THREE ESSAYS ON THE PROPOSED CARIBBEAN MONETARY UNION

A Dissertation

Submitted to

the Temple University Graduate Board

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in Partial Fulfillment

of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

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by

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May, 2014

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ABSTRACT

This thesis asks the question, is there economic justification for two CARICOM countries forming a currency union? There is a theoretical component consisting of a dynamic stochastic general equilibrium (DSGE) model, and an empirical component utilizing vector autoregressions and cointegration analyses. More specifically, the reactions of two, small, open economies, to symmetric and asymmetric shocks, with and without a currency union, are investigated. Secondly, the demand and supply shocks between country pairs are examined to determine whether positive correlations exist. Thirdly, the thesis looks at the issue of economic convergence, especially given the coordinated efforts of CARICOM member states towards an environment conducive for a currency union. The theoretical results support the traditional view that countries with symmetric shocks are better candidates for a currency union, while those with asymmetric shocks are not. The empirical work supports the formation of currency unions for the following country pairs, Grenada-St. Kitts, Grenada-St. Vincent, Trinidad-Grenada, and Trinidad-St. Vincent.

ACKNOWLEDGEMENTS

I am extremely grateful to the members of my committee - Drs. Fardmanesh, Khemraj, Kushnirsky and Swanson. Your patience and expert guidance made the process relatively smooth. I am particularly indebted to Dr. Fardmanesh for his foresight and execution. Thank you. To the professors whose courses I took, thank you. Without your input I would not have made it this far. To the heads of department (Drs Stull and Bognano), and graduate chairs (Drs Kushnirsky and Leeds), thank you for your unwavering support over the years.

To my fellow graduate students, especially Sandeep, thank you for your guidance and encouragement over the years. Your input was certainly indispensable to the process.

Without an undergraduate education I certainly would not have made it to graduate school, and as such it is only fitting to say thank you to the professors who played a role in my undergraduate education especially, Drs Solomon, Singh and Thomas, and Mr. Monplaisir.

To my wife, Lisa, and son, Joshua, thanks for your unwavering support, and for giving meaning to life. To my extended family, and friends, thank you. You have all played a part, and I am eternally grateful.

Thank you all.

for Mom, Lisa and Joshua

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CHAPTER 1
INTRODUCTION

1.1 Problem Statement

Is there economic justification for a member of the Caribbean Community (CARICOM) forming a currency union with another CARICOM member? While much has been said about a Caribbean monetary union (CMU), the project is often viewed in terms of several countries forming a union. This thesis moves away from this approach, and focuses on pairs of countries forming a union.

For a little more than two decades the members of CARICOM have been intermittently moving towards the formation of a CMU. In recent times their efforts have waned. The formation of a monetary union has costs and benefits. Countries within a currency union can benefit from reduced transactions costs; macroeconomic policy is more credible; and countries can share the burden of risk when incurring public debt. On the other hand, member countries lose the use of independent monetary policy. And, unless prevented, some countries are likely to "free ride" by incurring excessive public debt, thereby placing an unequal burden on other members of the union.

To reduce economic costs, while enhancing the economic benefits of being a member of a currency union, several criteria are desirable. Countries which are better suited to form a currency union should have similar business cycles and inflation rates; little or no restrictions on the movement of capital and labor; and are open economies with relatively high intra-regional trade with the potential members of the union. These criteria are known in the literature as the optimum currency area (OCA) criteria.

Pentecost and Turner (2010) explore the suitability of four CARICOM members integrating into a monetary union. The four countries they choose are the group B countries. The governors of CARICOM central banks in a 1992 report suggested that the move towards a CMU consist of two groups moving at different paces. The group A countries consisted of the more stable economies, while group B consisted

of the less stable economies. To address the issue, Pentecost and Turner (2010) first extract the supply and demand shocks for each country, and then find the correlation coefficient for each country pair. Positive, statistically significant, correlations of demand and supply shocks for a pair of countries, indicates the pair's suitability for being in a currency union. This is in keeping with the notion that countries with similar business cycles are good candidates for a monetary union.

This thesis goes a step further by looking at the entire proposed membership of a CMU. The rationale for doing is to test the implicit assumption by Pentecost and Turner (2010) that the group A countries are suitable candidates for a CMU. What is more, focus is placed on pairs of countries being suitable candidates for a CMU, as opposed to concentrating on all countries forming a CMU. To this end, the theoretical portion consists of a two country model, and the empirical analyses look at country pairs of CARICOM countries.

In an effort to address the question of whether a CMU is desirable, this thesis addresses three questions. First, are negative economic shocks amplified, or dampened, when two small, open, developing countries form a currency union? This question is addressed by examining the results of simulations of a Dynamic Stochastic General Equilibrium (DSGE) model, with frictions. Second, are the demand and supply shocks of the potential member countries of the proposed CMU correlated? Here, demand and supply shocks are "extracted" using the long run vector autoregression approach (LVAR). Positive significant correlations (demand and supply shocks) for a country pair is regarded as economic evidence of the suitability of two countries forming a union. And finally, is there evidence of economic convergence among the potential membership of the proposed CMU? To this end, the LVAR approach is used to explore whether there is evidence of convergence of demand and supply shocks, and cointegration analysis is used to test for possible long run relationships of the real effective exchange rate (REER) for pairs of CARICOM countries.

1.2 Rationale for Chapters

The economic analysis of the proposed CMU utilizes the two general approaches to economic analysis - theoretical and empirical. Indeed, a secondary purpose of this can be investigated and expressed. For example, Maurin and Watson (2002) note that while Caribbean scholars have done research using different methodological approaches, e.g. Vector Autoregressions (VARS) and Computable General Equilibrium (CGE) models, there is no work done with Dynamic Stochastic General Equilibrium Models (DSGE), whether New Keynesian or Real Business Cycle (RBC). From all indications the situation remains the same. It is against this backdrop that a small open economy model is presented here. The remaining chapters take an empirical approach.

Having separate chapters removes the erroneous expectation of a deeper connection between the use of each methodology, especially where the questions and parameters explored are similar. For example, DSGE models can be evaluated empirically by using LVARs. While both methodologies are used here to look at economic shocks, LVARs are not used to evaluate the DSGE model. Moreover, the DSGE model is not used to inform the structure of the LVAR. The separateness of the three chapters also makes for more meaningful analysis. For example, the conclusions drawn can either reinforce each other, or work as a caveat to the other result. This, in turn, can inform other relevant questions and future research.

1.3 Historical Context

On January 3, 1958, ten territories in the British Caribbean formed the West Indian Federation (Federation of the West Indies); a federation of territories with Chaguramas, Trinidad, as the Federal Capital. The members of the federation felt that they would be better able to secure independence from Britain, and collectively deal with the myriad of post-independence issues, as a unified group. However, the federation was dissolved in 1962 due in part to independence for major states; the geographic distance and separation of the territories by water which created logistical transportation problems; little or no effective coordination of policy (e.g. international

Table 1.1: The Members of CARICOM

Country	Population*	HDI	Area (km^2)
Non-ECCU			
Bahamas, The	316,182	0.794	13,940.0
Barbados	287,733	0.825	431.0
Belize	327,719	0.702	22,966.0
Guyana	741,908	0.636	214,970.0
Haiti	9,801,664	0.456	27,750.0
Jamaica	2,889,187	0.730	10,991.0
Suriname	560,157	0.684	163,270.0
Trinidad & Tobago	1,226,383	0.760	5,128.0
ECCU			
Antigua & Barbuda	89,018	0.760	442.6
Dominica	73,126	0.745	754.0
Grenada	109,011	0.770	344.0
Montserrat	5,164	n/d	102.0
St. Kitts	50,726	0.745	261.0
St. Lucia	162,178	0.725	616.0
St. Vincent	103,537	0.733	389.0

Sources: CIA World Factbook and Human Development Report 2013. *2013 estimates.

trade policy); and a general lack of political will. Jamaica was the first territory to leave the federation, seemingly frustrated by the slow pace of the independence movement, in addition to it not being chosen as the seat of the federal capital. The exit of Jamaica in 1961 led to the statement by Trinidad's then Prime Minister, Sir Eric Williams, that "one from ten leaves nought." In other words, without Jamaica, the federation was dead.

The 1960s marked a watershed in the political and economic history of the British Caribbean. It was the beginning of the end of British colonial rule in the Caribbean. Indeed, the independence movement in the British Caribbean was part of a greater world wide movement by British colonies around the world. Undoubtedly, energized by the demise of British superpower status in the aftermath of World War II, Caribbean countries fought tirelessly to take control of their own destinies. Jamaica and Trinidad were given independence from Britain in August of 1962, followed by

Barbados and Guyana in 1966. The other territories gained independence in the 1970s and 1980s. In 1965, Antigua and Barbuda (hereafter Antigua), Barbados, Guyana and Trinidad and Tobago (hereafter Trinidad), formed the Caribbean Free Trade Association (CARIFTA). This association was replaced in 1973 by the deeper integration movement, the Caribbean Community (CARICOM). This new organization was established by the Treaty of Chaguramas (1973), and the first signatories were the newly independent territories of Barbados, Guyana, Jamaica and Trinidad. Today the organization has fifteen full members - Antigua & Barbuda (hereafter Antigua), The Bahamas, Barbados, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts & Nevis (hereafter St. Kitts), St. Lucia, St. Vincent & The Grenadines (hereafter St. Vincent), Suriname, and Trinidad - see table 1. There are also five associate members - Anguilla, Bermuda, British Virgin Islands, Cayman Islands, and Turks and Caicos Islands. Antigua, Dominica, Grenada, Montserrat, St. Kitts, St. Lucia, St. Vincent and Anguilla are members of the Eastern Caribbean Currency Union (ECCU).

CARICOM initially provided the benefits of a customs union as well as cooperation in areas such as economic development, education, health, sport and agriculture. Unlike a union with a federal structure, there was no need for a central government. Each territorial head (Prime Minister or President) sits on the highest decision making body of the institution - the CARICOM Heads of Government. The territorial heads take turns chairing the group. While CARICOM has been relatively successful, the drive for creating a more integrated regional institution had not ended. It is against this backdrop that in 1989 the members of CARICOM ammended the Treaty of Chaguramas (TOC), creating the Revised Treaty of Chaguramas. The revised treaty provided the legal impetus for the creation of the Caribbean Single Market and Economy (CSME), where the vestigial barriers of factor immobility would be removed, and a common currency, the ultimate symbol of economic integration, would be created.

1.4 The Proposed Caribbean Monetary Union

The governors of the regional central banks in their 1992 report proposed the creation of a CMU among the members of CARICOM, by the year 2000. From the inception of the move towards a CMU, the Bahamas refused to be a part of any monetary arrangement. Montserrat is still a British colony, and Haiti's political and economic morass makes its inclusion impractical at this time. That leaves a total of twelve potential members. The report proposed a two-tiered, three stage approach to the creation of a CMU. The two tiers are concerned with the division of member states into group A, those member countries which have realized the convergence criteria, and group B comprised those members which had much work to do as regards achieving the convergence criteria. Group A consisted of Antigua & Barbuda, Dominica, Grenada, Montserrat, St. Kitts & Nevis, St. Lucia and St. Vincent, all members of the ECCU, in addition to The Bahamas and Belize. Group B consisted of Barbados, Guyana, Jamaica, and Trinidad & Tobago. Suriname and Haiti were not members of CARICOM at the time of the report. The 'three stage approach' is concerned with prospective members satisfying the '3-12-36-15' criteria i.e.;

1. Maintain sufficient reserves to cover 3 months worth of imports, and to maintain this reserve level for 12 consecutive months;

2. Maintain a stable exchange rate against the US dollar for 36 months. Also, the exchange rate must not have fluctuated by more than 1.5% during the 3 years prior to monetary union; and

3. Maintain an annual external debt service ratio of no more than 15% of the value of total annual exports.

The import cover criteria of item one was later strengthened to require that potential members keep reserves amounting to either 3 months import cover or 80% of central bank current liabilities, whichever is greater.

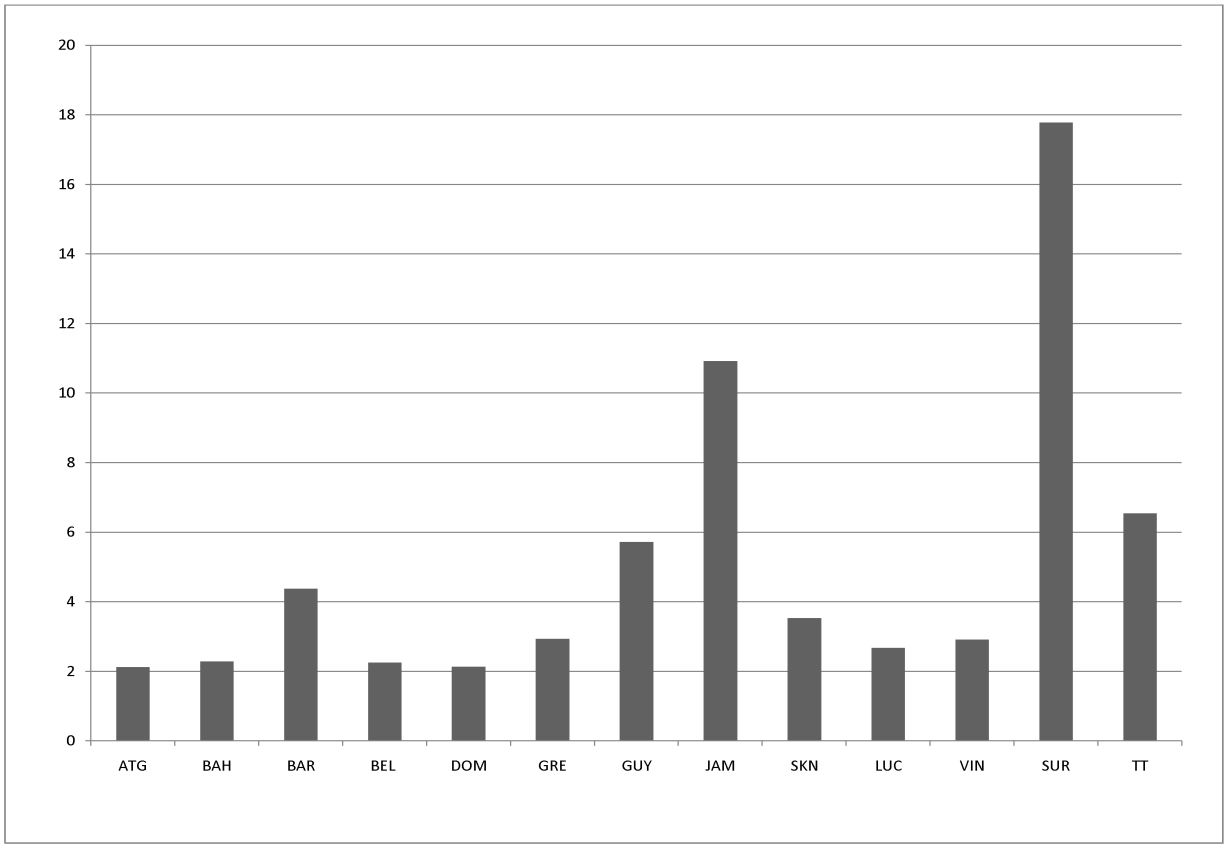
Baladi (2007) notes that none of the CARICOM countries had attained all of the criteria. He writes, "Trinidad and Tobago comes closest, having satisfied four out

Table 1.2: GDP, GDP COMPOSITION & PUBLIC DEBT IN CARICOM

Country	GDP[1]	Agri.[2]	Ind.[2]	Ser.[2]	Debt/GDP[3]	LCU/US$ [4]
Non-ECCU						
Bahamas, The	8.043	2.1	7.1	90.8	N/A	1.00
Barbados	4.490	3.1	13.9	83.0	82.9	2.00
Belize	1.554	13.0	23.0	64.0	90.1	2.00
Guyana	2.788	20.0	34.8	45.2	66.1	202.00
Jamaica	15.250	6.4	29.1	64.9	134.2	105.00
Suriname	4.738	10.6	38.3	51.2	N/A	3.30
Trinidad & Tobago	25.280	0.3	57.8	41.9	40.3	6.41
ECCU						
Antigua & Barbuda	1.176	7.0	11.0	82.0	89.0	2.70
Dominica	0.497	13.6	15.0	71.4	70.0	2.70
Grenada	0.790	5.4	16.1	78.5	110.0	2.70
St. Kitts	0.734	1.7	23.3	75.0	144.0	2.70
St. Lucia	1.220	3.1	16.3	80.7	77.0	2.70
St. Vincent	0.712	5.4	19.9	74.8	68.0	2.70

Source: CIA World Factbook - 2012 Estimates.
[1] GDP in Billions of US Dollars.
[2] Sectoral (Agriculture, Industry and Services) composition as a percentage of GDP
[3] Public Debt as percentage of GDP
[4] Exchange Rate - Local currency per US Dollar as of October, 2013.

of the five. The Bahamas and the ECCU area presently meet three of the five, but the Bahamas has no interest in CMU since its currency is already pegged 1:1 to the US dollar. Barbados and Guyana lag behind, meeting only two of the five criteria, and Belize and Jamaica are furthest behind, satisfying just one." At a special retreat (Guyana) for the CARICOM heads of government a decision was taken to put the single economy aspect of the CSME on hold, while consolidating the gains made from efforts towards the creation of the single market e.g. the free movement of skilled labor.



ATG = Antigua, BAH = Bahamas, BEL = Belize, BAR = Dominica, GRE = Grenada, GUY = Guyana, JAM = Jamaica, SKN = St. Kitts, LUC = St. Lucia, SUR = Suriname, TT = Trinidad , and VIN = St. Vincent.

Figure 1.1: Average Inflation Rates (2000-2011)

CHAPTER 2
LITERATURE REVIEW

In defining an optimum currency area (OCA), McKinnon (1963) writes:

> "Optimum is used here to describe a single currency area within which monetary-fiscal policy and flexible external exchange rates can be used to give the best resolution of three (sometimes conflicting) objectives: (1) the maintenance of full employment; (2) the maintenance of balanced international payments; and (3) the maintenance of a stable internal average price level."

The OCA literature can be divided into three parts; traditional, resurgent and recent. Researchers such as Broz (2005) and Horvath (2003) separate the OCA literature along the lines of traditional and modern work. The traditional work consists of the seminal works of Mundell (1961), McKinnon (1963) and Kenen (1969). This period spanned the 1960s and 1970s. The traditional work on OCA theory originated from the debate concerning the proposals for the international monetary system in the postwar period - Cesarano (2006). After a period of relative dormancy, the currency unification debate was revived by discussions regarding the formation of the Euro. This renewed interest was primarily a result of the move towards deeper European integration. Tavlas (1993) also credits the new developments in the macroeconomic field as another reason for this resurgence. Indeed, the movement towards developing macroeconomic models grounded in micro-foundations had gained root. In recent times, the OCA literature increasingly uses more numerical as opposed to qualitative and descriptive analyses of monetary unions. Given the new prominence of DSGE models among academics and central bankers, has contributed to the quantitative emphasis.

The following sections explore the literature thematically as opposed to chronologically. Section 2.1 treats with the issue of the OCA criteria. Indeed, the OCA criteria are a useful starting point for any work on currency unions. Sections 2.2 and 2.3 explore the relevant theoretical and empirical literature, respectively. And finally, Section 2.4 looks at the relevant research on the proposed CMU. The final section

presents the contributions of this thesis.

2.1 Traditional Criteria vs Endogeneity

The first traditional criterion has to do with the synchronicity of business cycles. This criterion implicitly assumes that government can initiate counter-cyclical monetary policy when necessary. However, in a union where several countries have dissimilar business cycles, it would be difficult to initiate a common effective policy at a supranational level. Indeed, a common monetary policy may worsen the economic situation in at least one country, assuming asymmetric business cycles. As a result, it has been argued that all countries seeking to join a monetary union should have similar business cycles, therefore minimizing the potential costs which arise as a result of a common monetary policy. Mundell (1961) supports the forgoing argument, and is regarded as the "godfather" of optimum currency area (OCA) theory. Dellas and Tavlas (2009) argue that other economists, such as Friedman (1953)), enumerated the traditional criteria but not as extensively as Mundell (1961). In fact, in the aftermath of the Bretton Woods conference the issue of the optimal type of exchange rate regime was widely debated. A policy is regarded as optimal if it is the best approach to achieving the macroeconomic objectives of price stability, economic growth and a sustainable external position.

The second criterion, labor mobility, is related to the first. Indeed, it reduces the necessity for the first criterion. There is likely to be some asymmetry of business cycles for countries within a monetary union. In fact, business cycles are likely to be different for different parts of a country, much more a group of countries, see Kouparitsas (2001). However, within the boundaries of a country it is easier for labor to move from one region to another when the need arises. Such mobility lowers the economic impact of a recession in one part of the country, and reduces the need for increased fiscal expenditures e.g. increased unemployment benefits. Moreover, the inconsistency of monetary policy to simultaneously meet the needs of all parts of the country will be less severe. Mundell (1961) argues for labor mobility and/or flexible wages in the event that "regions" are susceptible to asymmetric shocks. In other words, labor mobility

and/or flexible wages can correct both external and internal disequilibria without the need for exchange rate adjustment and independent monetary policy. In the absence of the forgoing, Mundell (1961) argues that countries with asymmetric shocks should have a flexible exchange rate. Kenen (1969) also makes a similar argument, but focuses on the correction of an external imbalance in a common currency area.

While effective labor mobility is difficult to achieve for a myriad of reasons, capital mobility is easier to accomplish and is complemented by a common currency. For capital mobility to have any meaningful impact there needs to be an active and relatively deep market for financial assets. Anything less will lead to a sub optimal level of risk sharing. Essentially, capital mobility and financial integration within a monetary union can mitigate the adverse consumption effects of an asymmetric shock to a member country. Moreover, the burden of the shock is shared with the rest of the union. Two examples of how this could work should suffice. First, assume that country A has experienced a negative shock, while the rest of the union is fine. The citizens of country A can borrow from the rest of the union to smooth their consumption and to fund investment opportunities without having to incur additional borrowing costs. In a flexible exchange rate regime, lenders would factor in a higher risk premium to counter any likely currency depreciations. Additionally, it is possible that a recession in country A would lead to a depreciation of that country's currency, which would most certainly lead to a worsening terms of trade in the short run. Assuming a relatively inelastic demand for imports and exports, the current account balance with the rest of the union will worsen. Falling domestic prices could exacerbate the situation. A common currency mitigates the foregoing adverse scenarios. In the second scenario, country A would have claims on the rest of the union, assuming the integration of financial markets, and as such will be able to smooth consumption. To be specific, the citizens of country A are expected to have equity in the rest of the union. Since the rest of the union is doing well, country A can smooth consumption through dividends, or sell its shares. On the other hand, the rest of the union will share the burden of country A since their equity in country A would have lost value. If financial markets within the union are not highly integrated, country A would have

to absorb a higher proportion of the loss. Mundell (1973), in what can be regarded as a corollary to Mundell (1961), supports the notion of international risk sharing in an environment of fixed exchange rates - see McKinnon (2004). Asdrubali, Sørensen, and Yosha (1996) empirically investigate the issue of risk sharing by decomposing the interstate risk sharing within the United States. They look at risk sharing from more than one source i.e. capital markets, credit markets and government. Their (Asdrubali, Sørensen, and Yosha (1996)) results indicate that 39% of the shocks were smoothed through capital markets, 23% through credit markets, and 13% through federal government activity. The remainder of the shocks were not smoothed.

The final criterion is intra-regional trade. It is expected that the higher the value of intra-regional trade, the greater will be the cost savings accruing to member states. It is not clear as to whether relatively open economies are better served by having a fixed exchange rate. On the one hand, an open economy can achieve price stability through a fixed exchange rate. This is due to restrictions on domestic monetary policy and the non existence of pass through effects of exchange rate fluctuations on the domestic price level. On the contrary, fixed exchange rates may not insulate an open economy from external pressures on domestic prices. Indeed, small economies - price takers - are relatively more open, and so flexible exchange rates could work to correct price changes. For example, assume that the price of a price elastic import increases, theory suggests that the total foreign currency value spent on that good will fall. Since the demand for foreign currency is derived from the demand for imports, then the demand for foreign currency is expected to fall (ceteris paribus), and the domestic currency appreciates, thus dampening the initial price increase in domestic currency terms. Of course it is possible that the adjustment process does not stop there, but the point is that the full effect of the foreign price increase is not passed on to the domestic market. If the currency were fixed the price increase would be faced by domestic consumers. In both scenarios it is assumed that there is nothing hindering exchange rate pass through effects other than changes in the foreign exchange market, and it is further assumed that domestic prices for imports are invoiced with the foreign currency as the numeraire. This results in little or no menu costs on the part of domestic importers.

McKinnon (1963) argues that small open economies are better served by a fixed exchange rate. On the other hand, Kenen (1969) implicitly contradicts McKinnon (1963) by suggesting that a country that has a relatively diversified economic structure can better withstand asymmetric shocks and as such does not need the services of a flexible exchange rate. The implicit contradiction arises since large closed economies are more likely to be relatively diversified.

The literature on endogeneity of the OCA criteria began in the aftermath of the resurgence of interest in OCA theory. The Euro project provided an ideal laboratory for the conduct of empirical studies. The endogeneity strand of the literature seems to have started with the work of Frankel and Rose (1997). They investigate whether or not the Euro could be justified *ex post* or *ex ante* by examining the intensity of bilateral trade and real economic activity (real Gross Domestic Product (GDP), total employment, unemployment and industrial production). Using data from twenty countries, for a period of thirty years, their findings support the notion that countries that trade extensively with each other are more likely to have highly correlated business cycles. Assuming that the formation of a currency union leads to increased intra-regional trade flows, business cycles are likely to become more correlated i.e. the criteria which are regarded as necessary for entry could be realized *ex post*. While their empirical work led to encouraging results, the authors acknowledge that increased trade and subsequent specialization is likely to lead to greater asymmetry of business cycles. On the other hand, increased integration can result in greater correlation of demand shocks.

De Grauwe and Mongelli (2005) provide an extensive survey of the literature on the endogeneity of the OCA criteria with particular reference to the European Monetary Union (EMU). The areas they explore are economic integration with regard to prices and trade; financial integration; symmetry of shocks and labor mobility. In general, the authors indicate "moderate optimism" as regards the endogeneity of the OCA criteria. Specifically, they note that there is significant integration of trade for countries within a currency union. This observation is qualified with regard to the empirical evidence in Europe where there was already significant trade integration.

Moreover, it would take more time for the effects of the monetary union to be fully accounted for.

2.2 Theoretical Models

Bayoumi (1994) presents one of the earliest general equilibrium models of a currency union. At that time his work satisfied the need for mathematical formalism in the analysis of currency unions. Bayoumi (1994) provides a micro-founded framework for analyzing the incentives that drive the creation of currency unions. He analytically compares welfare scenarios with and without a currency union, and with different variations of the currency union. For example, he assesses welfare in a currency union with and without labor mobility. The analysis, while covering different sectors of the economy, was void of any maximization, or minimization, problems. What is more, Bayoumi (1994) uses the analytical method - closed form solution approach. Alesina and Barro (2002) also use the analytical method. They find that a small open economy, that engages in significant trade with a large trade partner, has a business cycle that is highly correlated with that partner, and a history of high inflation, stands to gain more from abandoning its own currency. (Alesina and Barro, 2002) also examine the myriad variables (country sizes, trading costs etc.) that determine an optimal currency area.

The DSGE approach employs the numerical approach and is useful in that its results can be evaluated based on empirical evidence. Gali and Monacelli (2008) develop a NK DSGE model for analyzing optimal fiscal and monetary policy in a currency union. Their model is calibrated using quarterly Eurozone data, and solved through log-linearization techniques. There is a continuum of households, firms and countries. Prices are assumed to be rigid - see Calvo (1983), and by extension firms are not perfectly competitive. For comparative analysis a flexible price, first best solution, is established before the equilibrium conditions of a monetary union with inflexible prices are estimated. Their model stresses optimal fiscal policy at the country level that provides public goods, and more importantly supports the union's central bank in its mandate to ensure price stability. Gali and Monacelli (2008) seek to devise a

framework within which policy issues affecting currency unions could be evaluated. Like Gali and Monacelli (2008), Ferrero (2009) examines optimal monetary and fiscal policy using a NK DSGE model. Unlike Gali and Monacelli (2008), Ferrero (2009) uses a two country framework and incorporates distortionary taxation. Ferrero (2009) concludes that monetary policy should focus on flexible inflation targeting, while national fiscal policy is optimal when it does not lead to inflation expectations on a supra-national level.

2.3 Empirical Literature

According to Dellas and Tavlas (2009), the OCA literature subsided during the 1970s and 1980s. Eichengreen (1992) revived the literature in his consideration of the Euro, which was being proposed at the time. Eichengreen (1992) writes, "I ask whether Europe is (and is likely to remain)further than the United States and Canada from satisfying Mundell's criteria for an OCA: free mobility of labor within the area and stability of relative prices". Generally, the United States, or Canada, is used as a benchmark in empirical studies on OCAs. Both countries are multiple region countries with a common currency. Eichengreen (1992) finds that "Europe remains further than the US and Canada from the ideal of an OCA." For example, security prices and real exchange rates were found to be more variable in Europe than in the US. Given his results Eichengreen (1992) proposes the creation of "regional shock absorbers, such as fiscal federalism," to mitigate the effects of idiosyncratic disturbances.

Bayoumi and Eichengreen (1993) extend Eichengreen (1992), they analyze the feasibility of European monetary unification. This time, however, emphasis was placed on understanding demand and supply disturbances for eleven European Community (EC) countries. Using the United States as a benchmark, they use the eight United States Bureau of Economic Research (BEA) regions. The authors note that approaches which use relative prices to empirically investigate the issue "conflate information on the symmetry of shocks and on the speed of adjustment." In other words, by using relative prices, information on economic shocks, for example, are aggregated or indistinguishable. To avoid this shortcoming Bayoumi and Eichen-

green (1993) use the Structural Vector Autoregression (SVAR) approach (Blanchard and Quah (1989)), for distinguishing between disturbances. As a secondary issue, Bayoumi and Eichengreen (1993) addresses whether the United States, the common benchmark, is an OCA. They find that the United States is not an OCA. In terms of CARICOM, Pentecost and Turner (2010) and Augustine (2008) implicitly treat the ECCU as meeting the ideals of an OCA, relative to its regional counterparts.

2.4 Caribbean Monetary Union Literature

Much emphasis has been placed on how the CARICOM region measures up in terms of the OCA criteria. See Anthony and Hallet (2000), Baladi (2007), Jayaraman (2007) and Worrell (2003). They conclude that the countries of the proposed CMU do not constitute an OCA. For example, trade (exports and imports) with the United States is of greater importance to CARICOM member states, as opposed to intra-regional trade. This limits the potential gains to be derived from sharing a common currency. The issue of economic convergence has been explored in different ways and for different macroeconomic variables. Looking at all CARICOM countries Atkins and Derick (1998) find that the evidence does not support the long run convergence of per capita income in the post independence period. Using cointegration techniques Kendall (2000) investigates the convergence of exchange rates within the CARICOM bloc of countries - except Haiti. Data on both real and nominal exchange rates for the period 1967 - 1996 were used. Naturally, greater emphasis was placed on the real exchange rate. The results indicate little convergence of exchange rates. Modeste and Kendall (2003) look at the convergence of quarterly interest rates (1990:1 - 2000:2) for selected CARICOM countries (The Bahamas, Belize, Haiti and Suriname were excluded). They find complete convergence of lending rates, and partial convergence of deposit rates.

More recently, studies employing more rigorous econometric techniques have been done. Augustine (2008) compares the business cycle correlations between countries outside of the ECCU with those of the countries within the ECCU. His results show low correlations for business cycle pairs, thus questioning the practicality of a CMU.

His work does not separate the demand and supply components of the business cycle. Pentecost and Turner (2010) go a step further and use the Blanchard and Quah (1989) long run vector autoregression (LVAR) approach for extracting supply and demand disturbances. Pentecost and Turner (2010) focus on the OCA criterion which argues that economies seeking to share a common currency need to have similar disturbances. In short, if a majority of the countries studied are found to have significantly positively correlated demand and supply shocks then a case can be made for the creation of the proposed CMU. Pentecost and Turner (2010) posit that current asymmetries would be of little concern if the underlying supply and demand shocks are highly correlated. Therefore, current asymmetries may be an artifact of differing short term policy measures, as opposed to fundamental differences. A currency union would correct the asymmetries when they are primarily as a result of policy. The results of Pentecost and Turner (2010) indicate little or no correlation in terms of both demand and supply disturbances for the four countries (Barbados, Guyana, Jamaica and Trinidad) studied. Indeed, there was only one significant correlation i.e. the demand correlation between Trinidad and Barbados. Pentecost and Turner (2010) view a supply shock as being more important than a demand shock. As specified in the model, supply shocks have a long run impact on output, while demand shocks only have a temporary impact on long run output. Cuestas and Dobson (2011) build on the work of Pentecost and Turner (2010) by investigating inflation persistence among the potential twelve members of the proposed CMU. Using various time series methods, such as unit root tests, Cuestas and Dobson (2011) find evidence of a convergence club of inflation rates within the region. Their findings lend support for a unified monetary policy and by extension a common currency. This runs counter to general position of studies (e.g. Anthony and Hallet (2000), Baladi (2007), Jayaraman (2007)) on the proposed CMU.

2.5 Contribution of Thesis

This thesis uses both the traditional criteria and endogeneity views. By exploring the correlations of demand and supply shocks, and using same to comment on the

suitability of a CARICOM country joining one, or more, of its counterparts in a CMU, this thesis implicitly agrees with the traditional criteria. On the other hand, the convergence of demand and supply shocks (Chapter 5) centers upon the endogeneity view. As noted in Chapter 1, the proposed membership were given a set of convergence criteria in preparation for the creation of a CMU. Moreover, efforts have been made to deepen the integration process. For example, a double taxation policy, a harmonized tax structure, and a common investment code have been initiated, see Baladi (2007). And so while a currency union is not yet in place, the common thrust of all parties involved could result in outcomes that support the endogeneity view.

While there are DSGE models calibrated for developing countries, there does not appear to be any such models geared towards studying currency unions among developing countries. Additionally, this thesis is also motivated by the nascent state of macroeconomic modeling in the Caribbean. It is against this backdrop that a small, two country, open economy model is used here. A NK DSGE model without the traditional three equation framework is used. Like Bayoumi (1994) this thesis looks at two different policy regimes of an economy i.e. within and without a currency union. Moreover, and in keeping with dynamic models, such as Gali and Monacelli (2008) and Ferrero (2009), this thesis analyses the impact of a technology shock on economic variables, in two monetary policy regimes. The goal here is relatively modest. To be specific, the DSGE model compares the effects of a negative technology shock in two different states. It seems no other DSGE currency union study has compared two policy regimes in an effort to assess the rationale for creating or not creating a currency union.

The Blanchard and Quah (1989) method, employed by Bayoumi and Eichengreen (1993) and Pentecost and Turner (2010), of extracting demand and supply shocks is employed here. This thesis extends the work of Pentecost and Turner (2010) by looking at all of the potential member states of the proposed CMU. This section of the thesis is separate from the DSGE model. The Bahamas and the United States are also included in the study. Pentecost and Turner (2010) implicitly assume that the remaining potential members are ideal candidates for the proposed CMU. This im-

plicit assumption is based on the fact that the Governors of Caribbean central banks, in a 1992 report, singled out Barbados, Guyana, Jamaica, and Trinidad as countries needing to achieve the convergence criteria. Moreover, six of the other eight potential members are already part of a currency union - the ECCU. Suriname was not a part of that 1992 report since it was not yet a CARICOM member. First and foremost, this thesis focuses on the suitability of one country joining ranks with another country. However, if several pairs of countries are found to be suitable candidates for sharing a currency, then an argument can be made for a union consisting of more than two countries.

Like Kendall (2000), this thesis also uses cointegration to measure the convergence of exchange rates. Here, the real effective exchange rate is used. Unlike Kendall (2000), the purpose and specific approach are different. Data for the period 1991-2011 are used. This period corresponds with the period during which the proposed membership of the CMU were working towards monetary integration as specified in the convergence criteria (see Chapter 1). The convergence criteria includes restrictions on the movement of exchange rates. This thesis seeks to ascertain the efficacy of those policies on the real effective exchange rate. Instead of looking at all of the countries simultaneously, countries are investigated in pairs. In other words, convergence of the real exchange rates are investigated for specific pairs of countries. This is in keeping with the general thrust of this thesis as regards the suitability of unions between pairs of CARICOM countries, and not necessarily the entire bloc of countries. More details on the countries studied are provided in Chapter 5. By exploring the possibility of converging economic shocks, and real exchange rates, the work of Cuestas and Dobson (2011) is built upon.

CHAPTER 3
A GENERAL EQUILIBRIUM MODEL

The model developed here is a New Keynesian model of two, small, open, developing economies. For each country there are two sectors - households and firms. There is a foreign sector which models the interaction between the two countries. Each household holds money to satisfy a cash in advance (CIA) constraint. Three types of assets are held; domestic money, foreign bonds and domestic capital. There are two types of firms; final goods firms and intermediate firms. The intermediate firms operate in an imperfect market structure and have the ability to set price. The intermediate firms set prices based on a Calvo pricing rule, see Calvo (1983). In other words, only a fraction of intermediate goods firms change their prices in a given period. Intermediate goods firms sell their product to the final goods firms. The latter operates in a perfect competitive market structure. Final goods are assumed to be tradable. In each period the agents in one country either buys or sells foreign bonds to the other country. The removal of the exchange rate, and the assumed equalization of prices, are used here to mimic the move towards a currency union.

Two different monetary policy regimes are compared i.e. no currency union and a currency union. In the first instance, under both policy regimes, an asymmetric technology shock is applied to the home country. In the second scenario a symmetric technological shock is applied to both countries . At issue is whether the negative technology shocks amplify, or dampen, the change in variables for the two countries forming a currency union. To this end the mean and variance for each real variable is examined. Higher means, and lower variability are preferred. Negative technology shocks are chosen here over positive shocks since a country seeking to form a currency union would be more concerned about contending with negative shocks. Indeed, members of a currency union loose the ability to use independent monetary policy.

3.1 The Model

The equations for the households are representative of the home country. After adjusting for the exchange rate and bond purchases, or sales, the equations for the households represent the foreign country. The equations for the firms represent firms in the home and foreign countries. To make the presentation clearer, the complete model, specifying the final set of equations for each country, is presented after the derivations.

3.1.1 Model Specification

Households

There is a unit mass of an infinitely-lived agent (household). Each agent is denoted by $i \in [0,1]$. Agent i chooses $\{c_t^i, h_t^i, b_t^i, k_t^i, m_t^i\}_{t=0}^{\infty}$ to maximize,

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ln\, c_t^i \; + \; D h_t^i \right], \tag{3.1}$$

where $\beta \in (0,1)$ is the discount factor. In period t, c_t^i and h_t^i are the consumption and hours of work, respectively, of household i. Since the number of hours worked is a decreasing function of leisure, it is adjusted by the dis-utility parameter, D, in the utility function. The parameter D, has a negative value, and is assumed constant irrespective of the number of hours worked.

The objective function, equation 3.1, is subject to the budget constraint for each household in period t,

$$\begin{aligned} c_t^i + \frac{m_t^i}{P_t} + \frac{e_t b_t^i}{P_t} + k_{t+1}^i \;\; \leq \;\; & w_t h_t^i + r_t k_t^i + \xi_t^i + (1-\delta) k_t^i - \frac{\kappa}{2}\left(k_{t+1}^i - k_t^i\right)^2 \\ & + \frac{e_t (1 + r_{t-1}^b) b_{t-1}^i}{P_t} + \frac{m_{t-1}^i + (g_t - 1) M_{t-1}}{P_t}, \end{aligned} \tag{3.2}$$

where e_t is the purchasing power parity (PPP) exchange rate, r_t^b is the interest rate on bonds, and b_t^i is bond purchases, or sales, measured in dollars of foreign country bonds. If $b_t^i < 0$ the domestic country is selling bonds, or borrowing from the foreign country, and vice vera. As is customary, w_t is the wage, and r_t is the interest on

capital. Capital, k_t^i, is chosen in period $t-1$ and used in the current period, t. The rate of capital depreciation and capital adjustment costs are represented by δ and κ respectively. The amount of profit received by each household is represented by ξ_t^i.

The cash in advance constraint (equation 3.5) is embedded into the household budget constraint. Consumption in the current period is equal to money held over from the previous period, in addition to any government transfer or tax, adjusted by the price level i.e.

$$c_t^i = \frac{m_{t-1}^i + (g_t - 1)M_{t-1}}{P_t}, \tag{3.3}$$

where P_t is price in period t, m_{t-1}^i is the nominal money balance chosen in period $t-1$, and $(g_t - 1)M_{t-1}$ is the stochastic lump sum monetary transfer, $g > 1$, or tax, $g < 1$. The parameter g represents the gross growth rate of money.

The stochastic process for money growth rate is

$$ln\, g_t = \gamma^g\, lng_{t-1} \,+\, \epsilon_t^g. \tag{3.4}$$

where γ^g is the auto-regressive term reflecting the persistence of money growth, and ϵ_t^g is the error term or random money shock, with a mean of zero.

Rearranging equation 3.2 by moving price to the right hand side gives the real consumption constraint. This real constraint is a part of the real budget constraint facing the household.

The real budget constraint for each household in period t is defined as

$$\begin{aligned} c_t^i + \frac{m_t^i}{P_t} + \frac{e_t b_t^i}{P_t} + k_{t+1}^i \;\leq\; & w_t h_t^i + r_t k_t^i + \xi_t^i + (1-\delta)k_t^i - \frac{\kappa}{2}\left(k_{t+1}^i - k_t^i\right)^2 \\ & + \frac{e_t(1 + r_{t-1}^b)b_{t-1}^i}{P_t} + \frac{m_{t-1}^i + (g_t - 1)M_{t-1}}{P_t}, \end{aligned} \tag{3.5}$$

where e_t is the purchasing power parity (PPP) exchange rate, r_t^b is the interest rate on foreign bonds, and b_t^i is the amount of bond purchases (loans) in period t, or bond sales (debt) if $b_t^i < 0$. Bond purchases, or sales, occur between the home and foreign country. On other words, bonds issued by the home country are bought by the foreign

country and vice versa. As is customary, w_t is the wage, and r_t is the interest on capital. Capital, k_t^i, is chosen in period $t-1$ and used in the current period, t. The rate of capital depreciation and capital adjustment costs are represented by δ and κ respectively. The amount of profit received by each household is represented by ξ_t^i.

In every period, as specified on the left hand side of equation 3.5, each household purchases consumer goods, keeps a given level of real money balances to be spent in the next period $(t+1)$, purchases or sells (borrow) bonds, and chooses the level of capital for the next period. It should be noted that bonds are purchased and held for one period. On the right hand side of 3.5 are the returns to labor and capital, economic profits, returns on bonds, and the real money balance chosen in the previous period coupled with any government lump sum money transfer. Capital which is not lost through depreciation is added to household income. On the other hand, household income is reduced by capital adjustment costs if capital purchases are more than, or less than, what is needed to replace depreciated capital. The costs are written in such a way that there is symmetry in the cost of over or under investment. It should be noted that since the model has bonds the issue of choosing between investing in domestic capital and a foreign bond arises, and can lead to an indeterminate model. Adding capital adjustment costs is one way of resolving the indeterminacy problem.

Given equation (constraint) 3.2 the real budget constraint can be rewritten as

$$\begin{aligned} \frac{m_t^i}{P_t} + \frac{e_t b_t^i}{P_t} + k_{t+1}^i + \frac{\kappa}{2}\left(k_{t+1}^i - k_t^i\right)^2 \quad &\leq \quad w_t h_t^i + r_t k_t^i + \xi_t^i + (1-\delta)k_t^i \\ &\quad + \frac{e_t(1+r_{t-1}^b)b_{t-1}^i}{P_t}. \end{aligned} \tag{3.6}$$

The objective function 3.1 is maximized subject to the budget constraints as specified below:

$$L = \max_{\{c_t^i, k_{t+1}^i, h_t^i, \hat{m}_t^i\}} E_0 \sum_{t=0}^{\infty} \beta^t \left[\left(ln\, c_t^i \; + \; Dh_i \right) \; + \; \Lambda_t^1 \left(m_{t-1}^i - (g_t - 1) M_{t-1} - c_t^i P_t \right) \; + \; \Lambda_t^2 \left(w_t h_t^i \right.\right.$$
$$\left.\left. + \, r_t k_t^i + \xi_t^i + (1-\delta) k_t^i - \frac{\kappa}{2} \left(k_{t+1}^i - k_t^i \right)^2 + \frac{e_t (1 + r_{t-1}^b) b_{t-1}^i}{P_t} - \frac{m_t^i}{P_t} - \frac{e_t b_t^i}{P_t} - k_{t+1}^i \right) \right]$$

The first order conditions for the home country are:

$$\frac{\partial L}{\partial c_t^i} = \frac{1}{c_t^i} - \Lambda_t^1 P_t = 0 \qquad \Rightarrow \Lambda_t^1 = \frac{1}{c_t^i P_t}, \tag{3.7}$$

$$\frac{\partial L}{\partial m_t} = \Lambda_{t+1}^1 \beta - \frac{(\Lambda_t^2 + \Lambda_t^3)}{P_t} = 0 \qquad \Rightarrow (\Lambda_t^2 + \Lambda_t^3) = P_t \, \Lambda_{t+1}^1 \, \beta \tag{3.8}$$

$$\frac{\partial L}{\partial h_t^i} = D + \Lambda_t^2 w_t = 0 \qquad \Rightarrow \Lambda_t^2 = \frac{-D}{w_t}, \tag{3.9}$$

$$\frac{\partial L}{\partial k_{t+1}^i} = -(\Lambda_t^2 + \Lambda_t^3) \left[1 \; + \; \kappa (k_{t+1}^i - k_t^i) \right] + \beta (\Lambda_{t+1}^2 + \Lambda_{t+1}^3) \left[\kappa (k_{t+1}^i - k_t^i) + r_{t+1} \; + (1 - \delta) \right] \tag{3.10}$$

$$\frac{\partial L}{\partial B_t} = -\frac{(\Lambda_t^2 + \Lambda_t^3) e_t}{P_t} + E_t \frac{(\Lambda_{t+1}^2 + \Lambda_{t+1}^3) \beta e_{t+1} (1 + r_t^b)}{P_{t+1}} = 0 \tag{3.11}$$

Equation 3.7 implies that $\Lambda_{t+1}^1 = \dfrac{1}{c_{t+1}^i P_{t+1}}$ then equation 3.8 can be rewritten as

$$\Lambda_t^2 = \frac{P_t \, \beta}{P_{t+1} \, c_{t+1}^i}, \tag{3.12}$$

So as to remove the Lagrange multiplier Λ_t^2, given equation 3.12, equations 3.9, 3.10 and 3.11 can be rewritten respectively as

$$\frac{-D}{w_t} = \frac{P_t \, \beta}{P_{t+1} \, c_{t+1}^i} \tag{3.13}$$

$$E_t \frac{P_t \beta}{P_{t+1}\, c^i_{t+1}} \left[1 + \kappa(k^i_{t+1} - k^i_t)\right] = E_t \frac{P_{t+1}\, \beta^2}{P_{t+2}\, c^i_{t+2}} \left[\kappa(k^i_{t+1} - k^i_t) + r_{t+1} + (1-\delta)\right] \quad (3.14)$$

and,

$$E_t \frac{e_t}{P_{t+1}\, c^i_{t+1}} = E_t \frac{\beta e_{t+1}(1 + r^b_t)}{P_{t+2}\, c^i_{t+2}}. \quad (3.15)$$

To prevent the purchase of ever increasing amounts of the international bond, a limit is placed on how fast debt can grow, as specified by the transversality, or limit condition,

$$\lim_{t\to\infty} \frac{b_t}{(1+r^b)^t} = \lim_{t\to\infty} \beta^t b_t = 0. \quad (3.16)$$

Final Goods Firms

Final goods firms have the following constant elasticity of substitution (CES) bundler production function - see Dixit and Stiglitz (1977),

$$Y_t = \left[\int_0^1 Y_t(j)^{\frac{\psi-1}{\psi}} dj\right]^{\frac{\psi}{\psi-1}}, \quad (3.17)$$

where Y_t is the output of final goods; j represents an intermediate firm and $j \in [0,1]$; and $\psi > 1$ represents the elasticity of substitution in production.

In each period, and subject to the above CES bundler function, each profit maximizing final goods firm maximizes

$$\Pi_t = P_t Y_t - \int_0^1 P_t(j) Y_t(j) dj, \quad (3.18)$$

where Π_t represents profits. In other words, the cost of goods bought from the intermediate goods firms is subtracted from the revenue earned by the final goods firm.

Rewriting the above profit function and substituting the right hand side of the

CES bundler function for Y_t gives

$$\max_{\{Y_t(j)\}} P_t \left[\int_0^1 Y_t(j)^{\frac{\psi-1}{\psi}} dj \right]^{\frac{\psi}{\psi-1}} - \int_0^1 P_t(j) Y_t(j) dj. \tag{3.19}$$

Given that they operate in a competitive market, final good firms are expected to make zero profits. Taking the partial derivative of the profit function with respect to $Y_t(j)$ yields

$$P_t \left[\int_0^1 Y_t(j)^{\frac{\psi-1}{\psi}} dj \right]^{\frac{1}{\psi-1}} Y_t(j)^{\frac{-1}{\psi}} = P_t(j), \tag{3.20}$$

which, taking into consideration equation 3.17, reduces to the demand function for good j facing intermediate firm j

$$Y_t(j) = Y_t \left(\frac{P_t}{P_t(j)} \right)^{\psi}. \tag{3.21}$$

Substituting the demand for firm *j's* output into the CES bundler function gives

$$Y_t = \left[\int_0^1 \left[Y_t \left(\frac{P_t}{P_t(j)} \right)^{\psi} \right]^{\frac{\psi-1}{\psi}} dj \right]^{\frac{\psi}{\psi-1}} = Y_t \left[\int_0^1 \left(\frac{P_t}{P_t(j)} \right)^{\psi-1} dj \right]^{\frac{\psi}{\psi-1}}, \tag{3.22}$$

which in turn reduces to the final goods pricing rule

$$P_t = \left[\int_0^1 \left(\frac{1}{P_t(j)} \right)^{1-\psi} dj \right]^{\frac{1}{1-\psi}}. \tag{3.23}$$

Intermediate Goods Firms

In every period, each intermediate firm, j, decides on the profit maximizing output subject to the demand for its good $Y_t(j)$. Each intermediate firm does not change its price in every period. Rather, intermediate firms follow a Calvo pricing rule. In each period a randomly chosen proportion, ρ, of intermediate firms keep their prices fixed. The remaining firms, making up a proportion $(1-\rho)$ of all intermediate firms, select their period t price, $P_t^*(j)$. The firms which are not randomly selected to adjust

their price in period t, use the rule $P_t(j) = P_{t-1}(j)$ to determine their period t price. The profits earned are distributed to the households, the owners of the factors of production.

Each intermediate firm, j, has the production function

$$Y_t(j) = \lambda_t K_t^{\theta}(j) H_t^{1-\theta}(j), \tag{3.24}$$

where λ_t is the technology shock. The output elasticities with respect to capital and labor are θ, and $(1-\theta)$, respectively.

Each intermediate goods firm, j, which has been chosen to adjust its price in period t, chooses the price $P_t^*(j)$ to maximize the discounted present value of firm j's for the period during which the price set by firm j remains unchanged.

$$E_t \sum_{i=0}^{\infty} \beta^i \rho \left[P_t^*(j) Y_{t+i} \left(\frac{P_{t+i}}{P_t^*(j)} \right)^{\psi} - P_{t+i} r_{t+i} K_{t+i}(j) - P_{t+i} w_{t+i} H_{t+i}(j) \right], \tag{3.25}$$

subject to a production technology in which the output of an intermediate goods firm is equal to the demand for its goods. The constraint is specified as

$$Y_{t+i} \left(\frac{P_{t+i}}{P_t^*(j)} \right)^{\psi} = \lambda_{t+i} K_{t+i}^{\theta}(j) H_{t+i}^{1-\theta}(j).$$

Since,

$$Y_{t+i}(j) = Y_{t+i} \left(\frac{P_{t+i}}{P_t^*(j)} \right)^{\psi},$$

the constraint becomes,

$$Y_{t+i}(j) = \lambda_{t+i} K_{t+i}^{\theta}(j) H_{t+i}^{1-\theta}(j).$$

Firms are maximizing profits and minimizing costs simultaneously, however, the minimization problem is solved in isolation and its results substituted into the objective function 3.25. The cost minimization problem of the intermediate goods firm j

in period $t+i$ is

$$\min_{\{K_{t+i}(j),H_{t+i}(j)\}} r_{t+i}K_{t+i}(j) + w_{t+i}H_{t+i}(j), \tag{3.26}$$

subject to the production technology

$$Y_{t+i}(j) = \lambda_{t+i}K^{\theta}_{t+i}(j)H^{1-\theta}_{t+i}(j). \tag{3.27}$$

The Lagrangian function is

$$L = \min_{\{K_{t+i}(j),H_{t+i}(j)\}} \left(r_{t+i}K_{t+i}(j) + w_{t+i}H_{t+i}(j) + \Lambda_{t+i}\left[Y_{t+i}(j) - \lambda_{t+i}K^{\theta}_{t+i}(j)H^{1-\theta}_{t+i}(j)\right]\right) S,$$

and the resulting first order conditions are

$$\frac{\partial L}{\partial K_{t+i}} = r_{t+i} - \Lambda_{t+i}\lambda_{t+i}\theta K^{\theta-1}_{t+i}(j)H^{1-\theta}_{t+i}(j) = 0, \tag{3.28}$$

and

$$\frac{\partial L}{\partial H_{t+i}} = w_{t+i} - \Lambda_{t+i}\lambda_{t+i}(1-\theta)K^{\theta}_{t+i}(j)H^{-\theta}_{t+i}(j) = 0. \tag{3.29}$$

With a little algebraic manipulation the first order conditions yield

$$\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}} = \frac{H_{t+i}(j)}{K_{t+i}(j)}, \tag{3.30}$$

which together with the production technology results in firm j's demand for labor,

$$H_{t+i}(j) = \frac{1}{\lambda_{t+i}}\left[\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}}\right]^{\theta} Y_{t+i}(j) \tag{3.31}$$

and its demand for capital,

$$K_{t+i}(j) = \frac{1}{\lambda_{t+i}}\left[\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}}\right]^{\theta-1} Y_{t+i}(j). \tag{3.32}$$

The demand functions for labor and capital are then substituted into the cost equation

and yield

$$\frac{r_{t+i}}{\lambda_{t+i}}\left[\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}}\right]^{\theta-1} Y_{t+i}(j) \;+\; \frac{w_{t+i}}{\lambda_{t+i}}\left[\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}}\right]^{\theta} Y_{t+i}(j). \tag{3.33}$$

Using the demand function for each resource and expression 3.30, r_{t+i} in the above cost equation is replaced to give

$$\frac{\theta}{1-\theta}\left(\frac{w_{t+i}}{\lambda_{t+i}}\right)\left[\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}}\right]^{\theta} Y_{t+i}(j) + \frac{w_{t+i}}{\lambda_{t+i}}\left[\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}}\right]^{\theta} Y_{t+i}(j),$$

and with further algebraic manipulation

$$\left(\frac{\theta}{1-\theta}+1\right)\left(\frac{w_{t+i}}{\lambda_{t+i}}\right)\left[\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}}\right]^{\theta} Y_{t+i}(j),$$

$$\frac{w_{t+i}}{(1-\theta)\lambda_{t+i}}\left[\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}}\right]^{\theta} Y_{t+i}(j). \tag{3.34}$$

In every period, all firms face identical wages, rents and level of technology, by extension they face the same marginal cost, specified as

$$MC_{t+i} = \frac{w_{t+i}}{(1-\theta)\lambda_{t+i}}\left[\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}}\right]^{\theta}. \tag{3.35}$$

To see why the above equation represents the marginal cost of firm j, note that

$$MC_{t+i} = \frac{\partial\, TC}{\partial\, Q} = \frac{\partial\left[\frac{w_{t+i}}{(1-\theta)\lambda_{t+i}}\left[\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}}\right]^{\theta} Y_{t+i}(j)\right]}{\partial\, Y_{t+i}(j)} = \frac{w_{t+i}}{(1-\theta)\lambda_{t+i}}\left[\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}}\right]^{\theta}.$$

As noted before each firm explicitly maximizes profits and minimizes costs. To this end the marginal cost equation, and the equivalent of $Y_{t+i}(j)$ (see equation 3.21), are substituted into the profit function. The profit maximization problem is therefore

$$L = \max_{P_t^*(j)} E_t \sum_{i=0}^{\infty} \beta^i \rho \left[P_t^*(j) Y_{t+i}\left(\frac{P_{t+i}}{P_t^*(j)}\right)^{\psi} - \frac{P_{t+i}\, w_{t+i}}{(1-\theta)\lambda_{t+i}}\left[\frac{(1-\theta)r_{t+i}}{\theta w_{t+i}}\right]^{\theta} Y_{t+i}\left(\frac{P_{t+i}}{P_t^*(j)}\right)^{\psi}\right],$$

which reduces to

$$L = \max_{P_t^*(j)} E_t \sum_{i=0}^{\infty} \beta^i \rho \, Y_{t+i} \left(\frac{P_{t+i}}{P_t^*(j)} \right)^{\psi} \left[P_t^*(j) \; - \; \frac{P_{t+i} \, w_{t+i}}{(1-\theta)\lambda_{t+i}} \left[\frac{(1-\theta) r_{t+i}}{\theta w_{t+i}} \right]^{\theta} \right]. \quad (3.36)$$

Finding the partial derivative of the profit function with respect to $P_t^*(j)$ gives

$$\begin{aligned}
\frac{\partial L}{\partial P_t^*(j)} &= \beta \rho \, Y_{t+i} \left(\frac{P_{t+i}}{P_t^*(j)} \right)^{\psi} (1-\psi) \\
&\quad + \beta \rho \, Y_{t+i} \left(\frac{P_{t+i}}{P_t^*(j)} \right)^{\psi+1} \frac{\psi \, w_{t+i}}{(1-\theta)\lambda_{t+i}} \left[\frac{(1-\theta) r_{t+i}}{\theta w_{t+i}} \right]^{\theta} \\
&= \beta \rho \, Y_{t+i} \left(\frac{P_{t+i}}{P_t^*(j)} \right)^{\psi} \left[(1-\psi) \; + \; \left(\frac{P_{t+i}}{P_t^*(j)} \right) \frac{\psi \, w_{t+i}}{(1-\theta)\lambda_{t+i}} \left[\frac{(1-\theta) r_{t+i}}{\theta w_{t+i}} \right]^{\theta} \right] = 0 \\
&= \beta \rho \, Y_{t+i} \left[(1-\psi) \; + \; \left(\frac{P_{t+i}}{P_t^*(j)} \right) \frac{\psi \, w_{t+i}}{(1-\theta)\lambda_{t+i}} \left[\frac{(1-\theta) r_{t+i}}{\theta w_{t+i}} \right]^{\theta} \right] = 0,
\end{aligned}$$

or

$$0 = E_t \sum_{i=0}^{\infty} (\beta\rho)^i \, Y_{t+i}(j) \left[(1-\psi) \; + \; \frac{P_{t+i} \, \psi \, w_{t+i}}{P_t^*(j)(1-\theta)\lambda_{t+i}} \left[\frac{(1-\theta) r_{t+i}}{\theta w_{t+i}} \right]^{\theta} \right], \quad (3.37)$$

note that $Y_{t+i} \left(\frac{P_{t+i}}{P_t^*(j)} \right)^{\psi}$ is replaced with $Y_{t+i}(j)$. Manipulating the above first order condition gives

$$P_t^*(j) = \frac{\psi}{\psi - 1} \, \frac{E_t \sum_{i=0}^{\infty} (\beta\rho)^i \, Y_{t+i}(j) \, \frac{P_{t+i} \, w_{t+i}}{(1-\theta)\lambda_{t+i}} \left[\frac{(1-\theta) r_{t+i}}{\theta w_{t+i}} \right]^{\theta}}{E_t \sum_{i=0}^{\infty} (\beta\rho)^i \, Y_{t+i}(j)}. \quad (3.38)$$

Given that every firm that is allowed to fix its price in period t, has the same marginal cost and markup, then it is reasonable to suggest they will set the same price in period t, $P_t^*(j)$. Using the final goods pricing rule as specified in equation 3.23, in addition to the fact that firms not changing their price in period$t$ retain the period $t-1$ price, then the updated price of the final good will be

$$P_t^{1-\psi} = \rho P_{t-1}^{1-\psi} + (1-\rho)(P_t^*)^{1-\psi}. \tag{3.39}$$

Technology is assumed to follow the stochastic process

$$ln\,\lambda_t = \gamma^\lambda\, ln\,\lambda_{t-1} + \epsilon_t^\lambda + \epsilon_t^{common}. \tag{3.40}$$

where γ^λ is the auto-correlation term expressing technology persistence, ϵ_t^λ represents an asymmetric shock to technology, whose mean is zero, and ϵ_t^{common} represents a common technology shock that affects both countries.

Foreign Sector

Every household, i, in the home country either buys some amount of bonds (lends to a foreign country), or sells bonds (borrows from abroad). Additionally, in each period, t, each household will receive the principal and interest on bonds purchased in period $t-1$. If each household is a net borrower, then they would pay back the principal and some interest on the debt. Whether the new bond purchases are more than what is received from the last period's purchases is determined by the clearing condition

$$B_t - (1+r_{t-1}^f)B_{t-1} = P_t^f X_t, \tag{3.41}$$

where X_t is total real net exports, and is denominated in the foreign country's price P_t^f. This gives the nominal value of exports. Intuitively, if the home country has a surplus of exports to the foreign country, then there are two possibilities. First, the value of bonds purchased by the home country in the current period is more than the cost and return on bonds purchased in the previous period. In the second scenario,

the cost and return on bonds sold by the home country in the previous period is more than the cost of bonds sold in the current period i.e. there is a net outflow of funds. The nominal value for bonds is given in terms of the foreign country's money. The nominal value of bonds purchased by the home country is equivalent to the nominal value of bonds sold by the foreign country. Bonds in the home country's budget constraint have to be converted by the prevailing exchange rate to get the nominal price in terms of home country prices. This approach is for modeling convenience and is not indicative of an economically superior foreign country.

The real interest rate on bonds, r_t^b, depends on the level of bonds held by the home country, or the foreign country. The higher the value of bonds the higher will be the interest rate on bonds, r_t^b. If $B_t > 0$, then the home country is buying bonds (lending), and the foreign country is selling. Conversely, $B_t < 0$ the home country is selling bonds (borrowing) and the foreign country is buying bonds. In either scenario, the larger the absolute value of B, the higher the interest rate paid, or received. In short, the higher the quantity demanded of foreign bonds, the higher the price (interest). The foregoing is captured by the equation,

$$r_t^b = r^* + a\frac{|B_t|}{P_t^f}, \tag{3.42}$$

where r^* is the fixed interest rate which is determined in the international market and not influenced by the small countries modeled here. The exchange rate is a simple purchasing power parity (PPP) rate, and is specified as

$$e_t = \frac{P_t^h}{P_t^f}. \tag{3.43}$$

3.1.2 Equilibrium Conditions

It has been assumed that all families are identical. It is also assumed that in the aggregate there is a unit mass of families. Put differently, the capital letters are used to identify the aggregate variables while the common letters are representative of each household. Assuming a unit mass of households makes the aggregate behave like the

individual (representative) household, the following holds true in equilibrium;

$$C_t = c_t^i,$$

$$B_t = b_t^i,$$

$$H_t = h_t^i,$$

$$K_{t+1} = k_{t+1}^i,$$

and

$$M_t = m_t^i.$$

For an equilibrium to exist in the markets for labor and capital, it is necessary that the supply and demand for each factor are equal. The amount of hours used by all firms, k, necessitates that

$$H_t = \int_0^1 H_t(j)dj.$$

Given the previously determined demand for hours (equation 3.31) by an intermediate goods firm, j, the labor market equilibrium condition can be rewritten as

$$H_t(j) = \int_0^1 H_t(j)dj = \frac{1}{\lambda_t}\left[\frac{(1-\theta)r_t}{\theta w_t}\right]^{\theta} \int_0^1 Y_t(j)dj.$$

Using the same approach for capital, and given that in the market for capital

$$K_t = \int_0^1 K_t(j)dj,$$

then the equilibrium condition in the market for capital is

$$K_t(j) = \int_0^1 K_t(j)dj = \frac{1}{\lambda_t}\left[\frac{(1-\theta)r_t}{\theta w_t}\right]^{(\theta-1)} \int_0^1 Y_t(j)dj.$$

Given that households are the owners of the factors of production, and given the overriding representative agent assumption, each household, i, will have the same share of the total profits of the intermediate goods firms. Aggregate profits paid to

households are specified as

$$\begin{aligned} P_t\xi_t &= P_t\int_0^1 \xi_t^i di \\ &= P_t\int_0^1 \Pi(j)dj \\ &= \int_0^1 P_t(j)Y_t(j)dj - P_t\frac{w_t}{(1-\theta)\lambda_t}\left[\frac{(1-\theta)r_t}{\theta w_t}\right]^\theta \int_0^1 Y_t(j)dj. \end{aligned}$$

Firms in perfect competition make no profit and as such, total revenue is equal to total cost, i.e.

$$P_tY_t = \int_0^1 P_t(j)Y_t(j)dj.$$

Substituting no profit outcome for the final goods firms into the aggregate profit function of the intermediate goods firms, and factoring out the price P_t yields

$$\xi_t = Y_t - \frac{w_t}{(1-\theta)\lambda_t}\left[\frac{(1-\theta)r_t}{\theta w_t}\right]^\theta \int_0^1 Y_t(j)dj,$$

or put differently,

$$\xi_t = Y_t - w_tH_t - r_tK_t. \tag{3.44}$$

3.1.3 The Complete Model

In what follows the complete model is presented as derived from the previous subsections. These equations and the relevant steady state values (see next section) are inputted into Dynare (version 4.2.4) to solve the system. Dyanare is a preprocessor which operates on a Matlab base. A Taylor approximation at the steady state is used.

No Union Model Specification

Euler equations for capital purchased by households in each country.

$$E_t\frac{P_t^h}{P_{t+1}^hC_{t+1}^h}\left[1+\kappa(k_{t+1}^h-k_t^h)\right] = \beta E_t\frac{P_{t+1}^h}{P_{t+2}^hC_{t+2}^h}\left[r_{t+1}^h+(1-\delta^h)+\kappa(k_{t+2}^h-k_{t+1}^h)\right]$$

$$E_t \frac{P_t^f}{P_{t+1}^f C_{t+1}^f} \left[1 + \kappa(k_{t+1}^f - k_t^f)\right] = \beta E_t \frac{P_{t+1}^f}{P_{t+2}^f C_{t+2}^f} \left[r_{t+1}^f + (1-\delta^f) + \kappa(k_{t+2}^f - k_{t+1}^f)\right]$$

Euler equations for bonds purchased by households in each country. Note that in the Euler equation for the foreign country there is no exchange rate.

$$E_t \frac{e_t}{1} \left(\frac{1}{P_{t+1}^h C_{t+1}^h}\right) = E_t \frac{e_{t+1}}{1} \left(\frac{\beta(1+r_{t+1}^b)}{P_{t+2}^h C_{t+2}^h}\right)$$

$$E_t \left(\frac{1}{P_{t+1}^f C_{t+1}^f}\right) = E_t \left(\frac{\beta(1+r_{t+1}^b)}{P_{t+2}^f C_{t+2}^f}\right)$$

$$\frac{-D^h}{w_t^h} = \beta E_t \frac{P_t^h}{P_{t+1}^h C_{t+1}^h}$$

$$\frac{-D^f}{w_t^f} = \beta E_t \frac{P_t^f}{P_{t+1}^f C_{t+1}^f}$$

The cash in advance constraints for each country.

$$C_t^h P_t^h = g_t^h M_{t-1}^h$$

$$C_t^f P_t^f = g_t^f M_{t-1}^f$$

The budget constraints for households in each country. Note that for the case of the foreign country there is no exchange rate and the bond carries a negative sign.

$$\frac{M_t^h}{P_t^h} + \frac{e_t B_t^h}{P_t^h} + K_{t+1}^h + \frac{\kappa}{2}(K_{t+1}^h - K_t^h)^2 = Y_t^h + (1-\delta^h)K_t^h + \frac{e_t(1+r^b)B_{t-1}}{P_t^h}$$

$$\frac{M_t^f}{P_t^f} + \frac{(-B_t)}{P_t^f} + K_{t+1}^f + \frac{\kappa}{2}(K_{t+1}^f - K_t^f)^2 = Y_t^f + (1-\delta^f)K_t^f + \frac{(1+r^b)(-B_{t-1})}{P_t^f}$$

Income-output identities for both countries.

$$Y_t^h = w_t^h H_t^h + r_t^h K_t^h + \xi_t^h$$

$$Y_t^f = w_t^f H_t^f + r_t^f K_t^f + \xi_t^f$$

Price determining equations for intermediate firms in each country.

$$P_t^{*h}(j) = \frac{\psi}{\psi - 1} \left[\frac{E_t \sum_{i=0}^{\infty} (\beta\rho)^i \, P_{t+i}^h Y_{t+i}^h(j) \, \frac{w_{t+i}^h}{(1-\theta)\lambda_{t+i}^h} [\frac{r_{t+i}^h (1-\theta)}{w_{t+i}^h \theta}]}{E_t \sum_{i=0}^{\infty} (\beta\rho)^i \, Y_{t+i}^h(j)} \right]$$

$$P_t^{*f}(j) = \frac{\psi}{\psi - 1} \left[\frac{E_t \sum_{i=0}^{\infty} (\beta\rho)^i \, P_{t+i}^f Y_{t+i}^f(j) \, \frac{w_{t+i}^f}{(1-\theta)\lambda_{t+i}^f} [\frac{r_{t+i}^f (1-\theta)}{w_{t+i}^f \theta}]}{E_t \sum_{i=0}^{\infty} (\beta\rho)^i \, Y_{t+i}^f(j)} \right]$$

General price level determining equations for each country.

$$(P_t^h)^{1-\psi} = \rho (P_{t-1}^h)^{1-\psi} + (1-\rho)(P_t^* h)^{1-\psi}$$

$$(P_t^f)^{1-\psi} = \rho (P_{t-1}^f)^{1-\psi} + (1-\rho)(P_t^{*f})^{1-\psi}$$

Demand for hours of labor in each country.

$$H_t^h = \frac{1}{\lambda} Y_t^h \left(\frac{P_t^h}{P_t^{*h}(j)} \right)^{\psi} \left[\frac{(1-\theta) r_t^h}{\theta w_t^h} \right]^{\theta}$$

$$H_t^f = \frac{1}{\lambda} Y_t^f \left(\frac{P_t^f}{P_t^{*f}(j)} \right)^{\psi} \left[\frac{(1-\theta) r_t^f}{\theta w_t^f} \right]^{\theta}$$

Demand for capital in each country.

$$K_t^h = \frac{1}{\lambda} Y_t^h \left(\frac{P_t^h}{P_t^{*h}(j)} \right)^{\psi} \left[\frac{(1-\theta) r_t^h}{\theta w_t^h} \right]^{\theta-1}$$

$$K_t^f = \frac{1}{\lambda} Y_t^f \left(\frac{P_t^f}{P_t^{*f}(j)} \right)^{\psi} \left[\frac{(1-\theta) r_t^f}{\theta w_t^f} \right]^{\theta-1}$$

Money growth in each country.

$$M_t^h = g_t^h M_{t-1}^h$$

$$M_t^f = g_t^f M_{t-1}^f$$

Stochastic processes for money growth in both countries.

$$ln\, g_t^h = \gamma^g\, ln g_{t-1}^h \,+\, \epsilon_t^{gh}$$

$$ln\, g_t^f = \gamma^g\, ln g_{t-1}^f \,+\, \epsilon_t^{gf}$$

Stochastic processes for technology in both countries.

$$ln\, \lambda_t^h = \gamma^\lambda\, ln\, \lambda_{t-1}^h \,+\, \epsilon_t^{\lambda g}$$

$$ln\, \lambda_t^f = \gamma^\lambda\, ln\, \lambda_{t-1}^f \,+\, \epsilon_t^{\lambda g}$$

Purchasing Power Parity exchange rate for the domestic economy.

$$e_t = \frac{P_t^h}{P_t^f}$$

Clearing function for bonds and net exports between the domestic and foreign countries.

$$P_t^f X_t^h = B_t - (1 + r_{t-1}^b) B_{t-1}$$

Relationship between bond purchases and the interest rate on bonds.

$$|B_t| = \frac{P_t^f (r^b - r_t^*)}{a}$$

Currency Union Model Specification

Note that there is no distinction between the home and foreign price, and the exchange rate variable has been removed.

Euler equations for capital purchased by households in each country.

$$E_t \frac{P_t}{P_{t+1} C_{t+1}^h} \left[1 + \kappa(k_{t+1}^h - k_t^h)\right] = \beta E_t \frac{P_{t+1}}{P_{t+2} C_{t+2}^h} \left[r_{t+1}^h + (1 - \delta^h) + \kappa(k_{t+2}^h - k_{t+1}^h)\right]$$

$$E_t \frac{P_t}{P_{t+1} C_{t+1}^f} \left[1 + \kappa(k_{t+1}^f - k_t^f)\right] = \beta E_t \frac{P_{t+1}}{P_{t+2} C_{t+2}^f} \left[r_{t+1}^f + (1 - \delta^f) + \kappa(k_{t+2}^f - k_{t+1}^f)\right]$$

Euler equations for bonds purchased by households in each country. Note that in the Euler equation for the foreign country there is no exchange rate.

$$E_t\left(\frac{1}{P_{t+1}C^h_{t+1}}\right) = E_t\left(\frac{\beta(1+r^b_{t+1})}{P_{t+2}C^h_{t+2}}\right)$$

$$E_t\left(\frac{1}{P_{t+1}C^f_{t+1}}\right) = E_t\left(\frac{\beta(1+r^b_{t+1})}{P_{t+2}C^f_{t+2}}\right)$$

$$\frac{-D^h}{w^h_t} = \beta E_t \frac{P_t}{P_{t+1}C^h_{t+1}}$$

$$\frac{-D^f}{w^f_t} = \beta E_t \frac{P_t}{P_{t+1}C^f_{t+1}}$$

The cash in advance constraints for each country.

$$C^h_t P_t = g^h_t M^h_{t-1}$$

$$C^f_t P_t = g^f_t M^f_{t-1}$$

The budget constraints for households in each country. Note that in the foreign country budget constraint the bond carries a negative sign.

$$\frac{M^h_t}{P_t} + \frac{B_t}{P_t} + K^h_{t+1} + \frac{\kappa}{2}(K^h_{t+1} - K^h_t)^2 = Y^h_t + (1-\delta^h)K^h_t + \frac{(1+r^h)B_{t-1}}{P_t}$$

$$\frac{M^f_t}{P_t} + \frac{(-B_t)}{P_t} + K^f_{t+1} + \frac{\kappa}{2}(K^f_{t+1} - K^f_t)^2 = Y^f_t + (1-\delta^f)K^f_t + \frac{(1+r^f)(-B^f_{t-1})}{P_t}$$

Income-output identities for both countries.

$$Y^h_t = w^h_t H^h_t + r^h_t K^h_t + \xi^h_t$$

$$Y^f_t = w^f_t H^f_t + r^f_t K^f_t + \xi^f_t$$

Price determining equations for intermediate firms in each country.

$$P_t^{*h}(j) = \frac{\psi}{\psi - 1} \left[\frac{E_t \sum_{i=0}^{\infty} (\beta\rho)^i \, P_{t+i}^h Y_{t+i}^h(j) \, \frac{w_{t+i}^h}{(1-\theta)\lambda_{t+i}^h} [\frac{r_{t+i}^h (1-\theta)}{w_{t+i}^h \theta}]}{E_t \sum_{i=0}^{\infty} (\beta\rho)^i \, Y_{t+i}^h(j)} \right]$$

$$P_t^{*f}(j) = \frac{\psi}{\psi - 1} \left[\frac{E_t \sum_{i=0}^{\infty} (\beta\rho)^i \, P_{t+i}^f Y_{t+i}^f(j) \, \frac{w_{t+i}^f}{(1-\theta)\lambda_{t+i}^f} [\frac{r_{t+i}^f (1-\theta)}{w_{t+i}^f \theta}]}{E_t \sum_{i=0}^{\infty} (\beta\rho)^i \, Y_{t+i}^f(j)} \right]$$

Price determining equation for the entire union. The price level is determined by the interaction of the price setting processes of the home and foreign countries.

$$(P_t)^{1-\psi} = 0.5 * \left(\rho (P_{t-1})^{1-\psi} + (1-\rho)(P_t^* h)^{1-\psi}\right) + 0.5 * \left(\rho (P_{t-1})^{1-\psi} + (1-\rho)(P_t^{*f})^{1-\psi}\right)$$

Demand for hours of labor in each country.

$$H_t^h = \frac{1}{\lambda} Y_t^h \left(\frac{P_t}{P_t^{*h}(j)} \right)^{\psi} \left[\frac{(1-\theta) r_t^h}{\theta w_t^h} \right]^{\theta}$$

$$H_t^f = \frac{1}{\lambda} Y_t^f \left(\frac{P_t}{P_t^{*f}(j)} \right)^{\psi} \left[\frac{(1-\theta) r_t^f}{\theta w_t^f} \right]^{\theta}$$

Demand for capital in each country.

$$K_t^h = \frac{1}{\lambda} Y_t^h \left(\frac{P_t}{P_t^{*h}(j)} \right)^{\psi} \left[\frac{(1-\theta) r_t^h}{\theta w_t^h} \right]^{\theta-1}$$

$$K_t^f = \frac{1}{\lambda} Y_t^f \left(\frac{P_t}{P_t^{*f}(j)} \right)^{\psi} \left[\frac{(1-\theta) r_t^f}{\theta w_t^f} \right]^{\theta-1}$$

Money growth in each country.

$$M_t^h = g_t^h M_{t-1}^h$$

$$M_t^f = g_t^f M_{t-1}^f$$

Stochastic processes for money growth in both countries.

$$ln\, g_t^h = \gamma^g \, ln g_{t-1}^h + \epsilon_t^{gh}$$

$$ln\, g_t^f = \gamma^g\, ln g_{t-1}^f + \epsilon_t^{gf}$$

Stochastic processes for technology in both countries.

$$ln\, \lambda_t^h = \gamma^\lambda\, ln\, \lambda_{t-1}^h + \epsilon_t^{\lambda h} + \epsilon_t^{common}$$

$$ln\, \lambda_t^f = \gamma^\lambda\, ln\, \lambda_{t-1}^f + \epsilon_t^{\lambda f} + \epsilon_t^{common}$$

Clearing function for bonds and net exports between the domestic and foreign countries.

$$P_t X_t = B_t - (1 + r_{t-1}^b) B_{t-1}$$

Relationship between bond purchases and the interest rate on bonds.

$$|B_t| = \frac{P_t(r^b - r_t^*)}{a}$$

3.1.4 Steady State

In this subsection the parameter values, steady state values and the equations from which they are derived, are presented.

The parameter values for the dis-utility of labor parameter, D, the capital adjustment cost, κ and the parameter r^*, were calibrated at the steady state. The dis-utility parameter was found after assuming that The remaining parameters in table 3.1 are taken from the literature. The dis-utility parameter is determined in the steady state. To compensate for this undetermined parameter, it is assumed that households provide one-third of their time for productive effort. The capital adjustment cost parameter was adjusted to ensure that the response of bond purchases to an economic shock are in keeping with expectations. There is no special motivation behind choosing one safe for the "neutrality" of said number. What is clear is the larger the capital adjustment cost the better the response of bond purchases to an economic shock, whether positive or negative. For very small values of κ such as 0.1, bond purchases rise when they should fall, and vice versa. The constant r^* is calibrated to reflect a balanced trade account at the steady state, i.e. $X = 0$. By extension, no international bonds are purchased in the steady state. As is customary in the literature β corresponds to an annual discount rate of four percent. The parameter θ corresponds to the standard approximate value of capital's share of income, one-third. The value for ψ is as specified in Gali (2003). The value of ψ corresponds to a ten percent price markup.

The value for ρ, in keeping with econometric estimates and evidence from surveys in developed countries, is 0.75. Roland Craigwell (2011b), contributing to a study on Caribbean inflation dynamics, argue that prices are more flexible in developing countries. The Calvo pricing parameter is reduced from 0.75 to 0.25; i.e. for the developing countries 75% of firms are assumed to change their prices in every period, t. Put differently, 25% of firms keep their prices fixed. While the number of firms that can change their price in a given period is extremely high, it allows for some price rigidity as opposed to complete price flexibility ($\rho = 0$). Ganga (2011) and Roland Craigwell (2011a) study price changes in the Caribbean using micro data. An

Table 3.1: Quarterly Parameter Values

Parameter	Value (h)	Value (f)	Description	Source
a	0.01		constant coefficient of B_t	McCandless (2008)
D	-2.38211	-2.38211	disutility of labor	Author's Calibration
r^*	0.0101	0.0101	constant of r_t^f equation	Author's Calibration
β	0.99	0.99	discount factor	Mendoza (1991)
δ	0.0375	0.0375	rate of depreciation	Author's assumption*
θ	0.32	0.32	capital's share of output	Mendoza (1991)
κ	1.0	1.0	capital adjustment cost parameter	Author's Calibration
ρ	0.25	0.25	percentage of firms with unchanged prices in period t	Author's assumption*
ψ	11	11	cost markup parameter	Gali (2003)
γ^λ	0.95	0.95	persistence of technology	Gali and Monacelli (2008)
γ^g	0.45	0.45	persistence of money	McCandless (2008)
γ^f	0.8	0.8	persistence of foreign price	McCandless (2008)

*Assumptions are based on information provided by Bu (2006), Ganga (2011), and Roland Craigwell (2011a).

approach which has become quite common. They find that price changes occur quite frequently and in both directions e.g. Roland Craigwell (2011a) notes that between 50% and 80% of items in every category recorded a price adjustment every month on average in Barbados. While Ganga (2011) notes that between 47% and 97% of items in each category had a monthly price change on averages. As regards pricing in developed countries Roland Craigwell (2011b) notes that "prices take longer to change in developed countries than in developing economies."

The formula,

$$\frac{1}{1-\rho},$$

gives the number of periods (quarters) per year for which a firm uses a price, before changing. Put differently, the formula gives the number of periods for which a firm changes its price only once. Therefore, for $\rho = 0.5$, each firm will change its price every two quarters, or twice per year.

An annual rate of 15% is assumed here. Mélitz and Zumer (1999) uses an annual depreciation rate of 10%, or 2.5% per quarter. There are two competing theories as regards the rate of depreciation in developing countries relative to developed countries. In one case it is argued that in developing countries capital is underutilized relative to developed countries (Hazari and Bakalis (1985)). Given the reasonable assumption that depreciation is an increasing function of utilization (King and Rebelo (2000)) then the rate of capital depreciation should be smaller for developing countries, due to the relative under-utilization of capital in such countries. On the other hand, it can be argued that the rate of capital depreciation is actually higher than that of developed countries. To be sure, the lack of technical expertise and due diligence as regards maintenance can hamper the longevity of physical capital in developing countries. Moreover, high under-utilization of physical capital can lead to the marginal cost of maintenance outstripping the marginal benefits of the exercise. As a result, recommended maintenance times will not be adhered to, resulting in greater relative depreciation, (see Bu (2006)). That being said, the argument for a

Table 3.2: Steady State Values

Variable	Value (h)	Value (f)	Description
$\bar{B}$	0	0	Bonds
$\bar{C}$	0.60220	0.60220	Consumption
$\bar{e}$	1.0	1.0	PPP Exchange Rate
$\bar{\xi}$	0.07102	0.07102	Profits
$\bar{\lambda}$	1.0	1.0	Technology
$\bar{H}$	0.3333	0.3333	Hours worked
$\bar{K}$	4.77447	4.77447	Capital
$\bar{M}$	0.60220	0.60220	Nominal Money
$\bar{P}$	1.0	1.0	Price Level
$\bar{P}_j^*$	1.0	1.0	Price chosen by firm j
$\bar{r}$	0.0476	0.0476	Interest Rate (Capital)
$\bar{r}^b$	0.0101	0.0101	Interest Rate (Bonds)
$\bar{w}$	1.44899	1.44899	Wage Rate
$\bar{X}$	0	0	Net Exports
$\bar{Y}$	0.78124	0.78124	Real Output

higher depreciation rate seems more credible. Using firm level data for several developing countries - such as Ghana, Kenya, Indonesia,the Philippines and Zimbabwe - Bu (2006) estimates that depreciation rates are higher than the normal rate (10%) used for developed economies.

As regards the purchase, or sale, of bonds in the international market, the value of the parameter "a" (Table 3.1) means that for every one unit increase in the normalized value of the bonds bought, the interest rate on bonds, r_t^b, falls by one percent, and vice versa.

The values in table 3.1.4 are found by substituting the parameter values into the relevant steady state equations as presented below. The first two equations are easily transformed from their respective equations in the previous subsection.

$$\bar{r} = \frac{1}{\beta} - (1 - \delta) \tag{3.45}$$

$$\bar{r}^b = \frac{1}{\beta} - 1 \tag{3.46}$$

Since it has been assumed that the value of net exports (X) is zero, the following must hold,

$$\bar{X} = -\bar{r}^b \bar{B} = 0 \qquad \Rightarrow \bar{B} = 0 \quad where\ \bar{r}^b \neq 0, \tag{3.47}$$

and

$$\bar{B} = \frac{\bar{r^*} - \bar{r^b}}{a} = 0 \qquad \Rightarrow \bar{r^*} - \bar{r^b} = 0 \qquad \Rightarrow \bar{r^*} = \bar{r^b} \tag{3.48}$$

Given that

$$\bar{P}^{1-\psi} = \rho \bar{P}^{1-\psi} + (1-\rho)\bar{P^*}^{1-\psi}, \tag{3.49}$$

and

$$\begin{aligned} \bar{P^*}(j) &= \frac{\psi}{\psi - 1} \frac{\frac{1}{1-\beta\rho}\bar{P}\bar{Y}\frac{\bar{w}}{(1-\theta)\bar{\lambda}}\left[\frac{\bar{r}(1-\theta)}{\bar{w}\theta}\right]^{\theta}}{\frac{1}{1-\beta\rho}\bar{Y}} \\ &= \frac{\psi}{\psi - 1}\bar{P}\frac{\bar{w}}{(1-\theta)\bar{\lambda}}\left[\frac{\bar{r}(1-\theta)}{\bar{w}\theta}\right]^{\theta}, \end{aligned}$$

then in the steady state

$$\bar{P^*}(j) = \bar{P}(j) = \bar{P} \quad \Rightarrow \frac{\psi - 1}{\psi} = \frac{\bar{w}}{(1-\theta)}\left[\frac{\bar{r}(1-\theta)}{\bar{w}\theta}\right]^{\theta}.$$

From the equation above we get

$$\bar{w} = \left[\frac{(\psi - 1)(1-\theta)^{1-\theta}\theta^{\theta}}{\psi \bar{r}^{\theta}}\right]^{\frac{1}{1-\theta}}. \tag{3.50}$$

Assuming that workers spend one third of their time working, $\bar{H}$ is calibrated to equal 0.333. Given that $\bar{H} = 0.333$, and $\bar{P^*}(j) = \bar{P}(j)$, and assuming that $\bar{\lambda} = 1$ in the steady state, then $\bar{Y}$ and $\bar{K}$ can be found using the following equations,

$$\bar{H} = \bar{Y}\left[\frac{(1-\theta)\bar{r}}{\theta\bar{w}}\right]^{\theta}, \tag{3.51}$$

and,

$$\bar{K} = \bar{Y}\left[\frac{(1-\theta)\bar{r}}{\theta\bar{w}}\right]^{\theta-1}. \tag{3.52}$$

Given the results obtained above, $\bar{\xi}$, and$\frac{\bar{M}}{\bar{P}}$ are found as follows,

$$\bar{\xi} = \bar{Y} - \bar{w}\bar{H} - \bar{r}\bar{K}, \tag{3.53}$$

and

$$\bar{Y} = \frac{\bar{M}}{\bar{P}} + \delta\bar{K} - \bar{r}^b\bar{B}, \tag{3.54}$$

which in turn gives

$$\bar{C} = \frac{\bar{M}}{\bar{P}}. \tag{3.55}$$

In the steady state the value for $\bar{P}$ is assumed *a priori*, therefore the values for $\bar{C}$, and $\bar{M}$ can be found.

Finally, the dis-utility of labor is obtained by

$$D = -\frac{\beta\bar{w}}{\bar{C}}. \tag{3.56}$$

The remaining steady state conditions and their respective values can be found from the simple manipulation of their relevant equations in the previous subsection (*complete model*).

Money growth is specified as

$$\bar{M} = \bar{g}\bar{M} \qquad \Rightarrow \bar{g} = 0. \tag{3.57}$$

The function for the PPP exchange rate for the home country is

$$\bar{e} = \frac{\bar{P}^h}{\bar{P}^f}, \tag{3.58}$$

To reflect the move towards a monetary union, it is assumed that the exchange rate is equal to one. This means that one unit of the domestic currency exchanges for one unit of the foreign currency. More importantly, since the model uses a PPP exchange rate rule, then it is implicitly assumed that prices, domestic and foreign, are equal.

Therefore, equation 3.58 becomes

$$e_t = \frac{P_t^h}{P_t^f} = 1 \Longrightarrow P_t^h = P_t^f. \tag{3.59}$$

While each country maintains its own nominal money supply, they use the same currency, and monetary policy is identical. Equal price levels are used here as a proxy for the common monetary policy feature of currency unions. Having the identical price level variable necessarily means that inflation rates are identical for both countries. While inflation rates are not identical for countries within a currency union, inflation rates are likely to be lower and less divergent. This is quite evident among the member states of CARICOM. For example, using the average inflation rates for the period 2000-2011, the members of the ECCU recorded lower inflation rates than the non ECCU countries, especially the "floaters" (see Chapter 1). The "floaters" - Guyana, Jamaica, Suriname, and Trinidad - are those countries with flexible rates. What is more, the percentage spread between the highest and the lowest inflation rates is smaller for the ECCU countries as opposed to the "floaters". For the ECCU the percentage spread is 66% (Antigua - St. Kitts), while for the floaters it is 210% (Guyana - Suriname).

Apart from the foregoing, the final good price for the countries in the currency union is determined as follows,

$$\bar{P}^{1-\psi} = 0.5 * \left(\rho \bar{P}^{1-\psi} + (1-\rho)\bar{P^{h}_{*}}^{1-\psi}\right) + 0.5 * \left(\rho \bar{P}^{1-\psi} + (1-\rho)\bar{P^{f}_{*}}^{1-\psi}\right). \quad (3.60)$$

This means that the overall price level is determined by a combination of price setting initiatives by the firms in both countries. More importantly, price setting is now influenced by a common monetary policy.

3.1.5 Results

Summarizing the results, for countries facing a symmetric shock being a part of a currency union means a higher level for real variables and less variability (lower variance) of said variables. The IRFs for the symmetric case are not shown, however, the theoretical moments are shown on table 3.3. This outcome supports the view that countries with symmetric shocks are good candidates for a currency union. In the

case of an asymmetric shock, the effect of a negative technology shock to the home country is dampened when the home country forms a currency union with the foreign country. In other words the mean for the real variables increases and the variance falls. On the other hand, the effects of the shock are amplified for the foreign country when that country forms a currency union with the home country.

Figures 3.1, 3.2, 3.3 and 3.4 show the impulse response functions (IRFs) for the simulated economies, with and without a currency union and given an asymmetric shock. The IRFs for the symmetric case are not shown. The figures show the change in the levels of each variable, after a negative one percent temporary stochastic shock to the technology parameter, λf. Working with the model in levels is useful in this case due to the assumptions made about bonds and net exports. To be specific, bonds and net exports are assumed to be zero in the steady state and as such any change in their levels will have a corresponding percentage change that is undefined. Given the symmetric nature of the model, a positive shock will result in IRFs that are mirror images of the negative shocks. In short, the absolute values of the IRFs are the same for negative and positive shocks. It is apropos to reiterate that negative shocks are given prominence here. The concern surrounding the loss of monetary independence comes from the inability of countries within a union to enact independent monetary policy. It is reasonable to assert that a country will be more concerned about being unable to use independent monetary policy in a recession, as opposed to during a period of prosperity. First, the results for the scenario without the currency union are discussed. This is done separately for each country, and is followed by the results for the currency union state. For easier comparison, the graphs of the IRFs contain the results for both policy regimes - union and no union. Additionally, the steady state values are the same for each policy regimes.

The impulse responses for the variables of each country are as expected. The effects of the technology shock on the home country can be traced as follows. Starting from the "epicenter" of the shock, the home country, the first effect is a fall in real output, or income. Changes to domestic (home) variables can be seen in figures 3.1 and 3.2. A fall in real income reduces the demand for capital and labor, placing

downward pressure on the wage rate and interest rate. Falling output, coupled with a constant money supply, leads to an increase in the price level; reducing the real money supply. Lower real money balances and lower wages reduce domestic consumption. While exports and imports are not explicitly modeled, exports are expected to fall while imports rise. Indeed, net export, which is modeled, falls. This leads to a corresponding increase in borrowing from the foreign country - the home country sells bonds to the foreign country. The IRFs for net exports and the exchange rate are shown in figure 3.4.

Figures 3.3 and 3.4 show the IRFs for the foreign country. Here too, the outcomes are as expected. Output increased initially as it was expected to, but not as quickly due to the rigidity of prices. This increase comes about with the increased demand for foreign produced goods as evidenced by the trade deficit of the home country. To finance its increased imports the home country borrows (sells bonds) to the foreign country. The foreign country increases its purchases of bonds and reduces its purchases of capital. Therefore the increase in output comes about as a result of increased hours of labor. Eventually, the demand for foreign produced goods falls as demand from the home country falters and prices in the foreign country dampen demand. The economy returns to its steady state.

As noted before, it is assumed that both countries have identical prices (price level) in the currency union. Moreover, they share a common currency and monetary policy. Given the same negative technology shock as before, the effect on the home country variables are dampened, while the change in the variables for the foreign country are amplified. To understand these results it is apropos to look at prices. After all, the difference between the two policy regimes (union and no-union) has to do with prices. While the fall in the output of the home country is brought on initially by a negative technology shock, it is the changes to the price level which lead to the persistence of the downturn. In the case of the currency union, the price level is not entirely determined by home country factors. Indeed, the price level is also influenced by the economic state of the foreign country. Therefore, since the foreign country has not endured an economic shock, the change in the price level is lower

for the home country than it would have been were there no currency union. For the foreign country, however, the change in the price level is higher. As a result of the foregoing, the persistence of the shock on the variables is either dampened (home country) or amplified (foreign country). Therefore, in the currency union state, the transmission of the shock from the home country to the foreign country increases.

Table 3.3: Theoretical Moments

Variable	No Union - Asymmetric Shock	Union - Asymmetric Shock	No Union - Symmetric Shock	Union - Symmetric Shock
Y_h	0.783801, (0.001866)	0.784252, (0.000445)	0.783995, (0.001838)	0.784184, (0.001754)
Y_f	0.782509, (0.000178)	0.784252, (0.000445)	0.783995, (0.001838)	0.784184, (0.001754)
H_h	0.333194, (0.000036)	0.333307, (0.000003)	0.333248, (0.000014)	0.333258, (0.000013)
H_f	0.333517, (0.000010)	0.333307, (0.000003)	0.333248, (0.000014)	0.333258, (0.000013)
K_h	4.793616, (0.052796)	4.795530, (0.015522)	4.796179, (0.064514)	4.797201, (0.062223)
K_f	4.793164, (0.025983)	4.795529, (0.015522)	4.796179, (0.064511)	4.797201, (0.062223)
C_h	0.604166, (0.000746)	0.604462, (0.000193)	0.604210, (0.000796)	0.604349, (0.000769)
C_f	0.602747, (0.000024)	0.604461, (0.000193)	0.604210, (0.000796)	0.604349, (0.000769)
w_h	1.453722, (0.004319)	1.454434, (0.001119)	1.453829, (0.004610)	1.454163, (0.004451)
w_f	1.450307, (0.000138)	1.454433, (0.001119)	1.453829, (0.004610)	1.454163, (0.004451)
r_h	0.047578, (0.000003)	0.047580, (0.000001)	0.047572, (0.000002)	0.047572, (0.000002)
r_f	0.047520, (0.000001)	0.047580, (0.000001)	0.047572, (0.000002)	0.047572, (0.000002)

NB: Means (first moment) come first followed by variances (second moment) in parentheses.

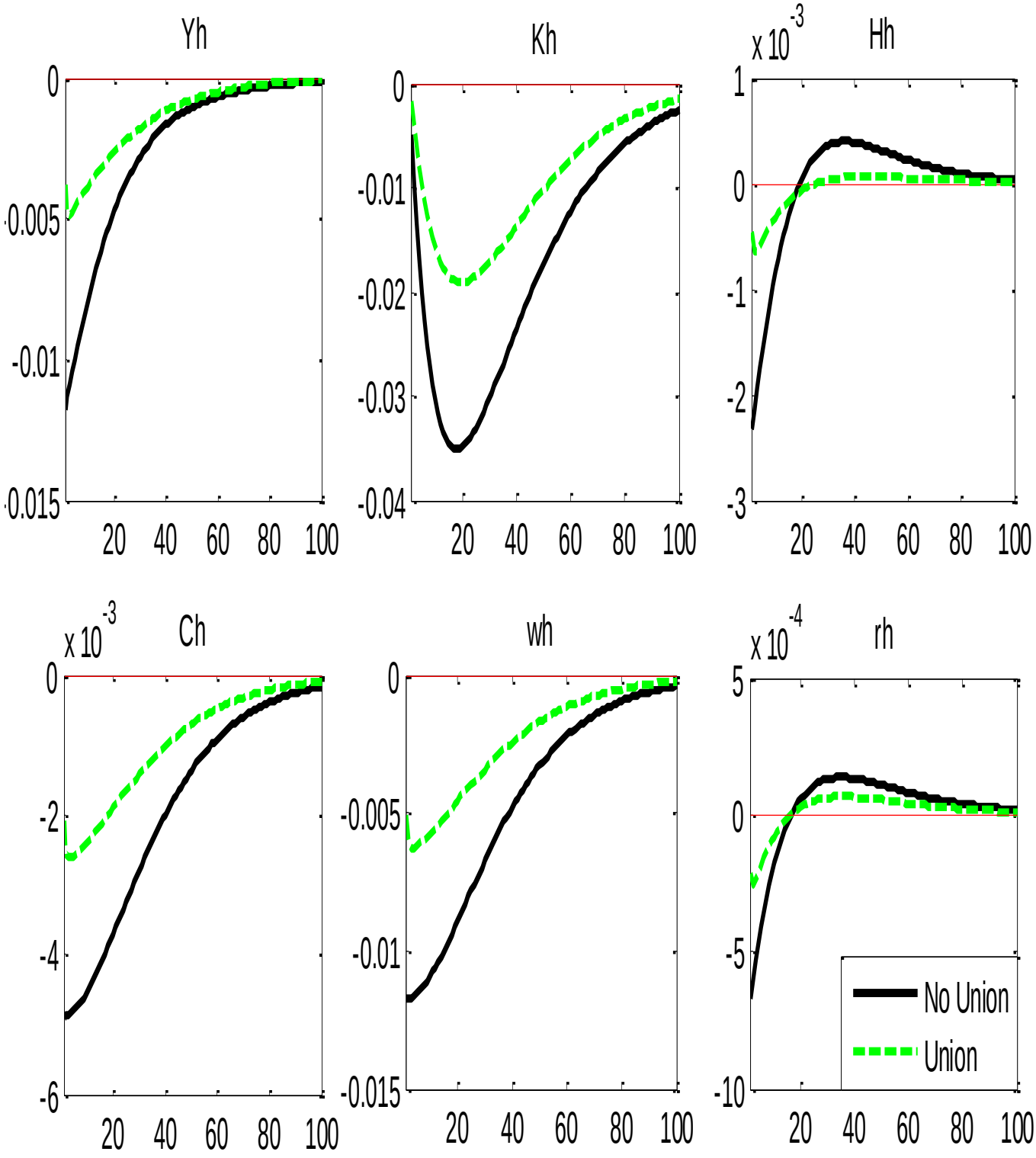


Figure 3.1: Impulse Response Functions - One Percent Asymmetric Technology Shock

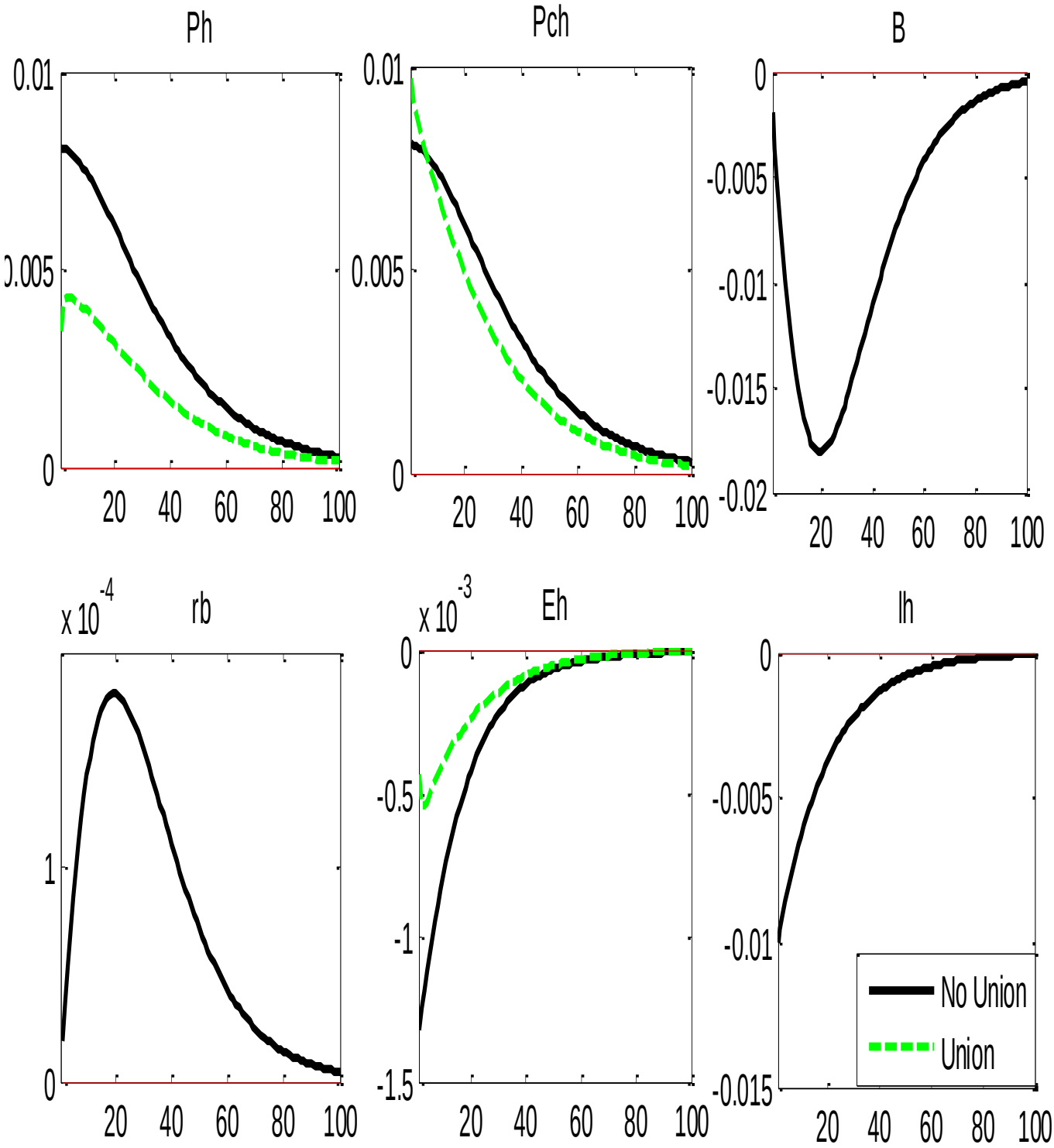


Figure 3.2: Impulse Response Functions - One Percent Asymmetric Technology Shock

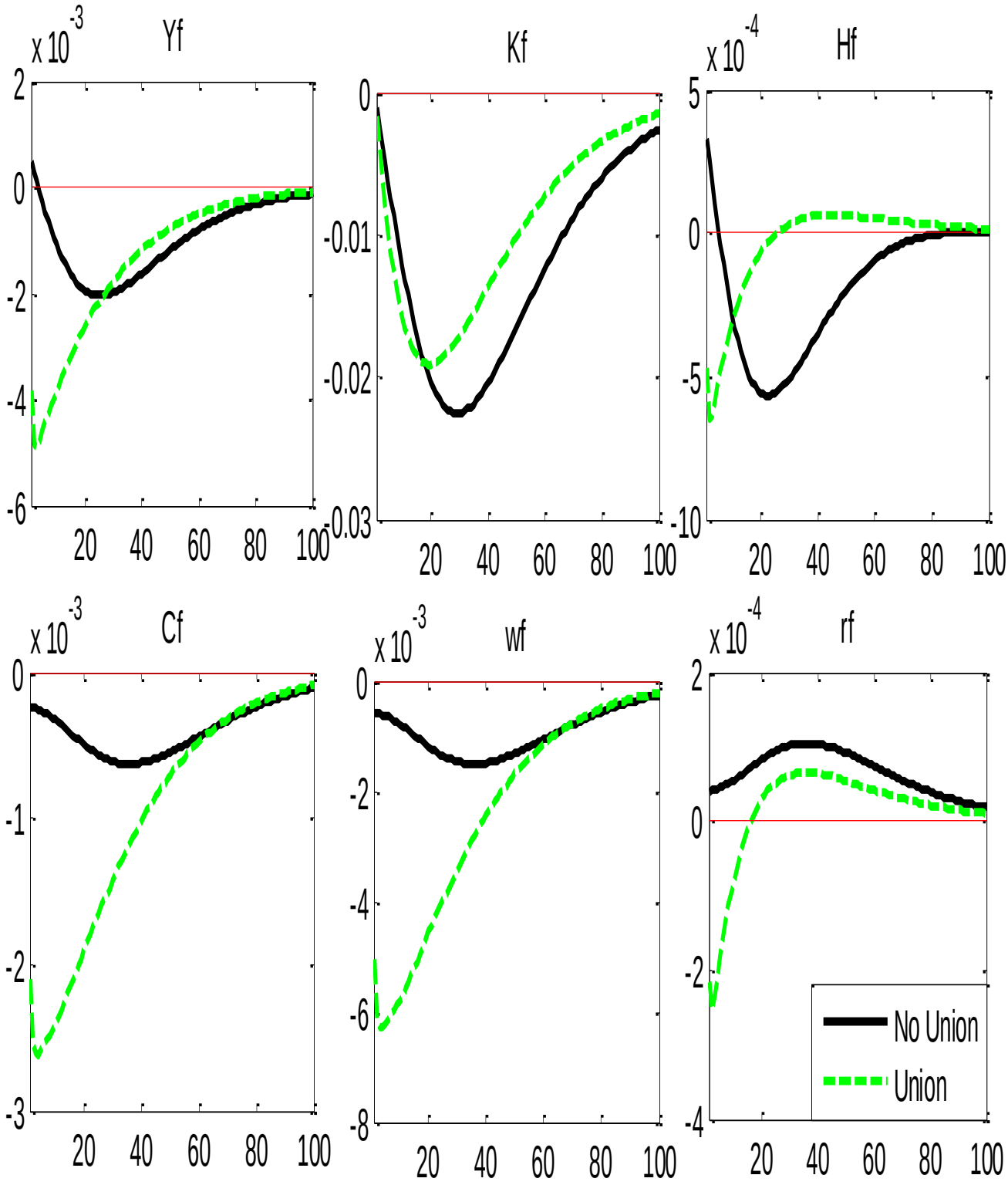


Figure 3.3: Impulse Response Functions - One Percent Asymmetric Technology Shock

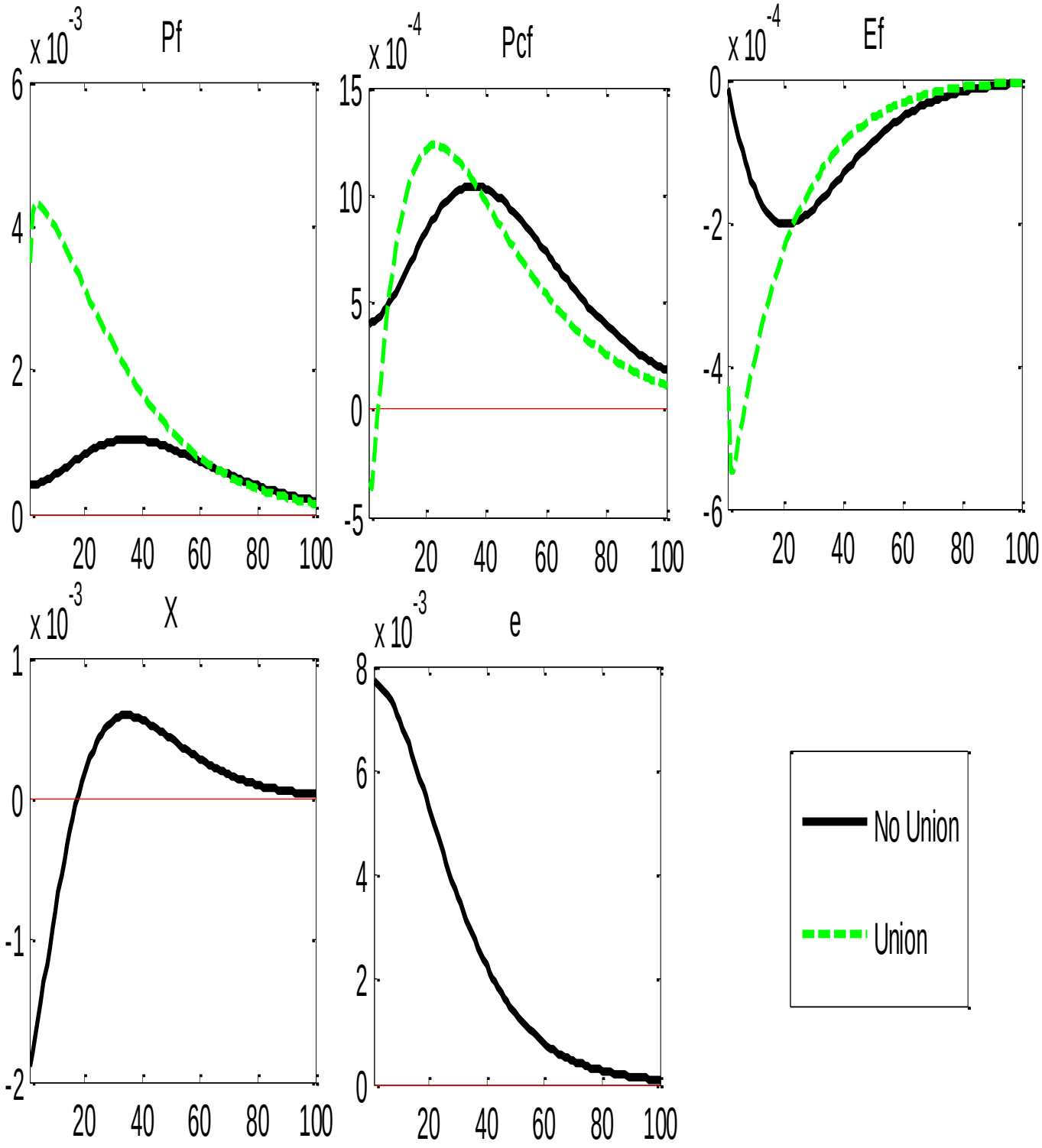


Figure 3.4: Impulse Response Functions - One Percent Asymmetric Technology Shock

CHAPTER 4
DEMAND & SUPPLY SHOCKS

The demand and supply shocks of the potential CMU members, the Bahamas, and the United States are analyzed using the long run vector auto-regression (LVAR) approach. The inclusion of the United States is warranted given the importance of that country to the region as regards international trade. CARICOM bilateral trade with the United States is approximately three times larger than intra-regional trade among CARICOM states. Additionally, it would be interesting to see how the United States performs given the methodology used.

The supply and demand shocks are extracted for each country and the correlation of shocks between different country pairs is estimated. If the correlation coefficient of a demand shock is positive and significant for a given country pair, then the countries are said to have similar demand shocks. The same holds for supply shocks. Should two countries have supply and demand shocks that are highly correlated, then those two countries may be good candidates for forming a union. While the primary focus is on country pairs, if a simple majority of country pairs have similar demand and supply shocks, then it can be concluded that there is economic evidence for the creation of a CMU made up of more than two countries.

4.1 Theory

A simple Keynesian aggregate demand and supply model is employed here. In the model, demand shocks are regarded as having a temporary effect on output, and a permanent impact on the price level. On the other hand, supply shocks have permanent effects on both variables.

In figure 6 the diagram to the left tells the story of an increase in aggregate demand having a temporary effect on output but a permanent impact on price. It has been assumed that the economy is initially at its full employment level of output, there is a subsequent increase in aggregate demand. Each firm regards the price increase as pertaining only to their good - misperceptions theory. In the long run firms realize

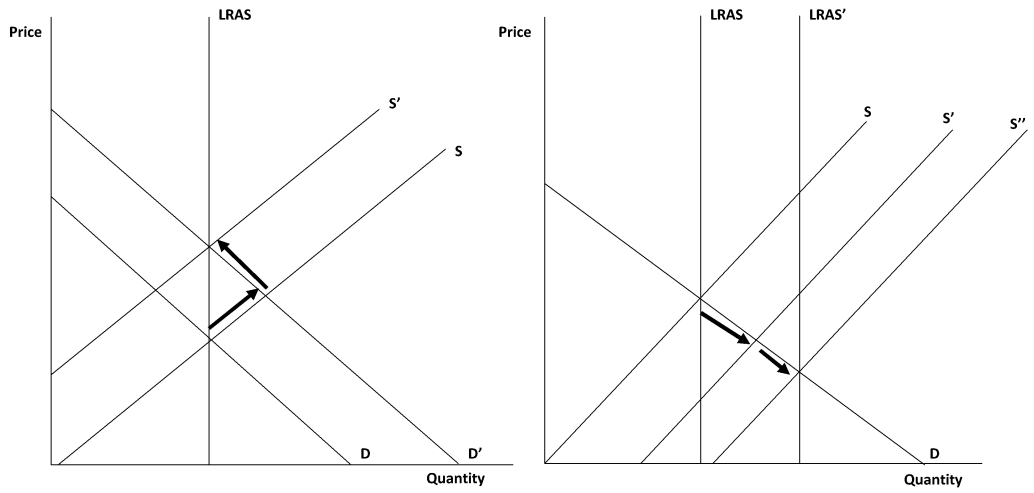


Figure 4.1: Aggregate Demand & Aggregate Supply Model

their mistake and reduce aggregate supply. This decrease results in further upward pressure on prices, and pushes output back to its full employment level.

The second digram illustrates the permanent effect of a supply shock (e.g. a positive technology shock) on output and prices. This positive shock results in an increase in the long run aggregate supply, or put differently, an increase in the full employment level of output. This increase in output is followed by a decrease in the price level, *ceteris paribus*. By lowering the cost of production, the initial technology shock can lead to an indirect increase in the supply curve since funds are freed up to employ more resources, e.g. labor.

4.2 Methodology

The demand and supply shocks, described in the previous section, are not directly observable, and are obtained through the LVAR technique for "extracting" structural shocks. This approach was first posited by Blanchard and Quah (1989).

The structure of the economy can be written as follows:

$$\begin{aligned} X_t &= B_0\epsilon_t + B_1\epsilon_{t-1} + B_2\epsilon_{t-2} + ... && (4.1)\\ &= \sum_{i=0}^{\infty} L^i B_i \epsilon_t && (4.2)\\ &= \sum_{i=0}^{\infty} B_i \epsilon_{t-i} && (4.3) \end{aligned}$$

where, $X_t = \begin{pmatrix} \Delta Y_t \\ \Delta P_t \end{pmatrix}$, $B_i = \begin{pmatrix} b_{1,1} & b_{1,2} \\ b_{2,1} & b_{2,2} \end{pmatrix}$, and $\epsilon_t = \begin{pmatrix} \epsilon_d \\ \epsilon_s \end{pmatrix}$.

It should be noted that L^i is lag operator, ΔY_t is the log difference of real GDP, and ΔP_t is the log difference of the price level, while ϵ_d and ϵ_s are the unobservable structural demand and supply shocks respectively. The B_i matrix contains the coefficients of the shocks with B_0 being the coefficient matrix of contemporary structural shocks.

Rewriting the structural system results in a reduced form VAR representation as follows:

$$X_t = D_1 X_{t-1} + D_2 X_{t-2} + ... + e_t \tag{4.4}$$

where D_i is a 2×2 coefficient matrix, and e_t is a 2×1 vector of residuals, or VAR errors, which are interpreted as the observable shocks.

Rearranging 4.1 and given that $X_t L^1 = X_{t-1}$, the following equations are obtained:

$$\begin{aligned} X_t - D_1 X_{t-1} - D_2 X_{t-2} - .... &= e_t && (4.5)\\ X_t(I - D_1 L^1 - D_2 L^2 - ....) &= e_t. && (4.6) \end{aligned}$$

Assuming that the terms in the parentheses of equation 4.6 are stationary (the mean and variance of the errors do not change with time), then said terms can be inverted to yield,

$$
\begin{aligned}
X_t &= (I - D_1L^1 - D_2L^2 - ....)^{-1}e_t && (4.7)\\
&= (I + D_1L^1 + D_2L^2 + ...)e_t \\
&= e_t + A_1e_{t-1} + A_2e_{t-2} + ... && (4.8)\\
&= \sum_{i=0}^{\infty} A_ie_{t-i}. && (4.9)
\end{aligned}
$$

where A_i is a 2×2 coefficient matrix, and $A_0 = I$ (identity matrix).

Comparing 4.1 and 4.8, and noting that the contemporaneous shocks to X_t are "equivalent" in both the structural (4.1) and moving average (4.8) forms, we get,

$$
e_t = B_0\epsilon_t, \qquad \forall\, t, \tag{4.10}
$$

and by extension,

$$
\begin{aligned}
\sum_{i=0}^{\infty} B_i\epsilon_{t-i} &= \sum_{i=0}^{\infty} A_ie_{t-i} && (4.11)\\
\sum_{i=0}^{\infty} B_i\epsilon_{t-i} &= \sum_{i=0}^{\infty} A_iB_0\epsilon_{t-i} && (4.12)\\
\sum_{i=0}^{\infty} B_i &= \sum_{i=0}^{\infty} A_iB_0 && (4.13)\\
B_i &= A_iB_0 \qquad \forall\, i. && (4.14)
\end{aligned}
$$

Having established the relationship between the structural and moving average representations, the next step is to solve the system and extract the structural shocks. Indeed, since e_t and B_0 can be estimated then the structural shocks, ϵ_t, can be obtained. Since B_0 has four unknowns, and ϵ_t has two unknowns, then an equivalent number of equations, or restrictions, are needed to ensure that the system is "identified".

First, it is assumed that B_0 is a 2×2 matrix with diagonal elements equal to one. Given this assumption there are now four unknowns to be determined; they will be determined through four equations.

We know from equation 4.10,

$$\begin{pmatrix} e_y \\ e_p \end{pmatrix} = \begin{pmatrix} 1 & b_{1,2} \\ b_{2,1} & 1 \end{pmatrix} \begin{pmatrix} \epsilon_d \\ \epsilon_s \end{pmatrix}, \tag{4.15}$$

where, $e_t = \begin{pmatrix} e_y \\ e_p \end{pmatrix}$, i.e. a vector of the estimated output and price residuals.

The variance covariance matrix of the residuals of the regression can be written as follows,

$$Var(e_t) = \begin{pmatrix} e_y \\ e_p \end{pmatrix} \begin{pmatrix} e_y \\ e_p \end{pmatrix}' = \begin{pmatrix} 1 & b_{1,2} \\ b_{2,1} & 1 \end{pmatrix} \begin{pmatrix} \epsilon_d \\ \epsilon_s \end{pmatrix} \begin{pmatrix} \epsilon_d \\ \epsilon_s \end{pmatrix}' \begin{pmatrix} 1 & b_{1,2} \\ b_{2,1} & 1 \end{pmatrix}' \tag{4.16}$$

Given 4.16, and assuming that the structural shocks, e_t, are uncorrelated, three of the four equations needed to identify the system are,

$$\epsilon_d^2 + b_{1,2}^2\epsilon_s^2 = \delta_y^2 \tag{4.17}$$

$$b_{2,1}^2\epsilon_d^2 + \epsilon_s^2 = \delta_p^2 \tag{4.18}$$

$$b_{2,1}\epsilon_d^2 + b_{1,2}\epsilon_s^2 = \delta_y\delta_p, \tag{4.19}$$

where, δ_y^2 and δ_p^2 are the variances of the regression residuals, and $\delta_y\delta_p$ is the covariance of the regression residuals.

The fourth and final equation needed to identify the system is based on the assumption that demand has no permanent impact on output, as outlined earlier. Assuming that the estimated cumulative response to the observed shocks is as follows,

$$\sum_{i=0}^{\infty} A_i = A, \tag{4.20}$$

and,

$$C = AB_0$$

$$\begin{pmatrix} 0 & c_{1,2} \\ c_{2,1} & c_{2,2} \end{pmatrix} = \begin{pmatrix} a_{1,1} & a_{1,2} \\ a_{2,1} & a_{2,2} \end{pmatrix} \begin{pmatrix} 1 & b_{1,2} \\ b_{2,1} & 1 \end{pmatrix}, \tag{4.21}$$

where C is the long run accumulated response of output and price to the structural shocks, ϵ_t. It should be noted that c_{12} and c_{22} are the coefficients for a supply shock on output and price respectively, while c_{21} is the coefficient for a demand shock on price.

From equation 4.21 the fourth restriction is as follows,

$$a_{1,1} + a_{1,2}b_{2,1} = 0. \tag{4.22}$$

The preceding system is solved using the Eviews software package, and the output consists of B_0, C, e_t, and e_t^2. The demand and supply shocks (ϵ_t) are extracted by transforming the residuals of the reduced form VAR and the estimated B_0, as follows,

$$e_t B_0^{-1} = \epsilon_t. \tag{4.23}$$

4.3 Data

The data were obtained from the World Bank's *World Development Indicators (WDI)* database and the International Monetary Fund's (IMF) *International Financial Statistics (IFS)* database, and cover the period 1960 through 2010. The starting period was not uniform for all countries, with the earliest being 1960 (Guyana and The United States), and the latest 1980 (St. Lucia). The data consist of real GDP and the GDP deflator, which are used to represent output and the price level respec-

tively. The only exception was the Bahamas where CPI data were used due to the unavailability of data on the GDP deflator. In keeping with Eichengreen (1992) the GDP deflator is used instead of the consumer price index, since the former reflects the price of output as opposed to the price of consumption. Data on the United States were also obtained in order to supplement the analysis.

4.4 Results and Analysis

While the supply and demand correlations are of greater importance, it is worthwhile to first look at the basic outputs of each country's LVAR estimates. Demand shocks have a direct relationship to price, while supply shocks are interpreted as having a positive impact on price and a negative impact on output. By interpreting supply shocks this way, both demand and supply shocks will have the same impact on price. Indeed, the methodology suggests that price is affected in the long run by the additive effects of supply and demand shocks. To this end, the Eviews output for the cumulative responses - the "C matrix" (equation 4.21) - is adjusted by multiplying c_{12} and c_{22} by negative one. The adjustment would be made as follows,

$$\begin{pmatrix} 0 & c_{1,2} \\ c_{2,1} & c_{2,2} \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} = \begin{pmatrix} 0 & -c_{1,2} \\ c_{2,1} & -c_{2,2} \end{pmatrix}.$$

Given the type of long run restriction employed here, it is expected that the c_{12} and c_{21} estimates would be statistically significant. Indeed, they are significant for all countries at the one-percent level of significance. The point of contention, however, is that of the price response to a supply shock; see table 4.1. Of the thirteen Caribbean countries, five - namely, the Bahamas, Dominica, Guyana, St. Vincent, and Suriname - have a positive sign for the cumulative response of price to a supply shock; of these, only Guyana, Dominica and St. Vincent record statistically significant shocks. The estimates for the United States are all significant and carry the correct signs.

Moving on, the coefficients of the "B Matrix" (equation 4.21), are expected to confirm with the theory for the short run interpretation of the model. That is,

Table 4.1: Cumulative Long Run Response Coefficients

	c_{12}	c_{21}	c_{22}
Antigua	-0.0917	0.0548	-0.0314
The Bahamas	-0.1064	0.0574	0.0046
Barbados	-0.0614	0.1019	-0.0131
Belize	-0.0628	0.0673	-0.0094
Dominica	-0.0460	0.0659	0.0372
Grenada	-0.0444	0.0467	-0.0177
Guyana	-0.0709	0.2897	0.1102
Jamaica	-0.0573	0.1986	-0.0081
St. Kitts	-0.0606	0.0564	-0.0216
St. Lucia	-0.0622	0.0245	-0.0048
St. Vincent	-0.0628	0.0994	0.0338
Suriname	-0.0664	0.7646	0.0690
Trinidad	-0.0845	0.1211	-0.0322
United States	-0.0274	0.0766	0.0250

b_{12} is expected to be negative, and b_{21} positive. The b_{12} coefficient is associated with the supply shock, and b_{21} the demand shock. Eight of the thirteen countries have the correct signs for both demand and supply; three have one correct sign, and the remaining four have incorrect signs for both demand and supply. Having an incorrect sign could mean that the slopes of the short run aggregate demand and aggregate supply functions are not as theory suggests. Table 4.2 shows the slopes of the aggregate demand and aggregate supply curves for each country. As regards the slope of aggregate demand, the Bahamas, Barbados, Dominica, Grenada, Jamaica St. Kitts and St. Vincent, together with the United States, have negatively sloping demand curves. The results are especially appealing for the Bahamas and the United States, given the former country's strong economic dependence on the latter. The short run aggregate supply curves for ten of the fourteen countries have the correct sign. In the case of the four countries with negative slopes, the magnitude of the slopes are sufficiently large in each case that the short-run aggregate supply curves are essentially vertical.

The analysis now turns to the issue of demand and supply correlations. Looking exclusively at the demand correlations, eleven significant cases of positive correlations

Table 4.2: Slopes for Aggregate Demand & Aggregate Supply (Short Run)

	Aggregate Demand	Aggregate Supply
Antigua	0.049	9.575
The Bahamas	-0.292	9.539
Barbados	-0.669	11.345
Belize	0.133	10.066
Dominica	-0.529	15.602
Grenada	-0.087	8.946
Guyana	0.129	-154.460
Jamaica	-0.438	76.166
St. Kitts	-0.263	74.507
St. Lucia	0.001	-20.679
St. Vincent	-0.529	3.026
Suriname	0.161	-24.696
Trinidad	0.403	-184.173
United States	-0.474	0.440

were found among the Caribbean countries studied. Adding the United States takes the number of significant positive correlations to thirteen, see table 4.3. The results clearly favor the member countries of the ECCU. Of the thirteen significant positive correlations, ten are for ECCU country pairs. Given the longevity of the ECCU these results are not surprising. While not significant, there is a relatively high positive correlation between the demand shocks for the United States and the Bahamas. A similar scenario obtains for Trinidad and St. Lucia. However, Trinidad was expected to have more correlations with the other countries in the region. To be sure, for the period 2001-2006 Trinidad's average percentage exports accounted for approximately eighty percent of intra-regional trade (CARICOM Secretariat Statistics). This figure includes intra-regional exports by all CARICOM countries except Haiti and the Bahamas.

Generally, the supply correlations tell a different story. There are nine cases of statistical significance. Of the nine the United States accounts for two cases, see table 4.4. Of the Caribbean country pairs, there is only one instance where both countries are from the ECCU - Grenada and St. Kitts. So for the more critical of the two shocks, the results for ECCU country pairs run counter to what is expected of them.

This time there is a statistically significant positive correlation between the United States and the Bahamas. While the connection between the Bahamas and the United States is not surprising, this finding adds credibility to the analysis.

Given the results for both demand and supply shocks, the only CARICOM country pair for which a strong case can be made for the formation of a union is Grenada and St. Kitts. Grenada and St. Vincent are also likely candidates but the correlation of supply shocks for this country pair falls short by 0.02 points. A correlation coefficient of 0.33 or more is required for statistical significance here. Significant correlations for both shocks were also found for St. Vincent and the United States. In terms of a broader currency union, the results do not support such an initiative. In fact, the results were dismal in this regard with only a few country pairs recording positive significant correlations.

Table 4.3: Demand Correlations (1960-2012)

	AG	BH	BR	BZ	DM	GR	GY	JM	KN	LC	SR	TT	US	VT
AG	1.00													
BH	0.07	1.00												
BR	0.01	0.14	1.00											
BZ	0.04	0.14	0.44	1.00										
DM	0.58	0.00	0.12	-0.19	1.00									
GR	0.68	-0.11	0.07	-0.06	0.56	1.00								
GY	0.22	0.08	-0.16	0.01	-0.05	-0.07	1.00							
JM	-0.04	-0.16	0.02	0.18	0.11	0.15	-0.15	1.00						
KN	0.51	0.01	-0.15	0.05	0.58	0.65	0.10	0.07	1.00					
LC	-0.32	-0.24	-0.15	-0.16	-0.36	-0.39	-0.14	-0.05	-0.37	1.00				
SR	0.19	0.03	0.03	-0.07	0.14	0.11	0.08	0.10	0.01	0.11	1.00			
TT	-0.32	-0.14	-0.54	-0.39	-0.11	-0.27	0.06	-0.22	-0.20	0.29	0.14	1.00		
US	0.07	0.23	0.14	0.36	-0.07	0.08	0.01	0.10	0.20	-0.07	-0.04	-0.30	1.00	
VT	0.50	-0.04	-0.09	0.10	0.43	0.55	-0.02	0.13	0.66	-0.54	0.07	-0.13	0.38	1.00

Bold figures represent the statistically significant positive values.

AG = Antigua, BH = Bahamas, BZ = Belize, BR = Barbados, DM = Dominica, GR = Grenada, GY = Guyana, JM = Jamaica, KN = St. Kitts, LC = St. Lucia, SR = Suriname, TT = Trinidad , VT = St. Vincent, and US = United States.

Table 4.4: Supply Correlations (1960-2012)

	AG	BH	BR	BZ	DM	GR	GY	JM	KN	LC	SR	TT	VT	US
AG	1.00													
BH	-0.23	1.00												
BR	-0.58	0.27	1.00											
BZ	0.25	0.11	- 0.01	1.00										
DM	-0.02	-0.51	0.12	-0.11	1.00									
GR	-0.30	0.27	0.22	-0.23	-0.01	1.00								
GY	0.01	0.30	-0.29	-0.02	0.10	0.42	1.00							
JM	-0.13	-0.23	0.12	0.22	0.20	0.17	0.06	1.00						
KN	-0.45	0.37	**0.53**	-0.19	-0.01	0.36	-0.09	0.05	1.00					
LC	0.30	0.04	-0.29	0.34	-0.37	-0.09	0.02	-0.12	-0.35	1.00				
SR	-0.16	0.13	-0.21	-0.10	-0.12	0.23	0.01	0.13	0.12	-0.03	1.00			
TT	0.29	-0.01	0.03	0.39	-0.06	0.01	-0.03	-0.02	0.02	0.00	0.27	1.00		
US	-0.38	**0.59**	0.14	0.23	0.10	0.31	0.28	-0.03	0.22	-0.18	0.07	0.08	1.00	
VT	-0.22	0.04	0.12	-0.17	0.29	0.31	0.21	0.47	0.29	-0.15	-0.10	-0.10	0.38	1.00

Bold figures represent the statistically significant positive values.

AG = Antigua, BH = Bahamas, BZ = Belize, BR = Barbados, DM = Dominica, GR = Grenada, GY = Guyana, JM = Jamaica, KN = St. Kitts Nevis, LC = St. Lucia, SR = Suriname, TT = Trinidad, VT = St. Vincent, and US = United States.

CHAPTER 5
ECONOMIC CONVERGENCE

This chapter seeks to ascertain whether there is evidence of convergence of demand and supply disturbances among the group B countries; Barbados, Guyana, Jamaica, and Trinidad. The group B countries were singled out by the Governors of the Caribbean central banks as countries needing to meet the convergence criteria before forming a CMU; see Chapter 1. What is more, these four countries carry enormous political and economic weight within CARICOM. As before, the LVAR methodology is employed. Along with demand and supply shocks, convergence of the real effective exchange rate (REER) is explored for a select number of CARICOM member countries. Ideally, the very same group B countries should have been used in the REER analysis. However, for reasons explained below, Trinidad, and eight other CARICOM countries are looked at.

5.1 Convergence of Demand & Supply Shocks:

Data

Data on exports (goods), and the consumer price index (CPI), were obtained from the *IMF's* International Financial Statistics database, for the period 1990-2011. While the GDP Deflator is the preferred price index, quarterly data is unavailable. The starting point, 1990, was chosen to coincide with the beginning of efforts to deepen the integration process. The revised Treaty of Chaguramas was signed in 1989. Given the small number of years being studied and the need for a "sizable" time series, quarterly data are used with exports of goods acting as a proxy for GDP. GDP aata are unavailable at higher than annual frequencies for the countries being studied. According to World Bank data, the average percentage of total exports to GDP for the period 1990-2010, ranges from approximately 43% for Jamaica, to 98% for Guyana. It should be noted that the percentage for Guyana is based on information prior to the re-basing of that country's GDP around 2006. To justify the use of exports (goods) as a proxy for real GDP, the growth rate of real GDP is regressed on the growth rate

Table 5.1: Real GDP-Exports (Goods) (1990-2010)

	Pearson's R	T-Statistic	Exports*	Services*
Barbados	0.434	1.926	55	75
Guyana	0.649	2.958	98	37
Jamaica	0.572	2.956	43	65
Trinidad	0.573	2.968	53	48

Source: World Development Indicators (*World Bank*)
*Exports (goods and services) & Services are given as a percentage of GDP (period average).

of exports(goods), and the Pearson Correlation Coefficient recorded; see Table 5.1. Information on the size of exports (goods and services) and services, as a percentage of GDP, is also given so as to highlight the significance of both sectors to the respective economies. Save for Barbados, the export (goods) coefficient is significant. More importantly, the correlation coefficients are relatively high, as would be expected for highly open small economies. The data show that the more important a country's service sector is to GDP, the lower will be the correlation between the growth rates of real GDP and exports of goods; and rightly so.

Results

Tables 5.2 shows the results for the demand correlations among the four countries studied. In no case is there a significant positive correlation between any country pair. The results for the supply shocks (table 5.3) are also dismal. There is no positive significant relationship between any country pair. These results are very similar to those obtained in the previous chapter which looked at a longer period.

From the results it can be concluded that there has been no noticeable convergence in the demand and supply shocks. A look at the latter half of the period 1990-2011 should shed some light on the issues facing the four countries studied here. The period 2000-2010 was undoubtedly a period of economic downturn and uncertainty, for the world in general, and the countries studied in particular. The year 2001 was marked by the September 11 attacks which led to a negative shock to the Caribbean tourism sector. The attacks certainly compounded the negative impact to the economy of

Table 5.2: Demand Correlations (1990-2011)

	BAR	GUY	JAM	TRI
BAR	1.0000			
GUY	-0.2754	1.0000		
JAM	0.1028	-0.1309	1.0000	
TRI	0.2843	0.1018	0.0837	1.0000

the United States brought on by the bursting of the dot-com bubble some months earlier. By 2003, oil prices started to rise precipitously. This was certainly good news for Trinidad as an exporter of oil and natural gas, but not for the others who are net importers. The latter half of the decade was marked by a spike in world food prices and the greatest recession in the US since the great depression. What is instructive about these developments is the way in which they affect the countries being studied. Trinidad benefits from increases in the price of oil since its export revenue rises, but the others, concessionary oil deals aside, are faced with a higher import bill. On the other hand, Barbados and Jamaica suffer as a result of a reduction in tourist arrivals. In terms of the food price hike, even Guyana, with 20% of GDP coming from agriculture, felt the effects of the higher world food prices, see Thomas (2009). The foregoing serves to show that the relatively diverse nature of the economies influence how they respond to global economic stimuli, and as such could be plausible reasons for the divergence seen in the data.

Table 5.3: Supply Correlations (1990-2011)

	BAR	GUY	JAM	TRI
BAR	1.0000			
GUY	-0.3178	1.0000		
JAM	0.1203	-0.1409	1.0000	
TRI	0.2513	0.0990	-0.0850	1.0000

5.2 Exchange Rate Convergence

Exchange rate convergence in general, and real effective exchange rate (REER) convergence in particular, is a natural concern for countries entering into a monetary union. To be sure, countries within a currency union will have a common monetary policy, and as such it is expected that the price level within the union would be similar. While the CMU is not yet functional, prospective members, especially those with flexible exchange rates, were required to adhere to several "convergence criteria" in the lead up to the launch of the union. Therefore, by looking at the REER the progress towards the creation of the union can be ascertained. To this end, the cointegration approach is employed.

In keeping with the general theme of this thesis, the analysis done here focuses on whether or not the REER of different country pairs exhibit long run convergence. Alternatively, the analysis could have been conducted for more than two countries at a time. Indeed, the Johansen (1988) methodology allows for that. As noted earlier, data constraints prevent the analysis of the group B countries. Instead, the lone group B country and the largest economy in the region, Trinidad, is paired here with the other countries, one at a time. Its size aside, it is worth reiterating that for the period 2001-2006 (CARICOM Secretariat Statistics) Trinidad is responsible for approximately 80% of the value of all intra-regional exports for the CARICOM bloc of countries. Surely, these factors make Trinidad a good candidate to pair with the other countries.

Methodology

The cointegration approach is employed here, and used to test for a long term trend among the variables (exchange rates for each country studied). The Johansen Cointegration procedure (see Johansen (1988)) is used instead of the Engle-Granger method (Engle and Granger (1987)). Ahking (2002) notes that the cointegration approach pioneered by Johansen (1988) "is arguably the most popular approach in estimating long-run economic relationships." There are a few reasons that make the Johansen approach superior to the Engle-Granger approach. First, the Engle-

Granger approach can only work with two variables. Moreover, there is the issue of simultaneous equations bias inherent in the Engle-Granger approach, and as such bi-causality is ignored, (see Brooks (2008): page 342). Finally, the Engle-Granger approach relies on a two step estimator, therefore, any errors that enter at the first stage (generation of error series), is carried over to the regression of the error series - Asteriou (2006).

It is common for macroeconomic time series data to have a unit root, i.e. they are non-stationary. This characteristic feature of macroeconomic variables requires careful econometric analysis. Failure to do so could lead to specious conclusions. Moreover, differencing of variables to achieve stationarity gets rid of the underlying long run relationship in the series (see Asteriou (2006)). Cointegration resolves both the loss of the long run properties and lack of stationarity. To accomplish same, the cointegration approach allows for the use of the variables in levels. If a linear combination of variables (integrated of order one *I(1)*), is found to be stationary (*I(0)*), the variables are said to be cointegrated (see Brooks (2008)).

The three general parts to the cointegration analysis is first presented below, followed by the mathematical presentation of the model.

1. The values for each variable are tested to ascertain the order of integration. More specifically, the variables are expected to be non-stationary, as is the case with most macroeconomic time series. The non-stationary variables are expected to be integrated of order one ($I(1)$). While it is not necessary for all variables to be integrated of the same order, variables not integrated of order one are excluded. This way there is uniformity of integration.

2. The next step is to find the lag length. To this end, un-restricted VARS of varying lag lengths are ran. The model with the lowest Schwarz Bayesian Criterion is chosen. A lag length of one was determined to be optimal in each case.

3. The next step is to ascertain the specification of the VECM. The VECM can include intercept and/or trend terms for both the short run and long run components of the model. There are five different possibilities, however, the first

and fifth model specifications are excluded. The first specification has no intercept or trend for either the short run or long run parts of the VECM, and is unlikely to occur in practice. The fifth specification has intercepts and trends for both the long run and short run components. Of the remaining specifications, model three wins out. Model three consists of intercepts for both the long run and short run components. The third model was selected after estimating the second, third and fourth model specifications. This meant moving from the most restrictive model (the second specification) to the least restrictive (the fourth one). The process ends when it is concluded that the null hypothesis of no cointegration is not rejected for a particular number of cointegrating equations. For example, if the hypothesis of no cointegrating is rejected, meaning there is at least one cointegrating relationship, then one must move on to the next (less restrictive) model and check for to see if that model also has at least one cointegrating equation. If yes, the process is repeated for that particular number of cointegrating equations before moving on to the next hypothesis, i.e. the existence of at most one cointegrating equation.

4. The number of cointegrating vectors are determined using two approaches, the maximimal eigen value static and the trace statistic. The mathematical model presented below goes into more detail as to the use of these statistics.

Since the REER of different country pairs are examined here, then

$$Z_t = [E_t^a, E_t^b] \tag{5.1}$$

where, Z_t is a vector containing the REER of two countries (a and b). As noted before the Johansen technique resolves the possibility of bi-causalty through its use of a VAR, in this case with k lags

$$Z_t = A_1 Z_{t-1} + ... + A_i Z_{t-k} + u_t. \tag{5.2}$$

For the Johansen test to be carried out equation 5.2 must be converted to a vector

error correction model of the form

$$\Delta Z_t = \Pi Z_{t-k} + \Gamma_1 \Delta Z_{t-1} + ... + \Gamma_{k-1} \Delta Z_{t-(k-1)} + u_t. \tag{5.3}$$

where $\Pi = I - A_1..... - A_k$, $\Gamma_i = I - A_1..... - A_{k-1}$ and $(i = 1, 2, ...k-1)$. The Γ matrix is concerned with the short run relationship of the variables and as such is not of primary importance here. On the other hand, the focus of the Johansen test is on the Π matrix. The Π matrix has information on the long run relationship of the system and is specified as follows,

$$\Pi = \alpha \acute{\beta} \tag{5.4}$$

where the α matrix contains the coefficients on the speed of adjustment to equilibrium, and $\acute{\beta}$ is the long run matrix of coefficients. The following equations are expansions of equation 5.2.

$$\begin{pmatrix} \Delta E_t^a \\ \Delta E_t^b \end{pmatrix} = \Gamma_1 \begin{pmatrix} \Delta E_{t-1}^a \\ \Delta E_{t-1}^b \end{pmatrix} + \Pi \begin{pmatrix} E_{t-1}^a \\ E_{t-1}^b \end{pmatrix} + e_t \tag{5.5}$$

$$\begin{pmatrix} \Delta E_t^a \\ \Delta E_t^b \end{pmatrix} = \Gamma_1 \begin{pmatrix} \Delta E_{t-1}^a \\ \Delta E_{t-1}^b \end{pmatrix} + \begin{pmatrix} \alpha_{11} \\ \alpha_{21} \end{pmatrix} \begin{pmatrix} \beta_{11} & \beta_{21} \end{pmatrix} \begin{pmatrix} E_{t-1}^a \\ E_{t-1}^b \end{pmatrix} + e_t \tag{5.6}$$

In the case of the maximal eigenvalue statistic, the null hypothesis that the rank of $\Pi = r$ is tested against the alternative hypothesis that the rank of $\Pi = r + 1$. On the other hand the trace statistic is concerned with a likelihood ratio test of the trace of Π. Here the null hypothesis says that the number of cointegrating relationships is $\leq r$. The process is usually done by starting at the highest possible r and working downwards until the null has been rejected.

Data

The data were obtained from the *International Financial Statistics* (International Monetary Fund), and span the period 1980-2011. Like the section on demand and supply shocks, focus is placed on the period 1990-2011, and for the same reason. Quarterly data on the REER were found for nine of the twelve potential members of the CMU. Of the nine, six are from the Eastern Caribbean Currency Union (Antigua, Dominica, Grenada, St. Lucia, St. Kitts and St. Vincent), the remaining three are Belize, Guyana and Trinidad. The Bahamas is also added to the list of countries, bringing the number to ten. No data were found for Barbados, Jamaica and Suriname.

To understand what is the REER, it is useful to understand the logic of the real exchange rate (RER). Take the following formula,

$$e_{a,b} = \frac{E_{a,b} \times P_b}{P_a}$$

where, $e_{a,b}$ is the RER of country *B's* currency in terms of country *A's* currency, $E_{a,b}$ is the nominal exchange rate rate (nominal price of country *B's* currency), P_b is the price level of country B, and P_a the price level of country A. It should be clear that an increase in the real exchange rate (depreciation of country *A's* currency) could come about if the nominal exchange rate rises, the price level in country B rises, or the price level in country A falls; and vice versa.

The REER expands upon the above logic by adding other countries into the mix. A weighted average of the RER of the major trading partners of country A are combined to form the REER. The weights are based on the level of trade between country A and its trading partners.

Results

As specified in the methodology, the order of integration for all the variables (REER for each country) are to be *I(1)*. Of the ten countries only nine meet this criteria. The REER data for Guyana were found to be stationary in levels i.e. the series is *I(0)*. Of the remaining 8 countries (Trinidad included) the REER for Trinidad

and Grenada, and Trinidad and St. Vincent were found to be cointegrated. In other words, the cointegration tests indicate a long run relationship of the REERs for each of the two country pairs. See tables 5.4 and 5.5 for the results of the Johansen tests for Grenada-Trinidad, and St. Vincent-Trinidad. Tables 5.6 and 5.7 contain the output for the VECM. Interestingly, Grenada, St. Vincent and Trinidad are geographically close to each other relative to the other countries in the region. The flight times for Trinidad to St. Vincent, Trinidad to Grenada, and Grenada to St. Vincent, are 28 minutes, 17 minutes, and 12 minutes respectively, when flying between the capital cities of each country. The gravity model suggests that trade flows should be relatively larger - controlling for size of GDP - for countries that are geographically closer. Data on the direction of trade for the Caribbean region corroborates this view, therefore lending support for the results of the cointegration analysis.

According to the IMF's Direction of Trade Statistics Trinidad's exports to Grenada and St. Vincent, as a percentage of their respective GDPs, are the highest and third highest respectively for the CARICOM countries is; see table 5.8. Moreover, exports from Grenada and St. Vincent to the US, as a percentage of the total exports to CARICOM and the United States, is below the regional average. This is also true for imports from the US. This information can be found in table 5.9.

While more favorable results, especially between Trinidad and the members of the ECCU, would have been preferred, the outcome is encouraging. In fact, the results align nicely with the drive for deeper regional integration by a few members of CARICOM. On August 14, 2008, Grenada, St. Lucia, St. Vincent, and Trinidad agreed to create "a single economy by 2011 and appropriate political integration by 2013," see Lewis (2009). This process was separate from the wider regional integration process of as it relates to a CMU. Apart from St. Lucia, the cointegration analysis conducted here supports this initiative. It should be noted that the formation of a single currency among the four countries was not part of the initiative. A quasi-currency board mechanism would have sufficed for Trinidad. And rightly so since Grenada, St. Lucia, and St. Vincent are already members of the ECCU - a currency union operating a quasi currency board. As regards regional integration at the CARICOM level, the

initiative by the four complements the wider integration process, as opposed to being a substitute for it. The architect behind the proposed union of the four was the then Prime Minister of Trinidad, Patrick Manning. He lost political office about two years after initiating the process. Loosing at the ballot box saw the end of his stint as leader, and with that the union was put on pause.

Table 5.4: Cointegration Results: Grenada-Trinidad

Trinidad – Grenada
Date: 10/09/13 Time: 01:01
Sample (adjusted): 1990Q3 2011Q4
Included observations: 86 after adjustments
Trend assumption: Linear deterministic trend
Series: T_T GRE
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.172684	16.40181	15.49471	0.0364
At most 1	0.001149	0.098868	3.841466	0.7532

Trace test indicates 1 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.172684	16.30294	14.26460	0.0235
At most 1	0.001149	0.098868	3.841466	0.7532

Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

T_T	GRE
0.077711	0.317474
0.070646	-0.052165

Unrestricted Adjustment Coefficients (alpha):

D(T_T)	-0.821839	0.094462
D(GRE)	-0.738666	-0.009052

1 Cointegrating Equation(s): Log likelihood -382.2294

Normalized cointegrating coefficients (standard error in parentheses)

T_T	GRE
1.000000	4.085326
	(0.78431)

Adjustment coefficients (standard error in parentheses)

D(T_T)	-0.063866
	(0.02847)
D(GRE)	-0.057402
	(0.01406)

Table 5.5: Cointegration Results: St. Vincent-Trinidad

Trinidad – St. Vincent
Date: 10/09/13 Time: 01:03
Sample (adjusted): 1990Q3 2011Q4
Included observations: 86 after adjustments
Trend assumption: Linear deterministic trend
Series: T_T VIN
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.183268	17.42645	15.49471	0.0253
At most 1	0.000189	0.016283	3.841466	0.8983

Trace test indicates 1 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.183268	17.41017	14.26460	0.0154
At most 1	0.000189	0.016283	3.841466	0.8983

Max-eigenvalue test indicates 1 cointegratingeqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

T_T	VIN
0.054132	0.174701
0.078325	-0.013123

Unrestricted Adjustment Coefficients (alpha):

D(T_T)	-1.081628	0.031730
D(VIN)	-1.068434	-0.010591

1 Cointegrating Equation(s): Log likelihood -410.8994

Normalized cointegrating coefficients (standard error in parentheses)

T_T	VIN
1.000000	3.227326
	(0.65107)

Adjustment coefficients (standard error in parentheses)

D(T_T)	-0.058550
	(0.01940)
D(VIN)	-0.057836
	(0.01425)

Table 5.6: Vector Error Correction Results: Grenada-Trinidad

Trinidad – Grenada
Vector Error Correction Estimates
Date: 10/09/13 Time: 00:52
Sample (adjusted): 1990Q3 2011Q4
Included observations: 86 after adjustments
Standard errors in ( ) & t-statistics in [ ]

CointegratingEq:	CointEq1	
T_T(-1)	1.000000	
GRE(-1)	4.085326 (0.78431) [5.20883]	
C	-522.5636	
Error Correction:	**D(T_T)**	**D(GRE)**
CointEq1	-0.063866 (0.02847) [-2.24365]	-0.057402 (0.01406) [-4.08181]
D(T_T(-1))	0.065338 (0.12239) [0.53387]	-0.022454 (0.06046) [-0.37136]
D(GRE(-1))	0.264373 (0.22752) [1.16199]	0.320232 (0.11240) [2.84894]
C	0.314777 (0.36884) [0.85342]	-0.016056 (0.18222) [-0.08811]
R-squared	0.066069	0.203714
Adj. R-squared	0.031901	0.174581
Sum sq. resids	946.1799	230.9418
S.E. equation	3.396878	1.678202
F-statistic	1.933655	6.992679
Log likelihood	-225.1464	-164.5049
Akaike AIC	5.328986	3.918719
Schwarz SC	5.443141	4.032874
Mean dependent	0.311824	-0.047131
S.D. dependent	3.452392	1.847171
Determinant resid covariance (dof adj.)		27.34565
Determinant resid covariance		24.86103
Log likelihood		-382.2294
Akaike information criterion		9.121614
Schwarz criterion		9.407003

Table 5.7: Vector Error Correction Results: St. Vincent-Trinidad

Trinidad – St. Vincent
Vector Error Correction Estimates
Date: 10/09/13 Time: 00:24
Sample (adjusted): 1990Q3 2011Q4
Included observations: 86 after adjustments
Standard errors in ( ) & t-statistics in [ ]

CointegratingEq:	CointEq1	
T_T(-1)	1.000000	
VIN(-1)	3.227326 (0.65107) [4.95694]	
C	-440.4097	
Error Correction:	**D(T_T)**	**D(VIN)**
CointEq1	-0.058550 (0.01940) [-3.01814]	-0.057836 (0.01425) [-4.05963]
D(T_T(-1))	0.021752 (0.12097) [0.17981]	-0.110082 (0.08884) [-1.23910]
D(VIN(-1))	0.189398 (0.15724) [1.20454]	0.425558 (0.11547) [3.68539]
C	0.356744 (0.36415) [0.97967]	-0.083955 (0.26743) [-0.31394]
R-squared	0.106017	0.233660
Adj. R-squared	0.073310	0.205623
Sum sq. resids	905.7089	488.4673
S.E. equation	3.323437	2.440680
F-statistic	3.241431	8.334040
Log likelihood	-223.2667	-196.7165
Akaike AIC	5.285271	4.667826
Schwarz SC	5.399427	4.781981
Mean dependent	0.311824	-0.227909
S.D. dependent	3.452392	2.738404
Determinant resid covariance (dof adj.)		53.26614
Determinant resid covariance		48.42638
Log likelihood		-410.8994
Akaike information criterion		9.788357
Schwarz criterion		10.07375

Table 5.8: Trinidad's Average Regional Exports: 1990 - 2012

Importing Country	Exports ($US) [1]	% of GDP[2]
Non - ECCU		
Bahamas, The	34,586,130	0.58
Barbados	245,832,340	9.49
Belize	14,835,937	1.66
Guyana	141,326,950	13.10
Jamaica	403,772,338	4.40
Suriname	51,663,828	2.95
ECCU		
Antigua & Barbuda	30,594,266	3.78
Dominica	25,684,278	7.98
Grenada	**75,525,069**	**14.84**
St. Kitts	31,268,412	7.12
St. Lucia	73,649,973	9.30
St. Vincent	**44,028,688**	**9.92**

Sources: World Bank Development Indicators & IMF - Direction of Trade Statistics.
[1] Average (1990-2012) value of Trinidad's exports to importing country.
[2] Trinidad's exports as a percentage of importing country's GDP; 1990-2012.

Table 5.9: US - CARICOM Exports and Imports: 1990 - 2012

Country	Exports (%) [1]	Imports (%) [2]
Non - ECCU		
Bahamas, The	97	97
Barbados	23	57
Belize	85	90
Guyana	65	50
Jamaica	91	76
Suriname	64	68
Trinidad	75	91
ECCU		
Antigua & Barbuda	19	76
Dominica	8	52
Grenada	36	41
St. Kitts	93	66
St. Lucia	58	57
St. Vincent	9	50
Average	56	67

Sources: IMF - Direction of Trade Statistics.
[1] Exports to the US as a percentage of total exports to the US and CARICOM.
[2] Imports from the US as a percentage of total imports from the US and CARICOM

CHAPTER 6
CONCLUSION

Is there economic justification for two CARICOM countries forming a currency union? This is the central question explored in this thesis. There is a theoretical component consisting of a dynamic stochastic general equilibrium (DSGE) model, and an empirical component utilizing vector autoregressions and cointegration analyses. More specifically, the reactions of two economies to symmetric and asymmetric shocks, with and without a currency union, are investigated. Secondly, the demand and supply shocks between country pairs are examined to determine whether positive correlations exist. And finally, the thesis looks at the issue of economic convergence, especially given the coordinated efforts of CARICOM member states towards an environment conducive for a currency union.

The results of the DSGE model corroborate the view that it is best for two countries to have symmetric business cycle. However, in the presence of asymmetric shocks, the model indicates that it will not be difficult to enact a common monetary policy since in the union the asymmetric shock is evenly distributed across the union. The DSGE model consists of two, small, open, economies, similar to those that constitute the CARICOM bloc. Agents derive utility from consumption and leisure. The model has money, but no utility is derived from holding money. Rather, money held in the current period is used to purchase goods and services in the following period - cash in advance. There are two types of firms; intermediate goods firms and final goods firms. The intermediate goods are produced in an imperfectly competitive market. The imperfect nature of the market is captured by the ability of firms to set prices. Prices are sticky and are determined based on the Calvo pricing method i.e. every period a given percentage of firms cannot change their prices, this percentage is given by the Calvo parameter. The Calvo parameter was assumed to be lower for the countries of CARICOM as compared to their developed world counterparts. The model also has a foreign sector where agents from either country can borrow (sell bonds), or lend (buy bonds), money to each other. The country that borrows does

so in the event of a trade deficit. Conversely the lending country will have a trade surplus. In both policy regimes (union, no union) a negative technology shock hits both economies. In the currency union, there is no exchange rate and both countries are assumed to have similar price levels. In the currency union the results indicate higher mean values for output, capital, wages, consumption and the return to capital, for both countries. Moreover, the variances for the real variables are lower in the currency union. Based on these results the formation of a currency union is justified. A negative shock to one country is also analyzed in the two policy regimes. Not surprisingly, the country hit by the shock is better off in the union, and the country not hit by the shock is worse off in the union. In other words, the burden of the shock is distributed more evenly in the currency union. Moreover, the country not experiencing the initial shock will have lower real variables and higher variances.

The vector autoregression analysis offers encouraging results, especially as regards the correlations of demand shocks for the countries within the Eastern Caribbean Curreny Union (ECCU). Moreover, two pairs of Caribbean countries, Grenada-St. Kitts and Grenada-St. Vincent, have relatively large positive correlations for both demand and supply shocks. The demand and supply shocks are determined through the use of the long run vector autoregression methodology, and utilize data on output and price (GDP deflator). The theoretical framework underpinning this approach assumes that demand shocks only have a long run impact on prices, but no long run impact on output. Supply, on the other hand, has a long run impact on both price and output. All the countries within CARICOM, save for Haiti and Montserrat, are included in the analysis. To answer the central question of the thesis, a correlation coefficient of 0.33 indicates significant correlation of the demand, or supply, shocks for a country pair. When the correlation coefficient is 0.33, or more, a simple regression of one country's supply shock on another country's supply shock indicates that the coefficient of the right hand side variable is significant. Country pairs with significant demand and supply correlations are regarded as good candidates for a currency union.

As regards the issue of economic convergence two approaches are used; vector autoregression analysis and cointegration analysis. The vector autoregression is used

to extract demand and supply shocks as in chapter four. The results are un-favorable for the big four economies - Barbados, Guyana, Jamaica and Trinidad. The big four economies were singled out in this part of the thesis because they were the countries that were identified in 1992, by CARICOM, as needing to do much work as regards achieving the convergence criteria. The convergence criteria are conveniently known as the "3-12-36-15 criteria"; maintain 3 months of import cover for 12 months, maintain a stable exchange rate for 36 months, and an external debt service ratio of no more than 15% of exports. The long run convergence of the real effective exchange rate (REER) between country pairs, is investigated. Trinidad, categorized here as the Germany of the region, being the constant in each pair. The results support the move spear-headed by Trinidad towards the formation of an economic union within the CARICOM bloc. To be specific, the cointegration analysis indicates a long run relationship between the REERs of Trinidad and Grenada, and Trinidad and St. Vincent. In August 2008 Trinidad launched an initiative to form an economic union with Grenada, St. Vincent and St. Lucia. These countries are geographically close to Trinidad. Countries in an economic union need not share a common currency. An economic union is a form of regional integration where member countries have moved beyond the customs union stage, and there is free movement of goods and factors of production.

In general, the results are mixed and are in keeping with previous research. The theoretical model supports a currency union in an environment where shocks are similar but not where shocks are asymmetric. The empirical work supports unions between some pairs of CARICOM countries. In particular, Grenada-St. Kitts, Grenada-St. Vincent, Trinidad-Grenada, and Trinidad-St. Vincent. While the emphasis here has been on two countries, the results can be interpreted to mean that a CMU consisting of all the countries studied is not justifiable. This dismal outcome for a broader currency union supports the view that efforts towards convergence have not borne fruit.

Arising from the work done here, it will be worthwhile to create a more elaborate DSGE model. Such a model will incorporate well defined government and banking

sectors. These sectors will be useful in better exploring the issue of a CMU. For example, the Caribbean's oligopolistic banking sector can be explored. In keeping with the favorable results for some country pairs, it would be worthwhile to do deeper economic analysis of said countries.

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APPENDIX A

DYNARE CODES

```
//MODEL - No Union

//VARIABLES
var Yh Kh Hh Ch wh rh Ph Pch B rb Mh Eh gh lh X e Yf Kf Hf Cf wf rf Pf Pcf Mf Ef gf lf;
varexo egh elh egf elf ey;

//PARAMETERS
parameters beta theta  deltah deltaf gamma gammag psi kappah kappaf rho a ri Dh Df;

//VALUES OF PARAMETERS
    beta    = 0.99;
    theta   = 0.32;
    deltah  = 0.0375;
    deltaf  = 0.0375;
    gamma   = 0.95;
    gammag  = 0.45;
    psi     = 11;
    kappah  = 1;
    kappaf  = 1;
    rho     = 0;
    a       = 0.01;
    ri      = 0.0101;
    Dh      = -2.38211;
    Df      = -2.38211;



//MODEL
model;
 0  = (e/(Ph(+1)*Ch(+1))) - beta*(e(+1)*(1+rb))/(Ph(+2)*Ch(+2));
 0  = (Ph/(Ph(+1)*Ch(+1)))*(1 + kappah*(Kh - Kh(-1))) - beta*(Ph(+1)/(Ph(+2)*Ch(+2)))*(1-
deltah + rh(+1) + kappah*(Kh(+1) - Kh));
 0  = Dh/wh + beta*(Ph/(Ph(+1)*Ch(+1)));
 0  = Mh/Ph + (e*B/Ph) + Kh + (kappah/2)*((Kh - Kh(-1))^2) - Yh - (1-deltah)*Kh(-1) -
(e*(1+rb)*B(-1))/Ph;
 0  = Yh - wh*Hh - rh*Kh(-1) - Eh;
 0  = Ph^(1-psi) - rho*Ph(-1)^(1-psi) - (1-rho)*Pch^(1-psi);
 0  = Pch - (psi/(psi-1))*Ph*(wh/((1-theta)*lh))*(((rh*(1-theta))/(wh*theta))^(theta));
 0  = (Hh*lh)/(Yh*(Ph/Pch)^psi) - (((1-theta)*rh)/(theta*wh))^(theta);
 0  = (Kh*lh)/(Yh*(Ph/Pch)^psi) - (((1-theta)*rh)/(theta*wh))^(theta - 1);
 0  = Ph*Ch - gh*Mh(-1);
 0  = Mh - gh*Mh(-1);
 0  = B - (1+rb(-1))*B(-1) - Pf*X;
 0  = rb - ri - a*(abs(B))/Pf;
 0  = e - Ph/Pf;
 0  = log(gh) - gammag*log(gh(-1)) - egh;
 0  = log(lh) - gamma*log(lh(-1)) - elh + ey;
 0  = (Pf*((beta*(1+rb))/(Pf(+2)*Cf(+2))))*(1 + kappaf*(Kf - Kf(-1))) -
beta*(Pf(+1)/(Pf(+2)*Cf(+2)))*(1-deltaf + rf(+1) + kappaf*(Kf(+1) - Kf));
 0  = Df/wf + beta*(Pf/(Pf(+1)*Cf(+1)));
 0  = Mf/Pf + (-B/Pf) + Kf + (kappaf/2)*((Kf - Kf(-1))^2) - Yf - (1-deltaf)*Kf(-1) -
((1+rb)*(-B(-1)))/Pf;
 0  = Yf - wf*Hf - rf*Kf(-1) - Ef;
 0  = Pf^(1-psi) - rho*Pf(-1)^(1-psi) - (1-rho)*Pcf^(1-psi);
 0  = Pcf - (psi/(psi-1))*Pf*(wf/((1-theta)*lf))*(((rf*(1-theta))/(wf*theta))^(theta));
 0  = (Hf*lf)/(Yf*(Pf/Pcf)^psi) - (((1-theta)*rf)/(theta*wf))^(theta);
 0  = (Kf*lf)/(Yf*(Pf/Pcf)^psi) - (((1-theta)*rf)/(theta*wf))^(theta - 1);
 0  = Pf*Cf - gf*Mf(-1);
 0  = Mf - gf*Mf(-1);
 0  = log(gf) - gammag*log(gf(-1)) - egf;
 0  = log(lf) - gamma*log(lf(-1)) + elf + ey;
end;
```

*The rest of the code for this model continues on the next page.

```
//INITIAL VALUES OF VARIABLES - check values
initval;
    Yh      = 0.78124;
    Kh      = 4.77447;
    Hh      = 0.3333;
    Ch      = 0.60220;
    wh      = 1.44899;
    rh      = 0.04760;
    Ph      = 1;
    Pch     = 1;
    B       = 0;
    rb      = 0.0101;
    Mh      = 0.60220;
    Eh      = 0.07102;
    gh      = 1;
    lh      = 1;
    e      = 1;
    X      = 0;
    Yf     = 0.78124;
    Kf     = 4.77447;
    Hf     = 0.3333;
    Cf     = 0.60220;
    wf     = 1.44899;
    rf     = 0.04760;
    Pf     = 1;
    Pcf    = 1;
    Mf     = 0.60220;
    Ef     = 0.07102;
    gf     = 1;
    lf     = 1;
end;


resid(1);
steady;
check;

shocks;
 var elh; stderr 0.01;
 // var elf; stderr 0.01;
// var ey; stderr 0.01;
end;

 // stoch_simul(periods=2000);
stoch_simul(irf=100);
```

```
//MODEL - Union

//VARIABLES
var Yh Kh Hh Ch wh rh P Pch B rb Mh Eh gh lh X Yf Kf Hf Cf wf rf Pcf Mf Ef gf lf;
varexo egh elh egf elf ey;

//PARAMETERS
parameters beta theta  deltah deltaf gamma gammag psi kappah kappaf rho a ri Dh Df;

//VALUES OF PARAMETERS
    beta    = 0.99;
    theta   = 0.32;
    deltah  = 0.0375;
    deltaf  = 0.0375;
    gamma   = 0.95;
    gammag  = 0.45;
    psi     = 11;
    kappah  = 1;
    kappaf  = 1;
    rho     = 0.25;
    a       = 0.01;
    ri      = 0.0101;
    Dh      = -2.38211;
    Df      = -2.38211;



//MODEL
model;
 0  = (1/(P(+1)*Ch(+1))) - beta*((1+rb))/(P(+2)*Ch(+2));
 0  = (P/(P(+1)*Ch(+1)))*(1 + kappah*(Kh - Kh(-1))) - beta*(P(+1)/(P(+2)*Ch(+2)))*(1-
deltah + rh(+1) + kappah*(Kh(+1) - Kh));
 0  = Dh/wh + beta*(P/(P(+1)*Ch(+1)));
 0  = Mh/P + (B/P) + Kh + (kappah/2)*((Kh - Kh(-1))^2) - Yh - (1-deltah)*Kh(-1) -
((1+rb)*B(-1))/P;
 0  = Yh - wh*Hh - rh*Kh(-1) - Eh;
 0  = P^(1-psi) - rho*P(-1)^(1-psi) - 0.5*(1-rho)*Pch^(1-psi) - 0.5*(1-rho)*Pcf^(1-psi);
 0  = Pch - (psi/(psi-1))*P*(wh/((1-theta)*lh))*(((rh*(1-theta))/(wh*theta))^(theta));
 0  = (Hh*lh)/(Yh*(P/Pch)) - (((1-theta)*rh)/(theta*wh))^(theta);
 0  = (Kh*lh)/(Yh*(P/Pch)) - (((1-theta)*rh)/(theta*wh))^(theta - 1);
 0  = P*Ch - gh*Mh(-1);
 0  = Mh - gh*Mh(-1);
 0  = B - (1+rb(-1))*B(-1) - P*X;
 0  = rb - ri - a*(abs(B))/P;
 0  = log(gh) - gammag*log(gh(-1)) - egh;
 0  = log(lh) - gamma*log(lh(-1)) + elh + ey;
 0  = (P*(beta*(1+rb)/(P(+2)*Cf(+2))))*(1 + kappaf*(Kf - Kf(-1))) -
beta*(P(+1)/(P(+2)*Cf(+2)))*(1-deltaf + rf(+1) + kappaf*(Kf(+1) - Kf));
 0  = Df/wf + beta*(P/(P(+1)*Cf(+1)));
 0  = Mf/P + (-B/P) + Kf + (kappaf/2)*((Kf - Kf(-1))^2) - Yf - (1-deltaf)*Kf(-1) -
((1+rb)*(-B(-1)))/P;
 0  = Yf - wf*Hf - rf*Kf(-1) - Ef;
 0  = Pcf - (psi/(psi-1))*P*(wf/((1-theta)*lf))*(((rf*(1-theta))/(wf*theta))^(theta));
 0  = (Hf*lf)/(Yf*(P/Pcf)) - (((1-theta)*rf)/(theta*wf))^(theta);
 0  = (Kf*lf)/(Yf*(P/Pcf)) - (((1-theta)*rf)/(theta*wf))^(theta - 1);
 0  = P*Cf - gf*Mf(-1);
 0  = Mf - gf*Mf(-1);
 0  = log(gf) - gammag*log(gf(-1)) - egf;
 0  = log(lf) - gamma*log(lf(-1)) + elf + ey;
end;
```

*The rest of the code for this model continues on the next page.

```
//INITIAL VALUES OF VARIABLES - check values
initval;
    Yh      = 0.78124;
    Kh      = 4.77447;
    Hh      = 0.3333;
    Ch      = 0.60220;
    wh      = 1.44899;
    rh      = 0.04760;
    P       = 1;
    Pch     = 1;
    B       = 0;
    rb      = 0.0101;
    Mh      = 0.60220;
    Eh      = 0.07102;
    gh      = 1;
    lh      = 1;
    X     = 0;
    Yf    = 0.78124;
    Kf    = 4.77447;
    Hf    = 0.3333;
    Cf    = 0.60220;
    wf    = 1.44899;
    rf    = 0.04760;
    Pcf   = 1;
    Mf    = 0.60220;
    Ef    = 0.07102;
    gf    = 1;
    lf    = 1;
end;

resid(1);
steady;
check;

shocks;
  var elh; stderr 0.01;
// var elf; stderr 0.01;
// var ey; stderr 0.01;
end;

stoch_simul(periods=2000);
// stoch_simul(irf=100);
```

APPENDIX B

LVAR ESTIMATES

Table B.1: LVAR Estimate: Antigua

ANTIGUA
Structural VAR Estimates
Date: 09/10/13 Time: 19:28
Sample (adjusted): 1979 2012
Included observations: 34 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 5 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.054752	0.006640	8.246211	0.0000
C(2)	0.091667	0.011116	8.246211	0.0000
C(3)	0.031371	0.010131	3.096410	0.0020

Log likelihood	123.8470

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.003475	0.046316
0.033272	0.002263

Table B.2: LVAR Estimate: The Bahamas

THE BAHAMAS
Structural VAR Estimates
Date: 09/13/13 Time: 13:30
Sample (adjusted): 1962 2012
Included observations: 51 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 5 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.057421	0.005686	10.09950	0.0000
C(2)	0.106444	0.010540	10.09950	0.0000
C(3)	-0.004557	0.008053	-0.565822	0.5715

Log likelihood	150.5545

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.004847	-0.064177
0.046235	0.018768

Table B.3: LVAR Estimate: Barbados

BARBADOS
Structural VAR Estimates
Date: 09/10/13 Time: 19:29
Sample (adjusted): 1962 2009
Included observations: 48 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 5 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.101867	0.010397	9.797959	0.0000
C(2)	0.061411	0.006268	9.797959	0.0000
C(3)	0.013066	0.014764	0.885043	0.3761

Log likelihood	161.0112

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.004003	-0.042528
0.045413	0.028448

Table B.4: LVAR Estimate: Belize

BELIZE
Structural VAR Estimates
Date: 09/13/13 Time: 13:31
Sample (adjusted): 1962 2011
Included observations: 50 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 5 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.067263	0.006726	10.00000	0.0000
C(2)	0.062787	0.006279	10.00000	0.0000
C(3)	0.009429	0.009559	0.986406	0.3239

Log likelihood	180.7824

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.004568	0.034714
0.045979	0.004634

Table B.5: LVAR Estimate: Dominica

DOMINICA
Structural VAR Estimates
Date: 09/13/13 Time: 13:29
Sample (adjusted): 1979 2012
Included observations: 34 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 6 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.065869	0.007988	8.246211	0.0000
C(2)	0.045953	0.005573	8.246211	0.0000
C(3)	-0.037161	0.012162	-3.055432	0.0022

Log likelihood 101.7451

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.003208	-0.056756
0.050051	0.030015

Table B.6: LVAR Estimate: Grenada

GRENADA
Structural VAR Estimates
Date: 09/13/13 Time: 13:33
Sample (adjusted): 1979 2012
Included observations: 34 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 5 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.046698	0.005663	8.246211	0.0000
C(2)	0.044396	0.005384	8.246211	0.0000
C(3)	0.017677	0.008291	2.132226	0.0330

Log likelihood 112.5677

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.005371	-0.044034
0.048046	0.003836

Table B.7: LVAR Estimate: Guyana

GUYANA
Structural VAR Estimates
Date: 09/13/13 Time: 13:35
Sample (adjusted): 1962 2012
Included observations: 51 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 6 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.289656	0.028680	10.09950	0.0000
C(2)	0.073296	0.007257	10.09950	0.0000
C(3)	-0.110225	0.042003	-2.624235	0.0087

Log likelihood	97.30666

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.001113	0.050493
-0.171914	0.006505

Table B.8: LVAR Estimate: Jamaica

JAMAICA
Structural VAR Estimates
Date: 09/13/13 Time: 13:36
Sample (adjusted): 1968 2012
Included observations: 45 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 5 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.198598	0.020934	9.486833	0.0000
C(2)	0.057297	0.006040	9.486833	0.0000
C(3)	0.008083	0.029617	0.272926	0.7849

Log likelihood	123.5884

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.001119	-0.043822
0.085230	0.019194

Table B.9: LVAR Estimate: St. Lucia

ST. LUCIA
Structural VAR Estimates
Date: 09/13/13 Time: 13:37
Sample (adjusted): 1982 2012
Included observations: 31 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 5 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.024473	0.003108	7.874008	0.0000
C(2)	0.062196	0.007899	7.874008	0.0000
C(3)	0.004808	0.004438	1.083415	0.2786

Log likelihood 103.4377

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.001434	0.070200
-0.029653	5.02E-05

Table B.10: LVAR Estimate: St. Kitts

ST KITTS
Structural VAR Estimates
Date: 09/13/13 Time: 13:36
Sample (adjusted): 1979 2012
Included observations: 34 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 5 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.056433	0.006844	8.246211	0.0000
C(2)	0.060578	0.007346	8.246211	0.0000
C(3)	0.021593	0.010026	2.153675	0.0313

Log likelihood 111.7487

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.000764	-0.038309
0.056923	0.010073

Table B.11: LVAR Estimate: St. Vincent

ST. VINCENT
Structural VAR Estimates
Date: 09/13/13 Time: 13:38
Sample (adjusted): 1962 2012
Included observations: 51 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 5 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.099362	0.009838	10.09950	0.0000
C(2)	0.062796	0.006218	10.09950	0.0000
C(3)	-0.033796	0.014310	-2.361658	0.0182

Log likelihood	155.1299

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.013181	-0.059665
0.039890	0.031542

Table B.12: LVAR Estimate: Suriname

SURINAME
Structural VAR Estimates
Date: 09/13/13 Time: 13:37
Sample (adjusted): 1977 2012
Included observations: 36 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 6 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.764627	0.090112	8.485281	0.0000
C(2)	0.066370	0.007822	8.485281	0.0000
C(3)	-0.068995	0.127697	-0.540304	0.5890

Log likelihood 48.17811

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.012030	0.051358
-0.297092	0.008268

Table B.13: LVAR Estimate: Trinidad

TRINIDAD & TOBAGO
Structural VAR Estimates
Date: 09/13/13 Time: 13:37
Sample (adjusted): 1962 2012
Included observations: 51 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 5 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.121144	0.011995	10.09950	0.0000
C(2)	0.084487	0.008365	10.09950	0.0000
C(3)	0.032211	0.017261	1.866162	0.0620

Log likelihood	136.3705

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.000556	0.039355
-0.102400	0.015866

Table B.14: LVAR Estimate: The United States

UNITED STATES OF AMERICA
Structural VAR Estimates
Date: 09/13/13 Time: 13:38
Sample (adjusted): 1962 2012
Included observations: 51 after adjustments
Estimation method: method of scoring (analytic derivatives)
Convergence achieved after 5 iterations
Structural VAR is just-identified

Model: Ae = Bu where E[uu']=I
Restriction Type: long-run text form
Long-run response pattern:

0	C(2)
C(1)	C(3)

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.076615	0.007586	10.09950	0.0000
C(2)	0.027407	0.002714	10.09950	0.0000
C(3)	-0.024961	0.011009	-2.267293	0.0234

Log likelihood	291.5468

Estimated A matrix:

1.000000	0.000000
0.000000	1.000000

Estimated B matrix:

0.014059	-0.015004
0.006185	0.007104