ** al 5%, * 10%. Coeff./Robust Standard Errors. The variable $\log(Y)$ is the log of US GDP.

Table B.4: Cointegration of Exports Equation Two-Step Engle-Granger 2

Variables	Costa Rica				Guatemala				El Salvador			
	1		2		1		2		1		2	
$\log(Y)$	2.3083***		2.3346***		0.9556***		0.9963***		2.6228***		1.9590***	
	0.04		0.04		0.17		0.21		0.33		0.16	
$CACM \cdot \log(Y)$	-0.0173		-0.0749		1.1077***		1.0671***		-1.1895**		-0.3623*	
	0.1		0.11		0.3		0.36		0.49		0.2	
$\log(ToT)$	-0.5628***		-0.5540***		0.2947		0.4018		-0.1751		-0.2708*	
	0.15		0.15		0.29		0.36		0.17		0.15	
$\log(RER)$	-0.1770***				-0.3851***				0.8503*			
	0.04				0.09				0.45			
$\Delta \log(Y)$		1.7799***		1.7672***		0.7121*		0.6065*		1.9126***		1.6335**
		0.31		0.3		0.4		0.34		0.64		0.64
$\Delta \log(ToT)$		-0.3530***		-0.3458***		-0.1069		-0.1429		-0.2319***		-0.2311***
		0.08		0.07		0.12		0.15		0.09		0.08
$\Delta \log(RER)$		-0.0275				-0.3505**				0.2525		
		0.04				0.13				0.28		
$Resid_{-1}$		-0.1886**		-0.1919**		-0.4232***		-0.3401***		-0.2798***		-0.2758***
		0.08		0.08		0.12		0.08		0.09		0.09
$CACM$	0.6273	0.0014	2.4154	0.0016	-32.3893***	0.0432**	-31.1373***	0.0414**	35.5473**	0.0074	11.4879*	0.021
	3.01	0.01	3.24	0.01	8.84	0.02	10.68	0.02	14.34	0.03	6.07	0.03
Constant	-44.1858***	0.0105	-45.0428***	0.0105	-7.2365*	0.0017	-9.0158*	0.0057	-56.3745***	-0.0156	-35.8020***	-0.016
	1.35	0.01	1.31	0.01	4	0.01	4.95	0.01	10.45	0.02	4.82	0.02
N	56	55	56	55	56	55	56	55	56	55	56	55
R^2	0.9949	0.4738	0.9946	0.4783	0.9714	0.4207	0.9561	0.4049	0.9304	0.317	0.9193	0.3326
AIC	-113.602	-172.472	-112.351	-174.945	-95.2609	-139.061	-73.3012	-139.577	-24.7357	-87.9957	-18.4432	-91.2606
BIC	-101.45	-160.428	-102.225	-164.909	-83.1088	-127.017	-63.1744	-129.54	-12.5836	-75.9517	-8.3164	-81.224

Note: Author's calculations based on WDI and MoxLAD Database. Significance level: *** 1%, ** al 5%, * 10%. Coeff./Robust Robust Standard Errors. The variable $\log(Y)$ is the log of US GDP.

Table B.5: Cointegration of Import Equation Two-Step Engle-Granger 1

Variables	Nicaragua				Honduras				Panama			
	1		2		1		2		1		2	
$\log(Y)$	1.9793***		2.2327***		1.0636***		1.0603***		0.9703***		1.0050***	
	0.07		0.09		0.05		0.05		0.05		0.04	
$CACM \cdot \log(Y)$	-0.7368***		-1.0544***		0.4074***		0.3957***		0.0867		0.0787	
	0.1		0.12		0.11		0.1		0.06		0.05	
$\log(ToT)$	0.1808		-0.2519**		0.237		0.1722		0.4269		0.5927*	
	0.12		0.11		0.16		0.12		0.32		0.33	
$\log(RER)$	-0.0420***				-0.0621				0.1786			
	0.01				0.05				0.18			
$\Delta \log(Y)$		1.5649***		1.2562***		1.7327***		1.7210***		1.9858***		2.0055***
		0.42		0.35		0.5		0.46		0.24		0.2
$\Delta \log(ToT)$		0.1143		0.0114		0.0236		0.0115		0.0478		0.0743
		0.1		0.19		0.14		0.14		0.41		0.39
$\Delta \log(RER)$		-0.0438**				0.018				0.3127		
		0.02				0.07				0.61		
$Resid_{-1}$		-0.5496***		-0.1669		-0.4810***		-0.4778***		-0.5260***		-0.5215***
		0.15		0.12		0.12		0.12		0.13		0.14
$CACM$	16.2747***	-0.0194	23.1145***	-0.0273	-8.8215***	0.0204	-8.5490***	0.021	-1.8	-0.0036	-1.6678	-0.0046
	2.31	0.03	2.74	0.04	2.37	0.02	2.26	0.02	1.29	0.02	1.25	0.02
Constant	-23.8873***	0.012	-27.7341***	0.0312	-2.9630***	-0.0302	-2.5947**	-0.03	-1.5686	-0.0532***	-3.1611	-0.0504***
	1.51	0.02	1.97	0.03	1.08	0.02	1.06	0.02	2	0.02	1.96	0.02
N	56	55	56	55	56	55	56	55	55	54	55	54
R^2	0.979	0.4708	0.9531	0.2443	0.9785	0.5605	0.9782	0.5556	0.9768	0.6022	0.9763	0.5905
AIC	-77.9897	-69.249	-34.9003	-51.651	-97.7839	-137.787	-98.9838	-139.175	-78.955	-113.42	-79.8007	-113.849
BIC	-65.8376	-57.205	-24.7735	-41.6143	-85.6317	-125.743	-88.857	-129.138	-66.911	-101.486	-69.7641	-103.905

Note: Author's calculations based on WDI and MoxLAD Database. Significance level: *** 1%, ** al 5%, * 10%. Coeff./Robust Standard Errors. The variable $\log(Y)$ is the log of the Central American country GDP.

Table B.6: Cointegration of Import Equation Two-Step Engle-Granger 2

Variables	Costa Rica				Guatemala				El Salvador			
	1		2		1		2		1		2	
$\log(Y)$	1.5454***		1.5147***		1.3508***		1.2965***		2.1525***		2.2968***	
	0.06		0.05		0.17		0.15		0.12		0.05	
$CACM \cdot \log(Y)$	-0.0307		0.021		-0.0728		0.006		-0.9300***		-1.0988***	
	0.08		0.07		0.26		0.24		0.17		0.1	
$\log(ToT)$	0.6953***		0.6732***		0.8240**		0.8846***		0.3871***		0.4005***	
	0.25		0.24		0.32		0.31		0.1		0.1	
$\log(RER)$	0.2306				0.1227				-0.2026			
	0.17				0.11				0.13			
$\Delta\log(Y)$		2.5693***		2.8040***		3.2977***		3.5126***		2.2303***		2.2746***
		0.28		0.34		0.49		0.55		0.3		0.3
$\Delta\log(ToT)$		0.2094**		0.2990**		0.1893		0.1935		0.1823**		0.1930***
		0.08		0.12		0.19		0.2		0.07		0.07
$\Delta\log(RER)$		-0.1873***				0.0025				0.0451		
		0.04				0.23				0.19		
$Resid_{-1}$		-0.2538***		-0.2743***		-0.3782***		-0.3623**		-0.3935***		-0.3627***
		0.06		0.06		0.12		0.15		0.13		0.13
$CACM$	0.9444	-0.0219	-0.3702	-0.0279*	2.0242	-0.0578**	0.124	-0.0632**	21.5558***	-0.0455*	25.3527***	-0.0469**
	2	0.02	1.63	0.02	6.29	0.02	5.64	0.02	3.78	0.02	2.33	0.02
Constant	-17.4211***	-0.0436***	-16.5544***	-0.0529***	-13.2797***	-0.0642***	-12.2221***	-0.0704***	-29.9866***	0.0027	-33.4805***	0.0013
	1.98	0.01	1.82	0.02	2.9	0.02	2.37	0.02	3.01	0.02	1.28	0.01
N	56	55	56	55	56	55	56	55	56	55	56	55
R^2	0.9895	0.7767	0.9889	0.7319	0.9661	0.5805	0.9651	0.5746	0.9883	0.6975	0.9876	0.6887
AIC	-83.6252	-168.578	-82.6481	-160.535	-70.7329	-119.062	-71.0996	-120.287	-104.253	-125.771	-102.958	-126.189
BIC	-71.4731	-156.534	-72.5214	-150.499	-58.5808	-107.018	-60.9729	-110.25	-92.1012	-113.727	-92.8309	-116.152

Note: Author's calculations based on WDI and and MoxLAD Database. Significance level: *** 1%, ** al 5%, * 10%. Coeff./Robust Standard Errors. The variable $\log(Y)$ is the log of the Central American country GDP.

Table B.7: Bayesian Estimation of the State Equation of Exports

Country	Var.	Random Parameters: c			AR(1): $\phi_{1,1}$			AR(2): $\phi_{1,1}$			AR(2): $\phi_{1,2}$		
		Median	p.5	p.95	Median	p.5	p.95	Median	p.5	p.95	Median	p.5	p.95
CR	$Constant$	0.004	-0.077	0.088	0.581	-0.039	0.939	0.663	0.140	1.092	0.025	-0.331	0.360
	$\log(Y)$	1.033	0.883	1.167	0.984	0.948	0.998	0.896	0.591	1.236	0.081	-0.264	0.379
	$\log(ToT)$	-0.038	-0.158	0.098	0.343	-0.225	0.794	0.376	-0.182	0.876	-0.020	-0.320	0.319
	$\log(RER)$	-0.072	-0.191	0.036	0.433	-0.163	0.885	0.585	0.044	1.030	0.002	-0.340	0.368
GTM	$Constant$	0.055	-0.028	0.145	0.881	0.602	0.978	0.819	0.356	1.215	-0.014	-0.323	0.317
	$\log(Y)$	0.896	0.801	0.999	0.971	0.930	0.996	0.928	0.633	1.272	0.027	-0.309	0.327
	$\log(ToT)$	-0.042	-0.162	0.072	0.528	-0.118	0.859	0.447	-0.138	0.966	-0.004	-0.340	0.344
	$\log(RER)$	-0.171	-0.282	-0.045	0.646	0.109	0.941	0.489	-0.137	0.948	0.021	-0.324	0.336
HON	$Constant$	0.047	-0.034	0.136	0.821	0.339	0.978	0.730	0.247	1.131	0.047	-0.289	0.354
	$\log(Y)$	0.924	0.786	1.033	0.959	0.907	0.992	0.930	0.630	1.280	0.013	-0.307	0.311
	$\log(ToT)$	-0.102	-0.208	0.001	0.387	-0.110	0.813	0.362	-0.216	0.868	-0.019	-0.344	0.315
	$\log(RER)$	-0.049	-0.171	0.077	0.645	0.051	0.919	0.460	-0.096	0.988	0.002	-0.306	0.304
NIC	$Constant$	0.006	-0.156	0.195	0.916	0.871	0.973	1.069	0.726	1.397	-0.128	-0.441	0.205
	$\log(Y)$	1.074	0.793	1.395	0.989	0.962	0.999	0.959	0.596	1.315	-0.021	-0.358	0.319
	$\log(ToT)$	-0.145	-0.446	0.452	0.472	-0.126	0.837	0.463	-0.033	0.926	0.002	-0.306	0.341
	$\log(RER)$	0.434	-0.106	0.730	0.917	0.868	0.958	0.848	0.298	1.234	0.007	-0.313	0.331
PAN	$Constant$	-0.010	-0.094	0.064	0.563	-0.053	0.918	0.649	0.171	1.055	-0.042	-0.360	0.295
	$\log(Y)$	1.439	1.143	1.717	0.982	0.944	0.998	0.948	0.635	1.296	0.022	-0.343	0.336
	$\log(ToT)$	-0.031	-0.131	0.063	0.419	-0.246	0.842	0.308	-0.287	0.837	-0.023	-0.336	0.316
	$\log(RER)$	-0.485	-0.773	-0.208	0.577	-0.043	0.941	0.696	0.031	1.104	-0.012	-0.338	0.324
SVD	$Constant$	-0.069	-0.214	0.070	0.978	0.919	0.999	1.070	0.731	1.367	-0.148	-0.425	0.155
	$\log(Y)$	0.993	0.406	1.478	0.987	0.950	0.999	0.926	0.570	1.260	0.016	-0.308	0.327
	$\log(ToT)$	0.023	-0.194	0.242	0.462	-0.044	0.856	0.443	-0.116	0.944	-0.016	-0.345	0.312
	$\log(RER)$	0.189	-0.338	0.610	0.897	0.625	0.990	0.756	0.275	1.153	0.015	-0.306	0.331

Note: Author's calculations based on WDI and and MoxLAD Database. Number of Iterations 110,000; Burning Sample: 100,000; Median and credible intervals at 10% are reported. The variable $\log(Y)$ is the log of the Central American country GDP.

Table B.8: Bayesian Estimation of the State Equation of Imports

Country	Var.	Random Parameters: c			AR(1): $\phi_{1,1}$			AR(2): $\phi_{1,1}$			AR(2): $\phi_{1,2}$		
		Median	p.5	p.95	Median	p.5	p.95	Median	p.5	p.95	Median	p.5	p.95
CR	$Constant$	-0.002	-0.081	0.083	0.562	-0.017	0.929	0.560	-0.003	0.987	0.007	-0.324	0.318
	$\log(Y)$	1.053	0.948	1.167	0.984	0.951	0.998	0.903	0.575	1.236	0.072	-0.255	0.406
	$\log(ToT)$	0.091	-0.039	0.194	0.365	-0.248	0.824	0.392	-0.202	0.856	-0.020	-0.350	0.357
	$\log(RER)$	-0.011	-0.135	0.092	0.490	-0.132	0.880	0.508	-0.074	0.936	0.009	-0.328	0.342
GTM	$Constant$	0.036	-0.052	0.103	0.896	0.407	0.984	0.888	0.381	1.292	-0.046	-0.389	0.277
	$\log(Y)$	1.070	0.976	1.157	0.985	0.958	0.998	0.938	0.609	1.266	0.034	-0.284	0.356
	$\log(ToT)$	0.313	0.199	0.412	0.724	0.166	0.960	0.612	-0.009	1.026	0.010	-0.294	0.342
	$\log(RER)$	-0.026	-0.135	0.073	0.496	-0.143	0.897	0.475	-0.113	0.951	0.005	-0.312	0.344
HON	$Constant$	0.033	-0.048	0.108	0.846	0.265	0.975	0.682	0.154	1.102	0.018	-0.301	0.334
	$\log(Y)$	0.957	0.846	1.063	0.965	0.916	0.993	0.943	0.620	1.253	0.017	-0.290	0.328
	$\log(ToT)$	0.055	-0.064	0.157	0.429	-0.177	0.826	0.359	-0.201	0.865	-0.022	-0.344	0.314
	$\log(RER)$	-0.018	-0.133	0.099	0.670	0.055	0.936	0.597	-0.109	1.041	0.003	-0.330	0.325
NIC	$Constant$	0.011	-0.065	0.084	0.880	0.859	0.904	0.877	0.532	1.251	-0.007	-0.331	0.291
	$\log(Y)$	0.671	0.581	0.774	0.983	0.947	0.999	0.920	0.601	1.258	0.027	-0.308	0.334
	$\log(ToT)$	0.112	-0.038	0.240	0.545	-0.051	0.893	0.428	-0.148	0.903	0.006	-0.316	0.328
	$\log(RER)$	-0.513	-0.649	-0.409	0.888	0.867	0.914	0.857	0.538	1.224	0.017	-0.298	0.308
PAN	$Constant$	0.003	-0.077	0.082	0.566	0.017	0.907	0.565	0.069	1.041	-0.019	-0.356	0.303
	$\log(Y)$	0.951	0.764	1.180	0.981	0.947	0.997	0.910	0.572	1.252	0.070	-0.271	0.399
	$\log(ToT)$	0.045	-0.050	0.139	0.417	-0.160	0.851	0.463	-0.100	0.919	-0.026	-0.384	0.304
	$\log(RER)$	0.038	-0.187	0.197	0.550	-0.086	0.926	0.565	0.005	1.032	0.011	-0.330	0.359
SVD	$Constant$	-0.027	-0.106	0.055	0.665	-0.050	0.921	0.615	0.121	1.050	0.010	-0.308	0.343
	$\log(Y)$	0.908	0.760	1.080	0.985	0.956	0.999	0.903	0.560	1.257	0.076	-0.278	0.423
	$\log(ToT)$	0.066	-0.054	0.191	0.291	-0.308	0.784	0.293	-0.300	0.816	-0.011	-0.344	0.310
	$\log(RER)$	-0.128	-0.257	0.023	0.563	-0.178	0.923	0.628	0.015	1.059	0.024	-0.320	0.351

Note: Author's calculations based on WDI and and MoxLAD Database. Number of Iterations 110,000; Burning Sample: 100,000; Median and credible intervals at 10% are reported. The variable $\log(Y)$ is the log of the US' GDP.

Table B.9: Granger Causality Test using only μ^i

	TVP	Random Coefficients				AR(1)				AR(2)			
	Dep. Var.	g_{ss}	g_n	g_{ss}	g_n	g_{ss}	g_n	g_{ss}	g_n	g_{ss}	g_n	g_{ss}	g_n
Level	g_{ss-1}	0.1528	-0.0271	-0.0321	0.0003	0.1079	-0.0274	-0.0419	-0.0031	0.1136	-0.0284	-0.0463	-0.0044
		0.1	0.03	0.11	0.04	0.11	0.03	0.12	0.04	0.11	0.03	0.11	0.04
	g_{n-1}	-0.1839	0.2954***	0.3043	0.1569	-0.196	0.2976***	0.1903	0.1628	-0.1792	0.2983***	0.2319	0.165
		0.43	0.11	0.47	0.14	0.41	0.11	0.45	0.14	0.41	0.11	0.45	0.14
	R^2	0.0219	0.0805	0.1302	0.1569	0.0109	0.0802	0.1011	0.157	0.012	0.081	0.1088	0.157
	AIC	949.5836	604.2516	944.0862	602.8056	946.4612	604.2885	943.8358	602.792	947.0387	604.1775	943.4326	602.7781
	BIC	958.232	612.9	967.1486	625.868	955.1096	612.9369	966.8982	625.8544	955.6871	612.8259	966.495	625.8405
HP GAP	g_{ss-1}	-0.1256	-0.0163	-0.1256	-0.0161	-0.1024	-0.0129	-0.1023	-0.0128	-0.1116	-0.0151	-0.1116	-0.015
		0.1	0.04	0.1	0.04	0.11	0.04	0.11	0.04	0.1	0.04	0.11	0.04
	g_{n-1}	-0.0793	0.018	-0.0802	0.0164	-0.1655	0.0143	-0.1672	0.0126	-0.12	0.0176	-0.1215	0.0159
		0.44	0.12	0.45	0.13	0.45	0.13	0.46	0.13	0.45	0.13	0.46	0.13
	R^2	0.0193	0.0031	0.0216	0.0055	0.0171	0.002	0.019	0.0044	0.0173	0.0027	0.0193	0.0051
	AIC	914.6221	573.197	924.3206	582.8812	919.5341	573.3467	929.2749	583.0314	918.6971	573.2509	928.4265	582.9364
	BIC	923.2705	581.8454	947.383	605.9437	928.1825	581.9951	952.3374	606.0939	927.3455	581.8993	951.4889	605.9988
FE		No		Yes		No		Yes		No		Yes	

Note: Author's calculations based on WDI and MoxLAD Database. Significance level: *** 1%, ** al 5%, * 10%. Coeff./Robust Standard Errors. FD stands for Fixed Effects.

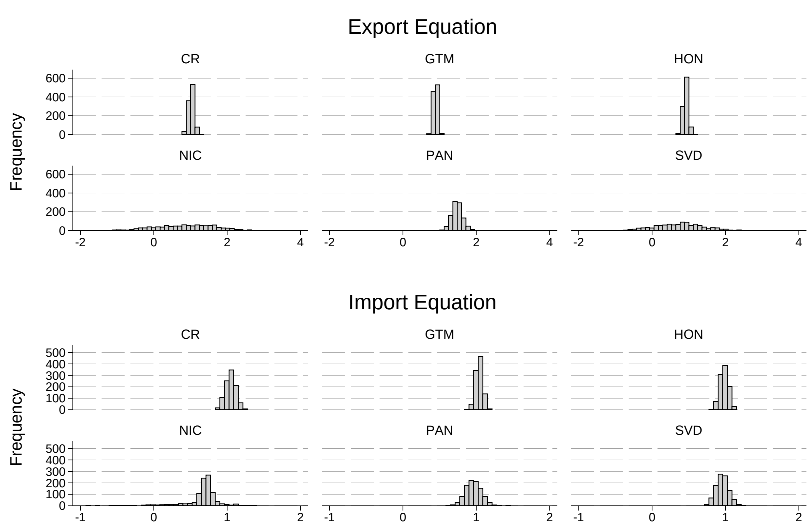
Table B.10: Unit Root Test on Observation Equations' Residuals

Country	Exports			Imports		
	Rand. P.	AR(1)	AR(2)	Rand. P.	AR(1)	AR(2)
CR	-2.98***	-4.35***	-4.33***	-2.56**	-4.01***	-4.15***
GTM	-2.37**	-5.88***	-6.06***	-4.29***	-6.57***	-7.11***
HON	-3.01***	-3.78***	-3.83***	-3.35***	-4.48***	-4.24***
NIC	-0.61	-5.71***	-3.42***	-3.70***	-3.80***	-3.81***
PAN	-3.07***	-3.86***	-3.96***	-2.93***	-3.23***	-2.78***
SVD	-1.17	-4.80***	-4.74***	-2.69***	-6.25***	-5.97***

Note: Author's calculations based on WDI and MoxLAD Database. Significance level: *** 1%, ** al 5%, * 10%. t-stats, Dickey Fuller with no intercept.

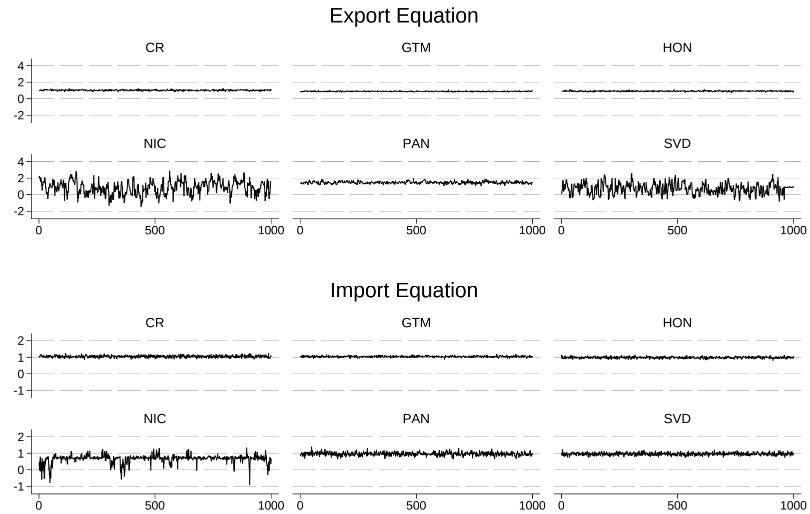
Appendix C Graphs

Figure C.1: Posterior Distribution c^i in the State Equation of propensities with Random Parameters



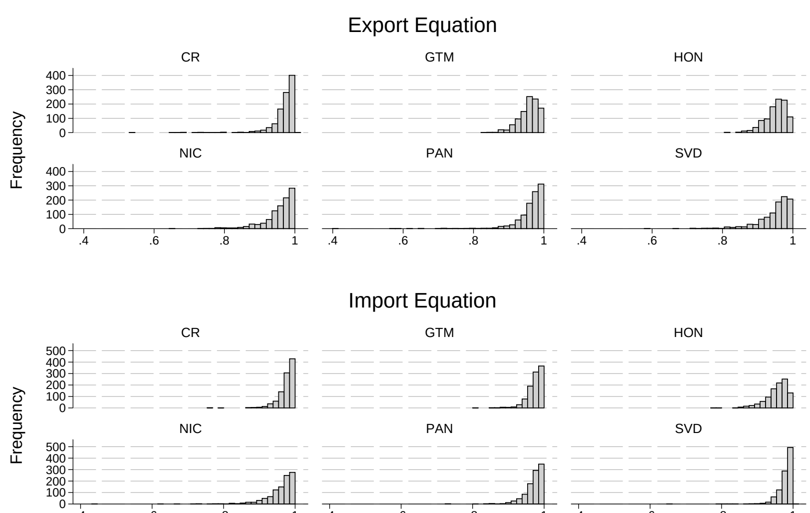
Note: Author's calculations based on WDI and MoxLAD Database. Number of Iterations 200,000; Burning Sample: 100,000; Thinning: Every 100th value.

Figure C.2: Draws after burning sample of c^i in the State Equation of propensities with Random Parameters



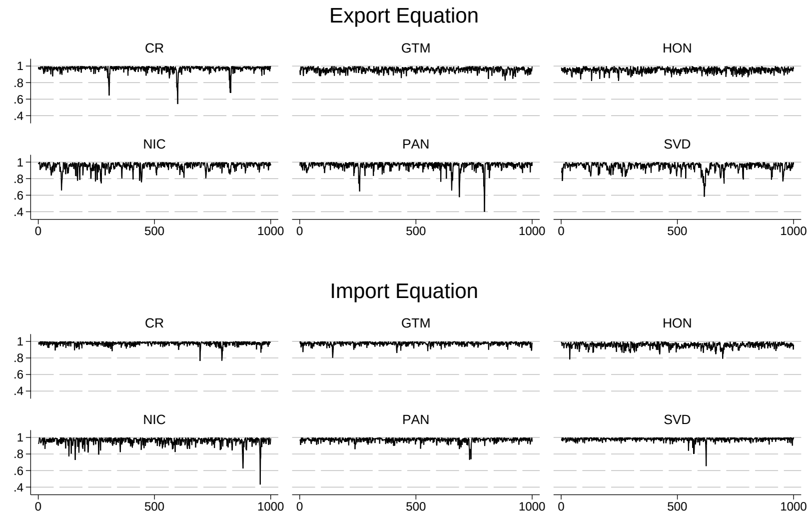
Note: Author's calculations based on WDI and MoxLAD Database. Number of Iterations 200,000; Burning Sample: 100,000; Thinning: Every 100th value.

Figure C.3: Posterior Distribution of $\phi^i_{1,1}$ in the State Equation with AR(1)



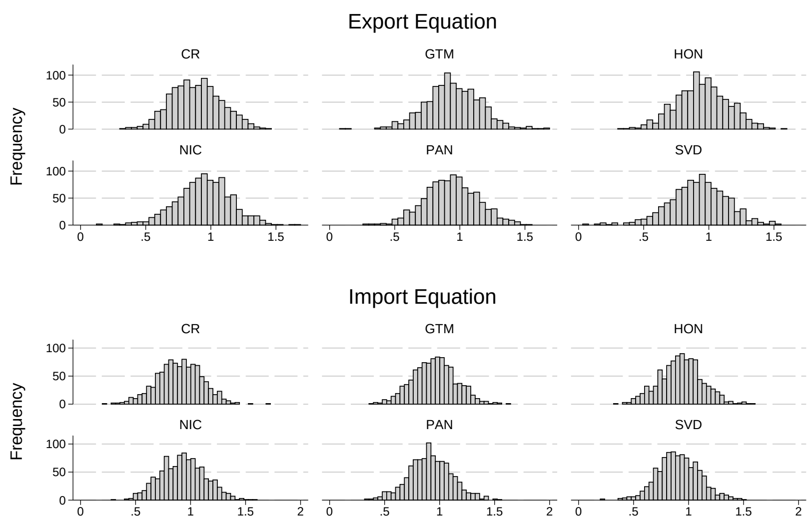
Note: Author's calculations based on WDI and MoxLAD Database. Number of Iterations 110,000; Burning Sample: 100,000.

Figure C.4: Draws after burning sample of $\phi^i_{1,1}$ in the State Equation with AR(1)



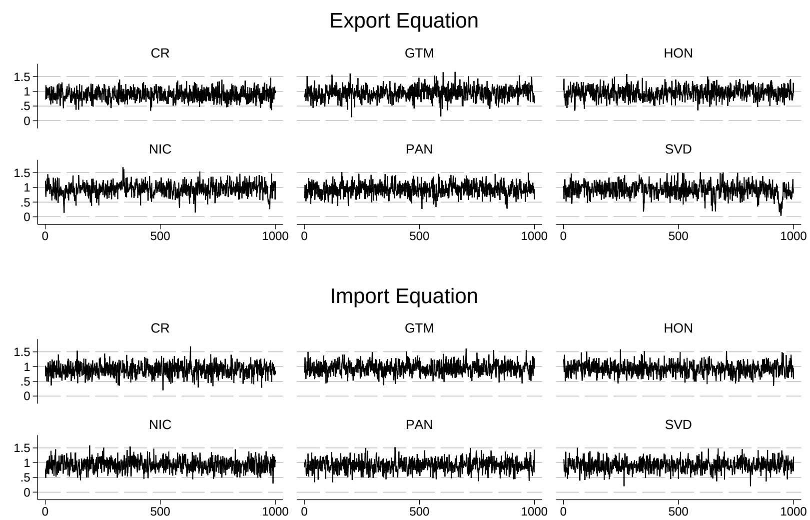
Note: Author's calculations based on WDI and MoxLAD Database. Number of Iterations 110,000; Burning Sample: 100,000.

Figure C.5: Posterior Distribution of $\phi^i_{1,1}$ in the State Equation with AR(2)



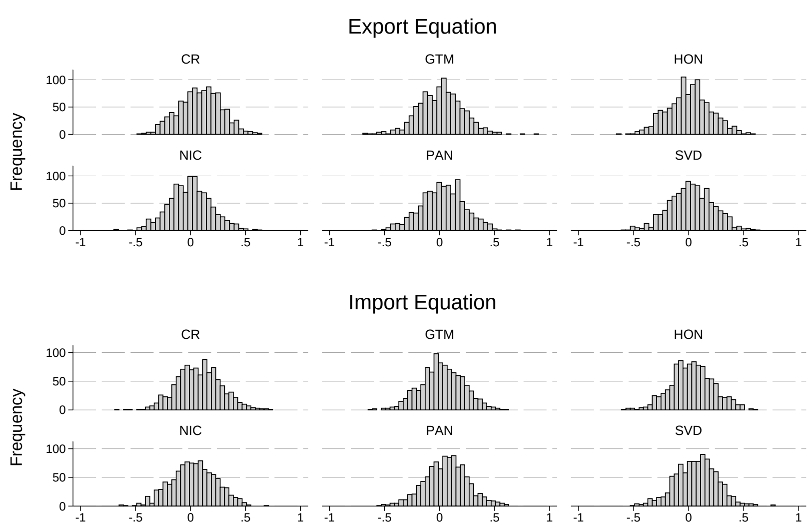
Note: Author's calculations based on WDI and MoxLAD Database. Number of Iterations 110,000; Burning Sample: 100,000.

Figure C.6: Draws after burning sample of $\phi^i_{1,1}$ in the State Equation with AR(2)



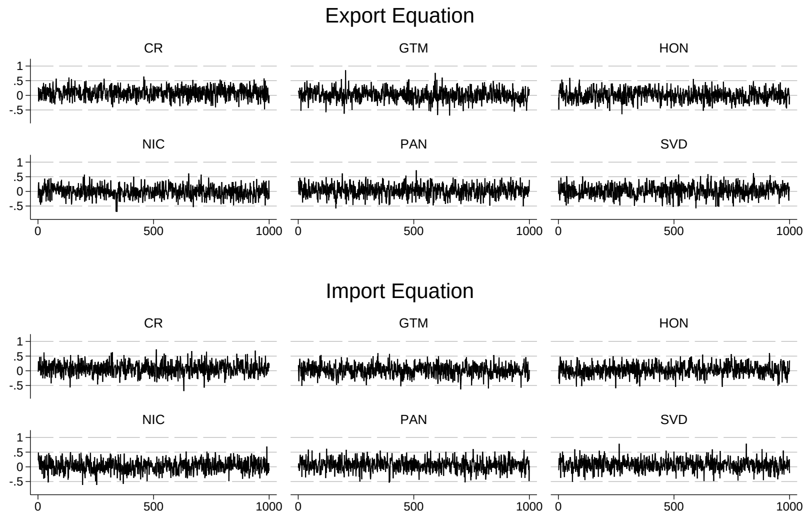
Note: Author's calculations based on WDI and MoxLAD Database. Number of Iterations 110,000; Burning Sample: 100,000.

Figure C.7: Posterior Distribution of $\phi^i_{1,2}$ in the State Equation with AR(2)



Note: Author's calculations based on WDI and MoxLAD Database. Number of Iterations 110,000; Burning Sample: 100,000.

Figure C.8: Draws after burning sample of $\phi^i_{1,2}$ in the State Equation with AR(2)



Note: Author's calculations based on WDI and MoxLAD Database. Number of Iterations 110,000; Burning Sample: 100,000.