Working Paper **Draft**

Modelling the Jamaican Business Cycle: A Structural Vector Autoregressive Approach

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May 2007

Abstract
This paper develops an open economy structural vector autoregressive (SVAR) model of the Jamaican economy. The purpose is to identify and disaggregate the main factors that drive the Jamaican business cycle. The model also provides an additional mechanism for the examination of the transmission of monetary policy to effect changes to prices in this small open island state. This paper follows the approach of Cushman and Zha (1997), Dungey and Pagan (2002) and Buckle, Kim, Kirham, McLellan and Sharma (2002) for identifying the impacts of foreign and domestic shocks on a small open economy. A key innovation of this study is the inclusion of a weather variable, which allows for the measurement of the magnitude and duration of its impact on the country's output. Though domestic factors were found to be the main drivers of the Jamaican business cycle, the findings highlight the importance of international variables. Weather proved to be a driver of the business cycle, albeit relatively less important than the other factors. Fiscal policy has a more direct impact on the business cycle than monetary policy conducted through interest rates. The findings suggest that any policy aimed at reducing the amplitude of the business cycle requires policy rules that accurately account for the numerous foreign and domestic channels. Also, policy should include automatic stabilizers to mitigate the impact of weather on the productive sector.

Keywords: Open Economy, Structural VAR models, Business Cycles, Climate, International Linkages

JEL Classification: E32, E44, F44

[†]The views expressed in this paper are not necessarily those of the Bank of Jamaica.

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Tables and Figures

1.0 Introduction

Recessions are defined as periods of sustained decline in economic activity in an economy. There is some debate, however, as to the duration and magnitude of the decline that is required to qualify as a recession. The most popular definition of a recession is two consecutive quarters of output decline. This has, however, come under some criticism, as this definition does not take into consideration changes in other economic variables like unemployment and consumer confidence. To address this problem in the United States of America, the National Bureau of Economic Research (NBER) has come up with a definition that directly addresses this deficiency. Also, using higher frequency, macroeconomic data, they are able to more precisely determine the beginning and end of a recession. The NBER definition is:

> *"A recession is a significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in real GDP, real income, employment, industrial production, and wholesale-retail sales. A recession begins just after the economy reaches a peak of activity and ends as the economy reaches its trough. Between trough and peak, the economy is in an expansion. Expansion is the normal state of the economy; most recessions are brief and they have been rare in recent decades."*[1]

For this exercise, the definition of two consecutive quarters of decline will be used as the measure of a recession. Over the 15-year period 1990 to 2005, Jamaica has experienced seven recessions with five occurring between 1995 and 2001.[2] These recessions were typically short-lived, lasting approximately two quarters, with the longest recession occurring between the June and December quarters of 1997. The most severe recession was experienced between the March and June quarters of 1995 where the economy declined by approximately 2.6% compared to 2.3% over the longest recession.[3] Coincidentally, these two periods coincide with the Bank of Jamaica (BOJ) changing its monetary policy approach to a formal quantum targeting of the monetary base in 1995 and a major financial sector crisis in 1997. These occurrences therefore add to the debate on the causes of booms and recessions in the Jamaican economy, and what is the role of fiscal and monetary policy. Since the fourth quarter of 2001, the country has not experienced a recession. That is the longest period during the sample in which the country experienced no recessions. However, it should be noted that the period was not without incident. In 2003 the country experienced significant instability in the foreign currency market, which necessitated an 815 basis points hike in the interest rate, the highest since 1997, to stabilize the market. The country also experienced three major hurricanes, which caused significant damage to the country's infrastructure and industries resulting in reduced output.

This paper seeks to disaggregate the numerous and complex myriad of impulses that drive the Jamaican business cycle into its measurable structural impulses using a

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[1] NBER definition of recessions from their website http://www.nber.org/cycles/recessions.html

[2] See Figure 2: Domestic Variables, Real GDP

[3] These changes were computed using output data adjusted for seasonality

structural vector autoregression (SVAR) framework. The use of vector autoregressions (VARs) as tools for policy assessment became popular since the seminal work of Sims (1980). Following this paper, some authors like Sargent (1984) and Sims (1986) have debated whether VARs should be utilized for forecasting or policy analysis. Though its forecasting properties have been generally accepted, there are some questions on the appropriate identification method to facilitate policy analysis from the parameter estimates or the impulse response functions. There are essentially two classes of identification methods that have been utilized to recover structural parameters from VARs. One method, popularised by Sims (1986), Bernanke (1986), and Blanchard and Diamond (1989, 1990), places restrictions on the structural parameters based on a priori theoretical knowledge of the interactions of the variables. The other, developed by Shapiro and Watson (1988) and Blanchard and Quah (1989), places restrictions on the long run multipliers in the system to achieve identification.

To sufficiently identify the main impulses that drive the Jamaican business cycle, the model will include an international and a domestic block of variables on the economy. Recent studies on small open economy VARs have highlighted the fact that the inclusion of more foreign variables is critical to the correct identification of the contemporaneous structural interactions of these variables. This is evident from the fact that economic conditions outside of the economy have a greater impact on monetary policy actions in small open economies than larger less open economies. The model will include a weather variable to ascertain the significance and magnitude of the contribution of weather to Jamaican real gross domestic product (GDP) outturn. This richer dynamic specification should provide a greater insight into the transmission of monetary policy through the real economy to inflation.

Jamaica is a small open island economy located in an area prone to extreme weather conditions. Its vulnerability is exacerbated by the fact that agricultural production, tourism, mining and quarrying account for almost 70% of its annual income and these industries are highly susceptible to extreme weather conditions. The need for including a weather variable in models of the economy has become more important due to the increased frequency of the droughts and hurricanes affecting Jamaica over the last five years. During the period 1990 to 2005, the country has been affected by three major hurricanes, which have all occurred between 2001 and 2005.

The rest of the paper is organized as follows. Section 2 presents a stylized description of the monetary transmission mechanism in Jamaica, Section 3 presents a description of the model, Section 4 describes the data utilized in the estimation, Section 5 presents a discussion of the identification and estimation issues, Section 6 discusses the results and Section 7 presents the conclusions.

2.0 Monetary Policy Transmission in the Jamaican Economy

There have been a number of studies on the monetary transmission process in the Jamaican economy. These include Robinson and Robinson (1997) and Allen and Robinson (2004). The main differences between this paper and the previous work are the

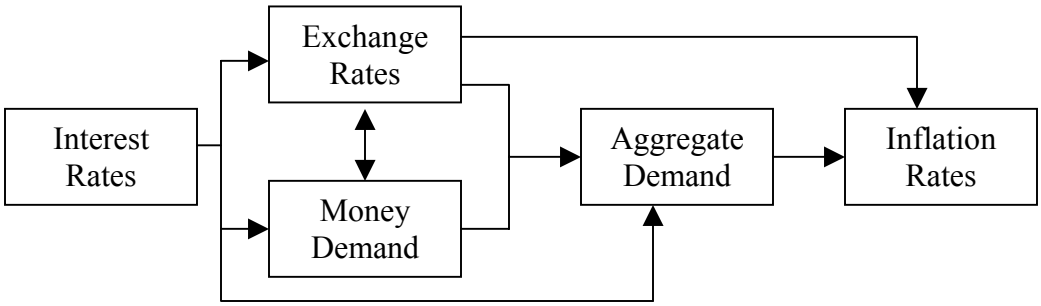
focus of the paper, the variables examined and the methodology. In the previous papers, the focus was the monetary transmission mechanism and its impact on inflation. In this paper the transmission mechanism is one of the factors, which will be examined, that affect the business cycle. The methodologies used in previous papers were mainly structural VARs or large dynamic models with error correction elements. This paper uses an SVAR approach for a relatively large-scale structural model of the economy and applies block exogeneity approach introduced by Cushman and Zha (1997) and Dungey and Pagan (2000) to identify the system. This approach allows for the utilization of impulse response functions to analyse the dynamic impact of exogenous variables on the output of the domestic economy. It will also give a clearer understanding of the relative importance of these variables in driving the business cycle and the inflation dynamics of the country.

There are two main dimensions to the monetary policy operations of the BOJ. The country operates a floating exchange rate. However, due to the susceptibility of the financial markets to numerous exogenous shocks, and the significant impact changes in the exchange rate have on the real economy, the BOJ uses the country's foreign reserves to reduce its volatility. The next channel comes through the use of its 180-day Repurchase Agreements (repos) rates, which investors have widely accepted as the Bank's policy rate. This process is illustrated below in Figure 1.

Changes in the repo rates result in changes in the entire menu of interest rates through the economy, which in turn affects the demand for money balances and credit, while changing the relative return on foreign and domestic assets. The change in the relative return on these assets results in adjustments in the foreign exchange market consistent with expectations from the uncovered interest parity theory. Financial market intervention is occasionally required to ensure that the transition to the new long-run equilibrium is orderly.

The resulting real exchange rate and interest rates then impact aggregate demand and supply of domestic and foreign goods. As the economy's equilibrium output changes relative to the potential output of the economy, there are resulting changes in prices to cause an adjustment of actual output towards potential. Due to the high import content of most of the goods and services in the economy, there is significant pass-through of foreign inflation to the domestic economy through the exchange rate.

Figure 1: Monetary Policy Transmission



3.0 The Model

The model consists of sixteen variables that should capture the main drivers of the Jamaican business cycle. They include foreign and domestic output, prices, interest rates and real asset returns. Import and export prices capture the dynamic price changes between Jamaica and the rest of the world. The domestic variables also include government spending, taxes and a measure of the money stock. The weather variable used in the model is rainfall.

Each variable is analysed in deviations from a long run trend, which is measured by a standard univariate Hodrick-Prescott filter. Therefore the analysis is focused on the deviation of the variables from a long run steady state in keeping with the vast literature on Dynamic Stochastic General Equilibrium (DSGE) models generally used in the modelling of real business cycles. This would make the responses directly comparable to the result of the calibrated general equilibrium model developed by Murray (2005). To obtain forecasts from these models, projections of the permanent component are added to projections of the short run dynamics as is done in the Bank of Canada's Quarterly Projection Model (QPM). In the future, the system could be modelled as a structural vector autoregressive (SVECM) model to fully exploit the information in both the long run and short run dynamics.

The model takes the form of a standard structural VAR specified as

$$B_0 y_t = c + B_1 y_{t-1} + ... + B_p y_{t-p} + \varepsilon_t \qquad (1)$$

where $\varepsilon_t \sim iid(0, D)$. The variables y_{t-i} and ε_t are *k x 1* vectors whilst B_i are *k x k* matrices for *i =0, 1, 2, ... p*. The matrix B_0 is non-singular, with ones on the main diagonal and captures the contemporaneous relationships of the *k* variables in the y_t vector. This contemporaneous relationship makes the estimation of (1) difficult. This estimation problem may be addressed by pre-multiplying the system by B_0^{-1} which gives the reduced form;

$$y_t = \kappa + A_1 y_{t-1} + ... + A_p y_{t-p} + u_t \qquad (2)$$

where $\kappa = B_0^{-1} c$, $u_t = B_0^{-1} \varepsilon_t$ and $A_i = B_0^{-1} B_i$ for *i = 1, 2, ..., p*. It is also assumed that

$$E[u_t u_t'] = E\left[B_0^{-1} \varepsilon_t \varepsilon_t' \left(B_0^{-1}\right)'\right] = B_0^{-1} D \left(B_0^{-1}\right)' = \Omega \qquad (3)$$

i.e. $B_0^{-1} D \left(B_0^{-1}\right)' = \Omega \qquad (3')$

and $E[u_t] = E[B_0^{-1} \varepsilon_t] = 0 \qquad (4)$

As the regressors of (2) are all predetermined and the residuals are ergodic, it can be estimated consistently and efficiently by maximum likelihood.

Equation (2) can be rewritten

$$A(L)y_t = \kappa + u_t \qquad (2')$$

where $A(L) = I_n - A_1 L - ... - A_p L^p$.

The structural innovations and parameters in (1) can be found from (2) if an appropriate identification method can be found for the system. The identification method entails placing zero restrictions on the B_0 matrix based on theoretical assumptions of the contemporaneous interactions of the variables. With the orthonormality restriction on structural innovations, the left-hand-side of (3') has $n(n + 1)$ parameters to be estimated using the $n(n + 1)/2$ parameters on the right-hand-side. Normalizing the main diagonal elements of B_0 to ones means that the system requires at least $n(n - 1)/2$ restrictions for identification.

All the variables in the system therefore have a structural equation and an associated error term. These error terms are interpreted as shocks or innovations of that variable on the system. This structure has two main advantages. The system is able to provide insights into the dynamic response of domestic output to a 'weather shock' or 'foreign shock' through the use of impulse response functions. Also, since all variables are endogenous by construction, the system can therefore provide forecasts without the need for assumptions.

4.0 The Data

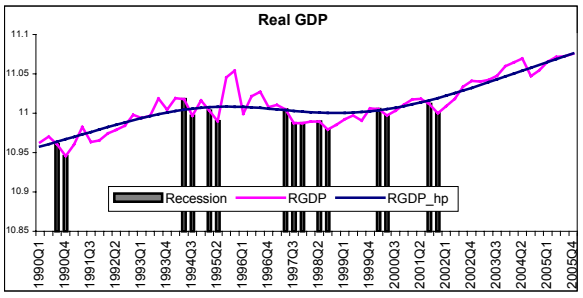
The data utilized in this study are quarterly data over the period 1990 to 2006, with the estimation period being 1990 to 2005. The United States of America is used as the proxy for the foreign economy as this is Jamaica's country's closest, and main trading partner. Output in both economies is measured using the real Gross Domestic Product (GDP). Interest rates are measured as the 180-day Treasury bill rate. Wealth in the economies is measured using the stock market indexes, the Dow Jones Industrial Average (DJIA) and the Jamaican Stock Exchange (JSE) index. Price changes are measured using the Consumer Price Index (CPI) for each country. Fiscal policy in the Jamaican economy is measured as the ratios of taxation and government consumption to GDP. Other domestic variables include the stock of money (M2), the nominal exchange rate calculated as Jamaican dollars per US dollar, a measure of the opportunity cost of money calculated as *h2 = (bm/m2)*tbill* and rainfall. Indices of the price of Jamaican imports and exports are included to capture the impact of international trade on the Jamaican economy. Table 1 below shows the list of variables and their symbols.

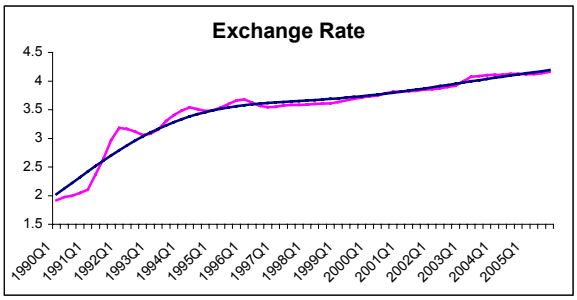
Table 1:Variables

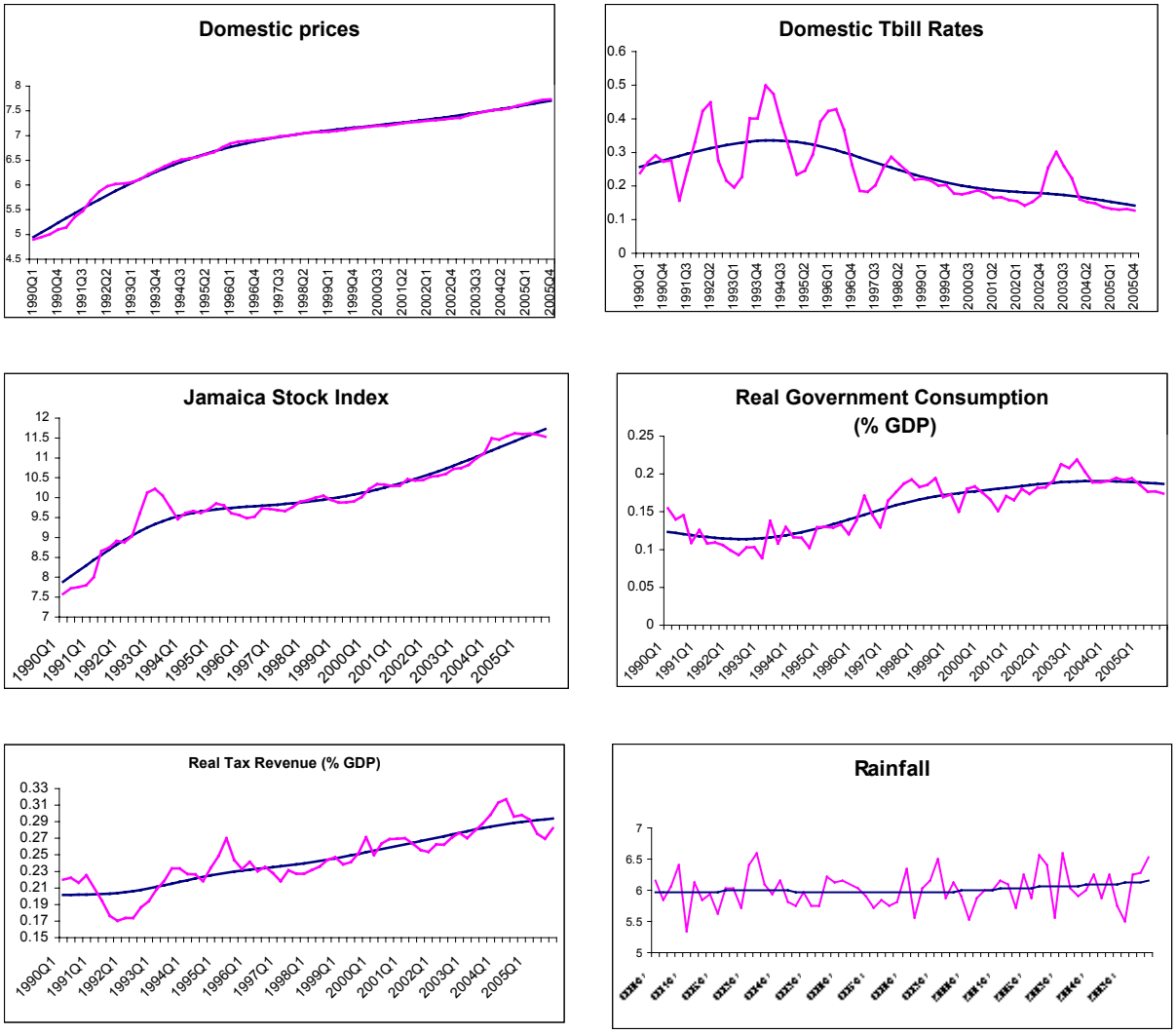
	Symbol	Variable
1	y_t^*	Foreign output (GDP)
2	i_t^*	Foreign nominal interest rates
3	q_t^*	Foreign assets (Dow Jones Industrial Average)
4	p_t^*	Foreign price levels (consumer price index (CPI))
5	px_t^*	Foreign price of Jamaican exports
6	pim_t^*	Foreign price of Jamaican imports
7	s_t	Nominal exchange rate
8	m_t	Money stock (M2)
9	y_t	Domestic output
10	p_t	Domestic price levels (consumer price index (CPI))
11	i_t	Domestic nominal interest rates
12	q_t	Real returns on equities (JSE)
13	T_t	Real Tax revenue
14	g_t	Real government spending (wages, salaries and programmes)
15	w_t	Weather variable
16	$h2_t$	Opportunity cost of money

Figure 2 graphs the domestic variables around their long-run trends. The real GDP graph shows the number of recessions that occurred over the review period. The first recession occurred in the third quarter of the calendar year 1990 and the last occurring in the forth quarter of 2004. All domestic variables display similar long run patterns except for taxation and rainfall. The interest rate path seems the most 'sticky' of the variables and seems to display a strong correlation with the movements in the exchange rate and the stock market index. There seems to be a positive correlation between the long-run patterns of real GDP and rainfall.

Figure 2: Domestic Variables

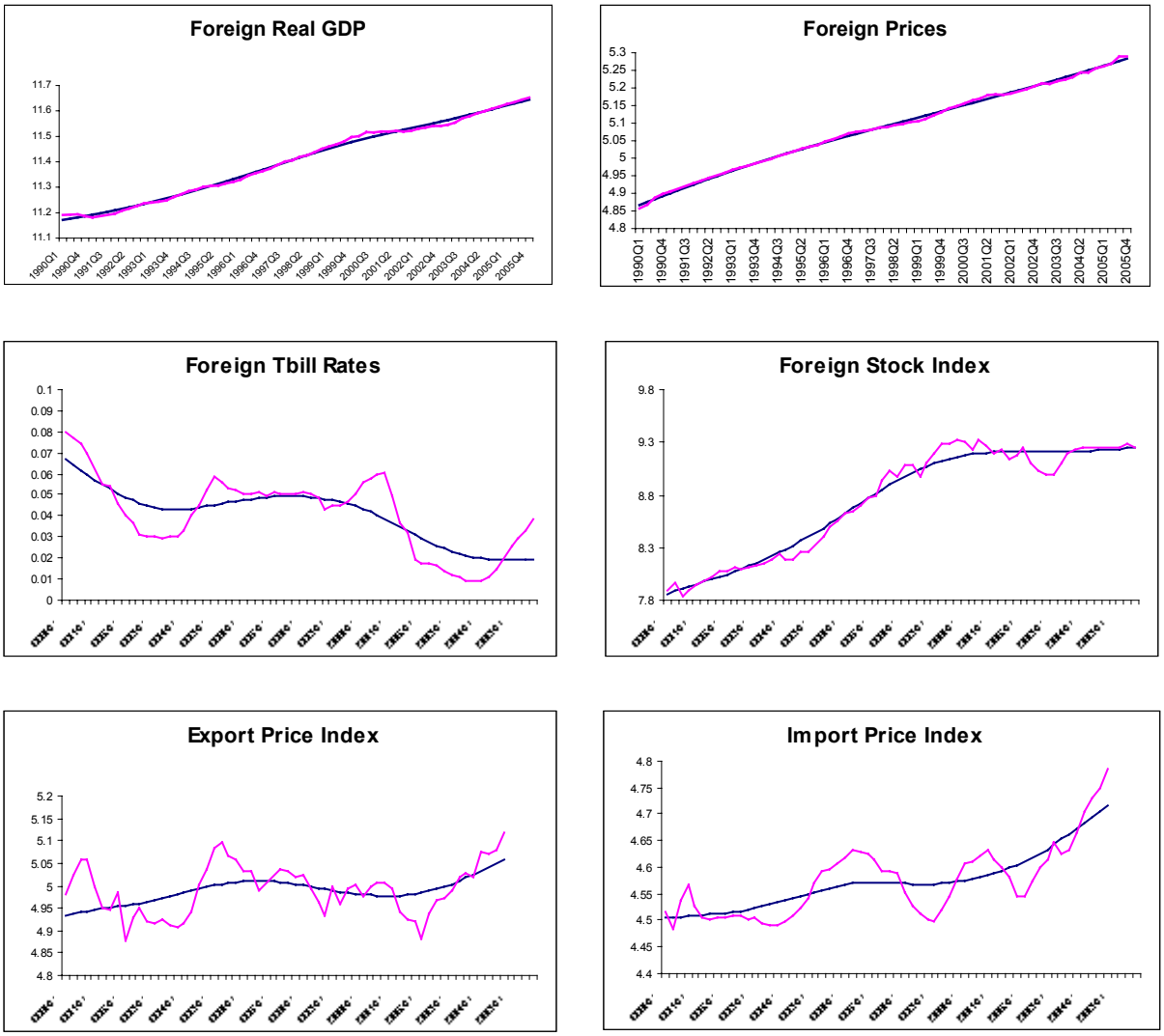






The international variables are shown in Figure 3. Foreign output and prices show strong positive correlation in the long-run patterns. As in the case of Jamaica, the foreign interest rates again seem to display the most "stickiness" of the variables over the sample period. Interestingly, the foreign and domestic price index seems to display a very strong positive correlation in their long-run adjustment patterns. This highlights the small open economy assumption of the Jamaican economy that both import and export prices are externally determined.

Figure 3: Foreign Variables

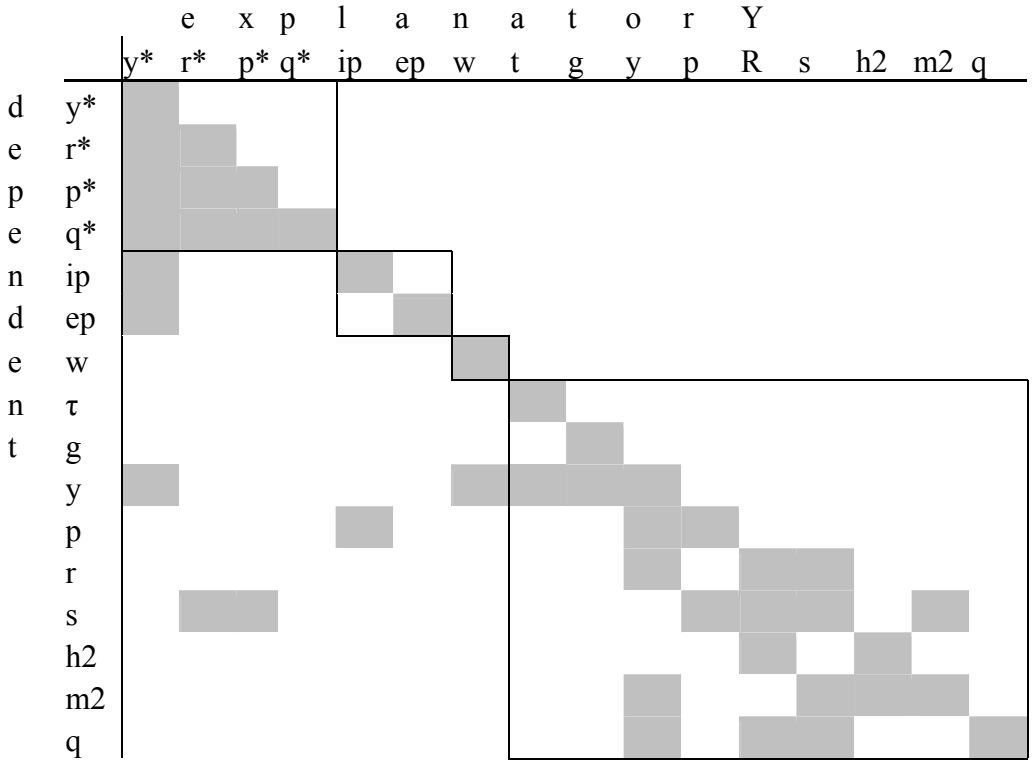


5.0 Identification and Estimation

Estimating the model requires specification of appropriate block exogeneity restrictions, consistent with theoretical assumptions of the contemporaneous interactions of the variables. It is also required that there are enough restrictions applied to identify the structural innovations.

Table 2 summarizes the contemporaneous restrictions in the matrix B_0. It also illustrates the four blocks in the system. The international economic block is identified in the top left-hand corner. The international prices are next, followed by the weather block. The bottom right hand corner contains the domestic block. Each row represents the dependent variables and each column the explanatory variables. There are 212 unshaded cells, which represent zero restrictions on the contemporaneous interactions. The sixteen variable system requires at least 120 restrictions for identification, thus the system is over identified.

Table 2: Contemporaneous variable restrictions



One lag was selected for estimating the system based on the Schwartz information criterion (SIC). This criterion was chosen for reasons of parsimony, as there are a large number of parameters to be estimated from a relatively small data set. The criterion was not tested for the entire system, but done for the domestic and international blocks separately as seen in Table 3.

Table 3: Lag length Criteria Tests

Domestic

Lag	**Ln(*L*)**	**LR**	**AIC**	**SIC**	**HQ**
0	796.074	NA	-26.038	-24.102	-25.286
1	939.843	211.871	-29.819	-26.593*	-28.565
2	1011.145	90.065	-31.058	-26.541	-29.303*
3	1060.976	52.454*	-31.543*	-25.737	-29.286

Foreign

Lag	**Ln(*L*)**	**LR**	**AIC**	**SIC**	**HQ**
0	738.441	NA	-24.080	-23.942	-24.026
1	888.879	276.213	-28.488	-27.796*	-28.217

2	912.372	40.055*	-28.734*	-27.488	-28.245*
3	926.168	21.7111	-28.661	-26.862	-27.956

Notes:
(a). Indicates lag order selection by criteria at 5% level for the, Akaike information criterion (AIC), Schwarz information criterion (SIC) and the Hannan-Quinn information criterion (HQ).
(b) The information criterion are calculated as follows: AIC = -2ln(L)/T+2k/T, SIC= -2ln$L$/T+kln(T)/T and HQ = -2ln$L$/T+2kln(T)/T

5.1 International Economic Block

The international block is modelled similar to Buckle, Kim, Kirham, McLelland and Sharma (2002). It includes the real output, interest rate, price levels and stock index for the US. Jamaica purchases and sells a significant proportion of its goods and services to the US and therefore changes in the output of the US will have a direct contemporaneous impact on the Jamaican economy. The BOJ holds its reserves in US dollars and uses this exchange rate as the target rate to measure instability in the foreign currency market. Due to the link between the US and Jamaican goods and financial markets, with the US economy being the dominant player, domestic prices, exchange rate and monetary policy will depend on changes in the prices and interest rates in the US economy. The DOW Jones industrial average is a measure of wealth in the US economy and could reflect the propensity for investments and consumption from the Jamaican economy.

The contemporaneous structure of this is specified similar to a Cholesky decomposition with ordering of the variables from first to last being output, interest prices and the stock index. The residuals from these equations will then be able to provide insights into the importance of shocks of these foreign variables to the Jamaican business cycle.

5.2 International Prices Block

The transmission of prices of goods and services between the two economies is captured in the import and export price indices. Import prices are extremely important to the Jamaican economy, as the country's imports are almost equal to its total output. Also, its size makes it a price taker in all markets and hence changes in international prices are filtered directly into the economy. Since 2003, there has been some instability in many of the oil producing countries of the Middle East and Africa. As Jamaica imports all of its petroleum products and does not have significant consumption of alternative fuels, understanding its impact on the economy will be critical to future forecasting and policy exercises. The changes in international fuel prices will have a direct and large impact on Jamaica's import price index. Due to the size of the Jamaican economy, most of its goods and services exports are not priced in the domestic currency. It is therefore unclear what impact changes in the export prices will have on the domestic economy.

The contemporaneous specification states that import and export prices are determined by foreign output and its own lagged values as in Buckle, Kim, Kirham, McLelland and Sharma (2002).

5.3 Weather Block

The weather block consists of the inches of rainfall recorded in Jamaica in each quarter over the sample period. The inclusion of this variable in the SVAR is due to the fact that almost 70 per cent of the country's national income is derived from agriculture, mining and quarrying and tourism. These industries are all highly susceptible to climatic conditions. Jamaica's location in the Caribbean Sea is in a corridor that faces a high probability of exposure to Atlantic Ocean tropical cyclones during the June to September months. The area is also susceptible to extremely dry weather conditions between January and May.

In 2003, the country experienced some of the worse drought conditions in recent history, which was followed by three hurricanes between 2004 and 2005. Inflation outturns during these periods were much higher than all forecasts. In contrast, the calendar year 2006 experienced unusually favourable weather and the inflation outturn was the lowest in three decades, well below that year's projections. This sparked a debate on the need for the incorporation of weather in any credible forecasts of inflation and output. Also, discussions on sustainable development now include policies that mitigate the impact of weather on key industries.

Weather is an exogenous variable. However, the model's structure allows for the residuals from the weather equation to be used to ascertain the impact of weather on output and inflation in the economy. It will therefore provide much more information for forecasting the main macro economic variables in the economy.

5.4 Domestic Economy Block

The domestic block in the economy consists of the main real and nominal variables that are the focus of macroeconomic policy. The structure therefore allows for the examination of the impact of a number of external exogenous variables as well as domestic policy variables on the domestic economy. Due to the open nature of the economy and the expected impact of a large dominant trading partner, this rich formulation is key to tracing the impact of domestic policies on the economy. In particular, changes in domestic nominal variables will have a direct impact on the domestic real variables. However, these changes will also result in adjustments in the relative prices and the demand for foreign goods, which will in turn have an impact on the domestic economy.

The real variables included are real output (y_t) and the ratios of government spending to output (g_t) and taxation to output (τ_t). Nominal variables include price level (p_t), interest rates (r_t), nominal exchange rates (s_t), the opportunity cost of holding money, nominal money stock ($m2_t$) and the nominal index of stock returns (q_t) as a measure of wealth.

The contemporaneous specifications state that domestic output is determined by foreign output, fiscal policy stance and weather. The price specification is a backward-looking open economy Phillips curve where prices are determined by deviations of the country's output from potential, imported prices and lagged inflation. Interest rates are set by a

backward-looking Taylor rule similar to the specification in Murray (2005). The rule sets nominal interest rates based on the output, exchange rate and price deviations from a long-run equilibrium. Exchange rate is determined by purchasing power parity (PPP), uncovered interest parity (UIP) and a domestic money stock variable to capture foreign exchange market intervention by the BOJ.[4] The opportunity cost of money is directly related to interest rates. Money is specified as a Cagan money demand, which is a function of income/output, opportunity cost of money, exchange rate and lagged values of money. The wealth measure (q_t) is specified to depend on the income/output level and the opportunity costs associated with holding wealth in this form. These costs are interest rate and exchange rate changes.

6.0 Results

6.1 Foreign Output Shock

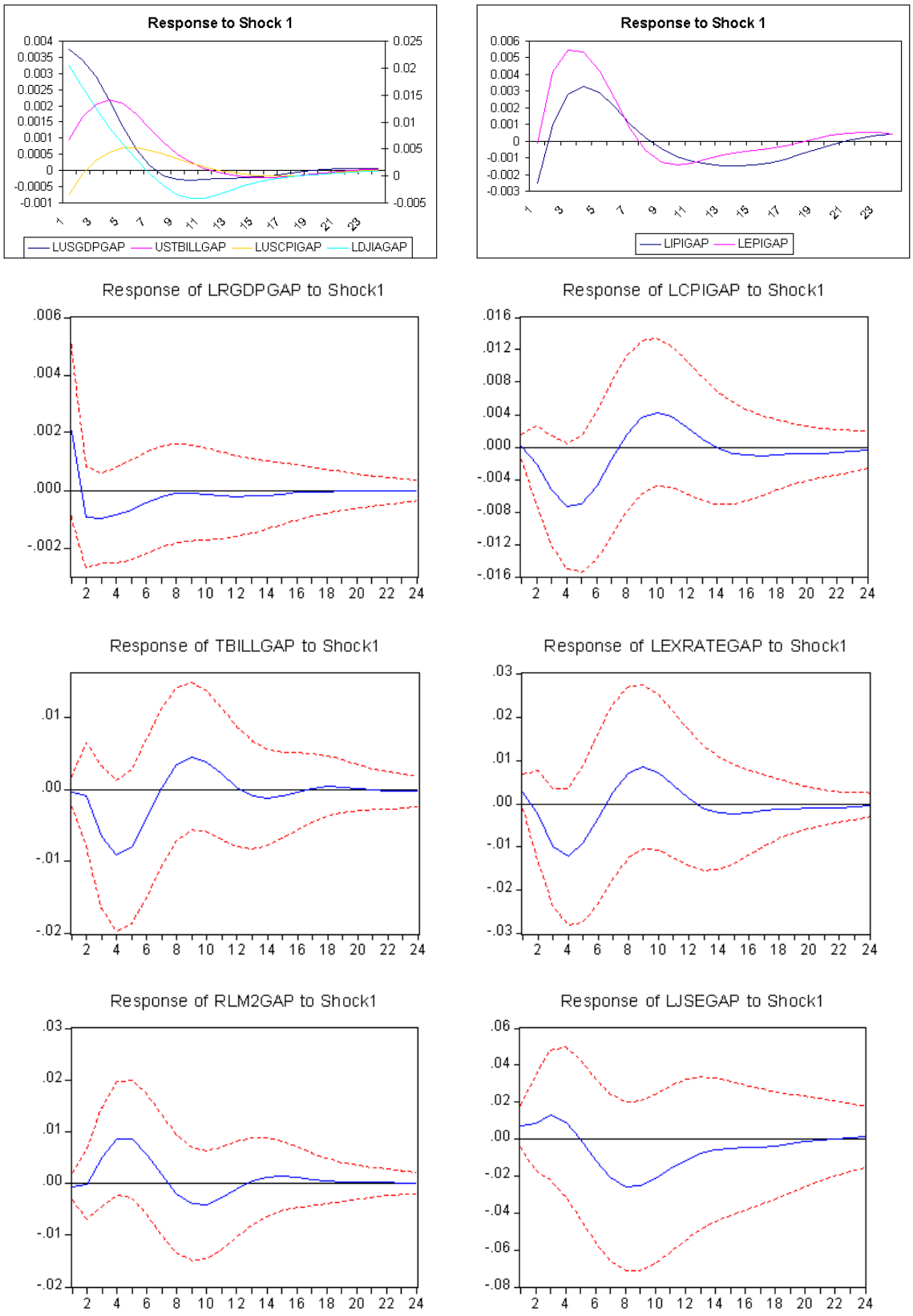
A positive output shock of a foreign economy is expected to have a positive impact on the output of the smaller domestic trading partner. Figure 4 shows the impact of such a shock on the smaller, Jamaican economy. The immediate impact of the shock is a rise in foreign wealth, and foreign interest rate and a fall in foreign prices. Foreign prices increases after approximately 3 quarters whilst wealth declines after approximately 8 quarters. The economy returns to its steady state after approximately 4 years. The dynamic response of the economy captures the response of the monetary authorities to reduce the inflationary impact of the increased output on the economy. Interest rates are immediately increased in order to restrict the growth in demand and hence inflation. Interest rate increases are gradual to match the pattern of price increases. The interest rate peaks after approximately 5 quarters whilst price peaks after approximately 6 quarters.

The import and export price indices follow a similar pattern of response to the foreign output shock. Both fall initially, though the magnitude of the decline is greater for imported prices. Prices then gradually increase to peak after approximately 4 and 5 quarters respectively, for export and import prices. This pattern is in keeping with a small economy in which both imports and exports are priced in the currency of the larger country.

The impact on the domestic economy is an immediate increase in domestic output and wealth. Surprisingly, output then falls in the second quarter and continues to decline for approximately 8 quarters. This may be due to the net impact of the changes in import and export prices on the import and export quantities of the domestic economy, causing domestic output to decrease. This decrease in output causes a fall in domestic prices. The domestic exchange rate initially increases in response to the foreign rate adjustment, but subsequently falls due to the price differential in foreign and domestic prices. The nominal variables interest rates, prices and exchange rate all follow a similar pattern of decline before returning to a steady state after approximately 14 quarters.

[4] Increasingly, theoretical and empirical models of small open economies have had to account for the multiple policy strategies pursued by central banks in these economies. See Escudé (2006)

Figure 4: Response to Foreign Output Shock



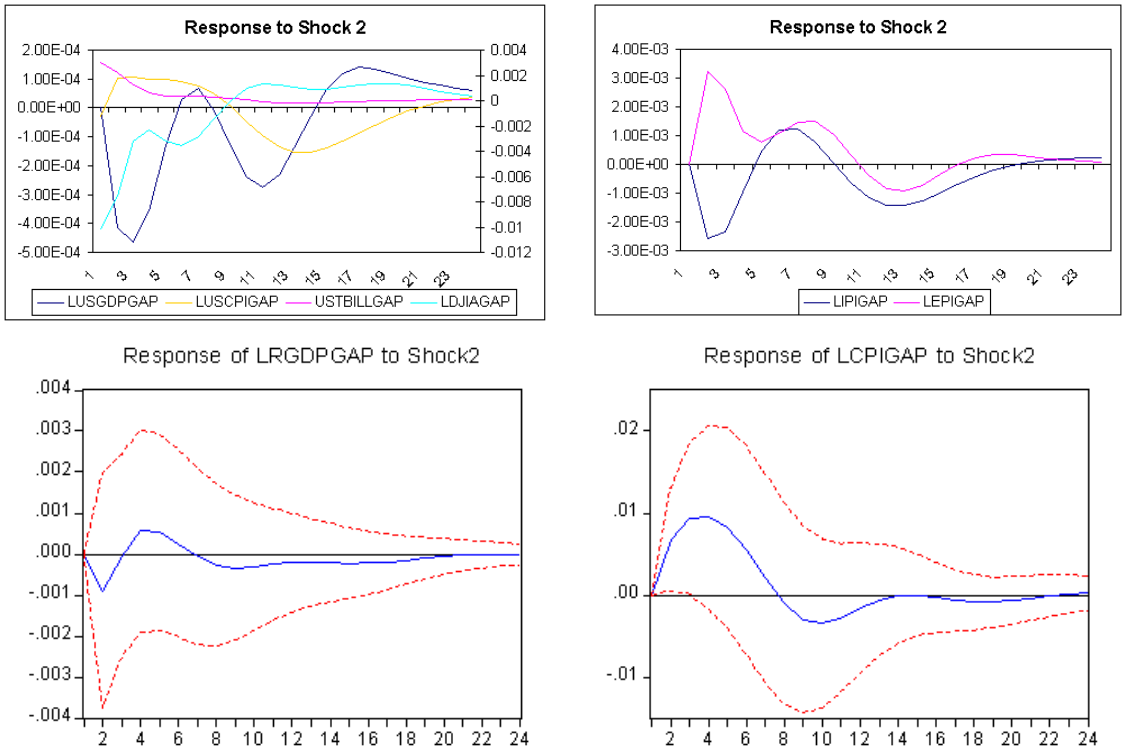
Note: The secondary (right hand side) axis in the first impulse response is for the DJIAGAP

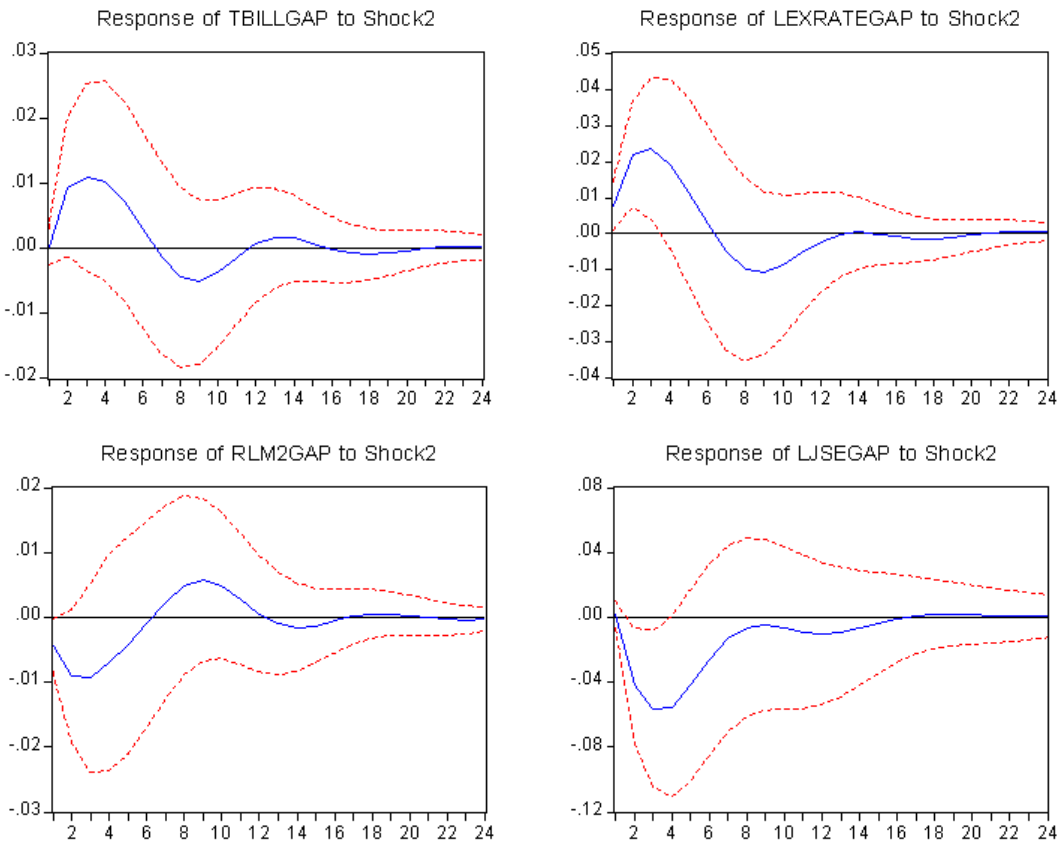
6.2 Foreign Interest Rate Shock

A positive foreign interest rate shock results in an immediate decrease in foreign wealth. Foreign output gradually declines while prices rise, reaching their respective maximum declines and increases in about the third quarter. The impact on these variables dissipates after approximately 24 quarters. The initial impact of this shock causes import prices to gradually fall due to the fall in foreign prices, while export prices rise due to the depreciation of the domestic currency. This continues for three quarters, then the import prices begin to increase while the export prices gradually falls until the 7th quarter where both import and export price dynamics become dominated by the foreign price dynamics.

The impact on domestic output is short lived as output initially falls in the first quarter following the shock, before rising in the next two quarters. After approximately 8 quarters, the impact on output is negligible. The interest rate shock causes an initial depreciation of the domestic currency. This depreciation triggers gradual increases in domestic prices and interest rates until the fourth quarter. They then decrease until the 9th quarter before returning to a long run steady state after approximately 14 quarters. The demand for money again mirrors this pattern. The wealth in the domestic economy follows the pattern of the domestic output though the impact of the foreign interest rate seems to have a more prolonged impact on domestic wealth than on domestic output.

Figure 5: Response to Foreign Interest Rate Shock





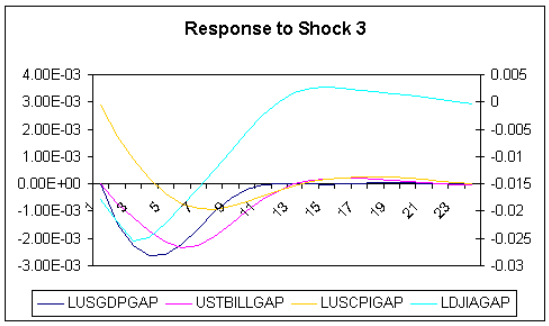
Note: The secondary (right hand side) axis in the first impulse response is for the DJIAGAP

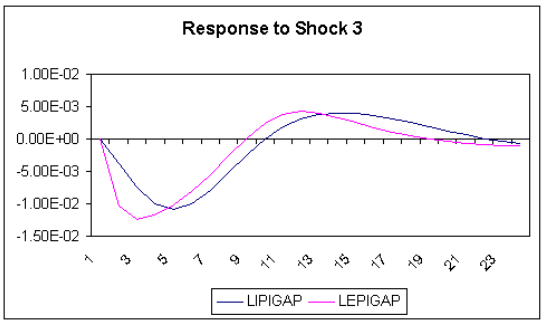
6.3 Foreign Price Shock

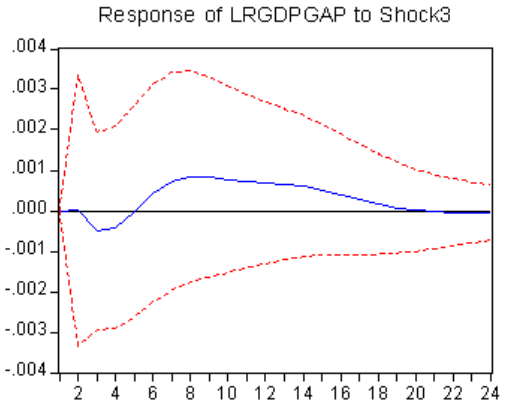
A positive shock to foreign prices results in gradual reductions in foreign output, interest rates and wealth. This fall in foreign output and interest rates may indicate that the increased prices result in reduced demand for foreign products and therefore the monetary authority reduces foreign interest rates to boost foreign demand and hence foreign output. The fall in foreign output, wealth and interest rates continue until the 5th, 4th and 7th quarters respectively before gradually returning to the steady state equilibrium in the 13th quarter. Interestingly, instead of increasing, the import and export prices follow a pattern of decline similar to the foreign output and interest rate.

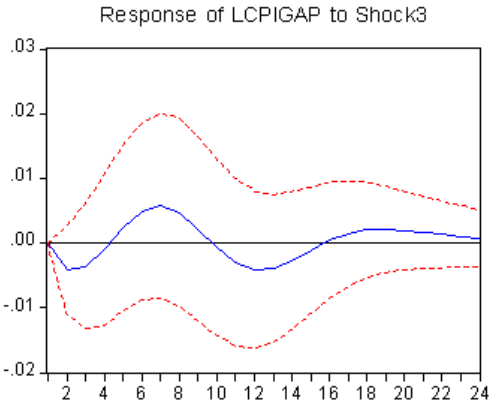
Output in the domestic economy is initially unaffected until the 3rd quarter when it declines. The declines continue into the 4th quarter then output increases until the 18th quarter. This increased output results from the positive impact of the fall in import prices outweighing that of the fall in export prices until the 14th quarter when the domestic output gradually returns to its long run equilibrium. The net impact of the foreign price increase and foreign interest rate decrease is an initial appreciation of the exchange rate. This appreciation results in reductions in domestic prices and interest rates. The domestic nominal variables prices, interest rates, exchange rate, money and wealth follow a pattern of negative and positive adjustments until the 20th quarter.

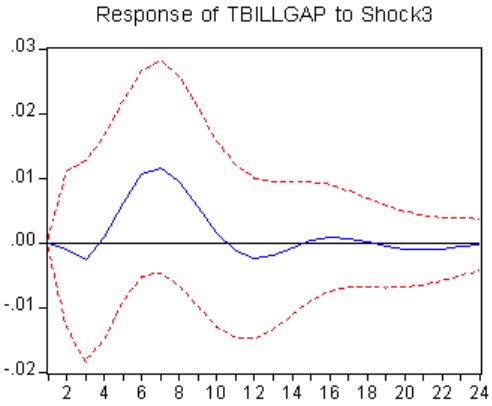
Figure 6: Response to Foreign Price Shock

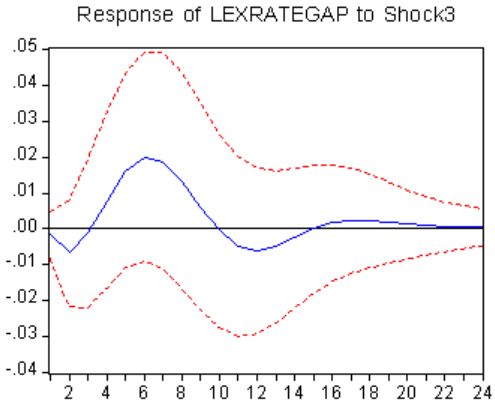


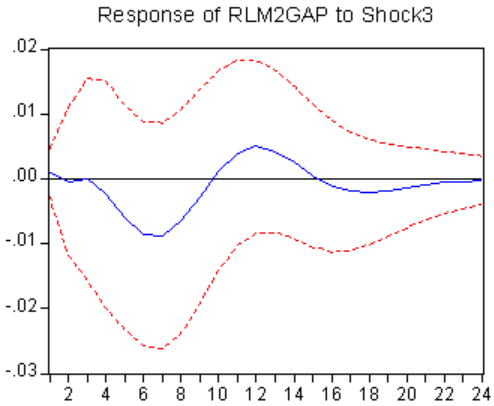


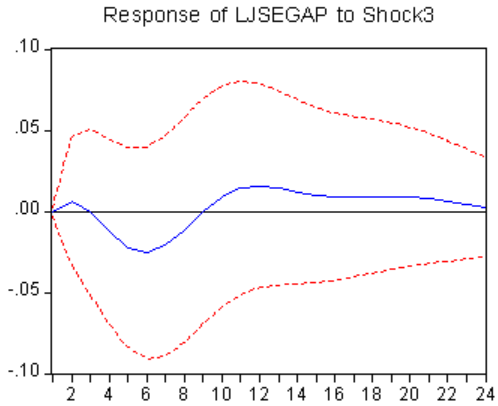










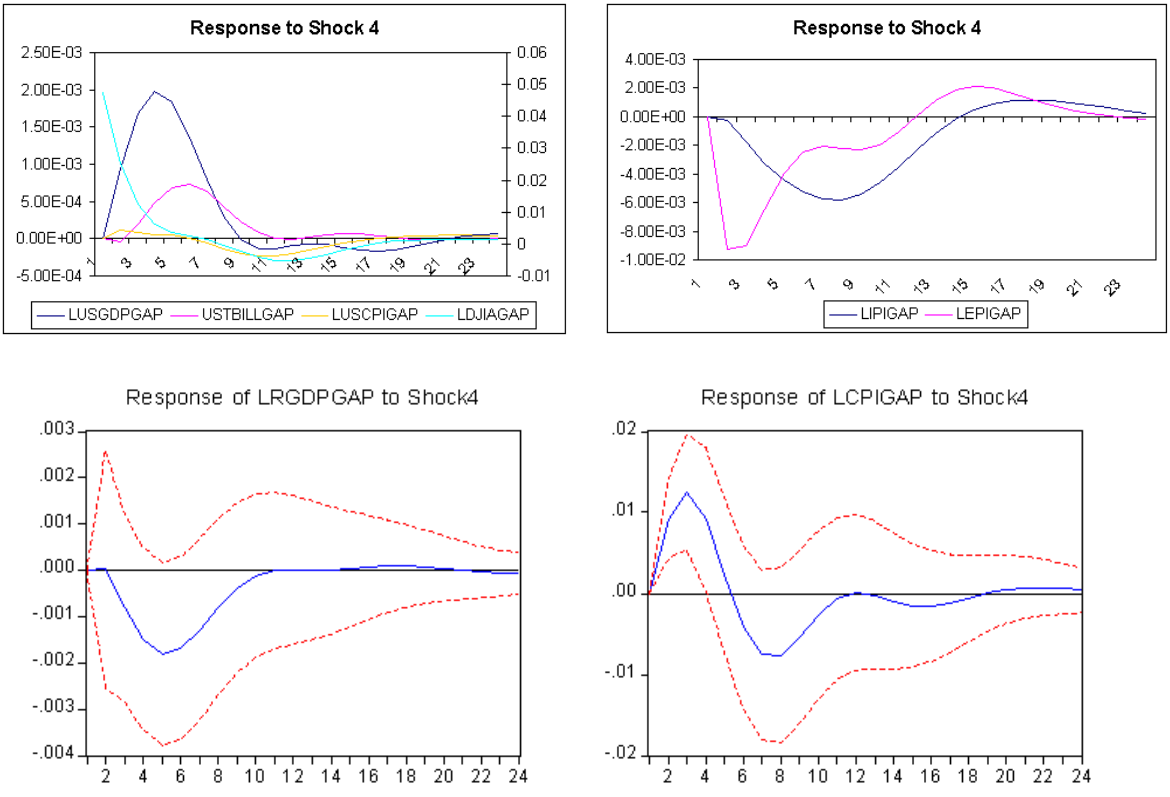


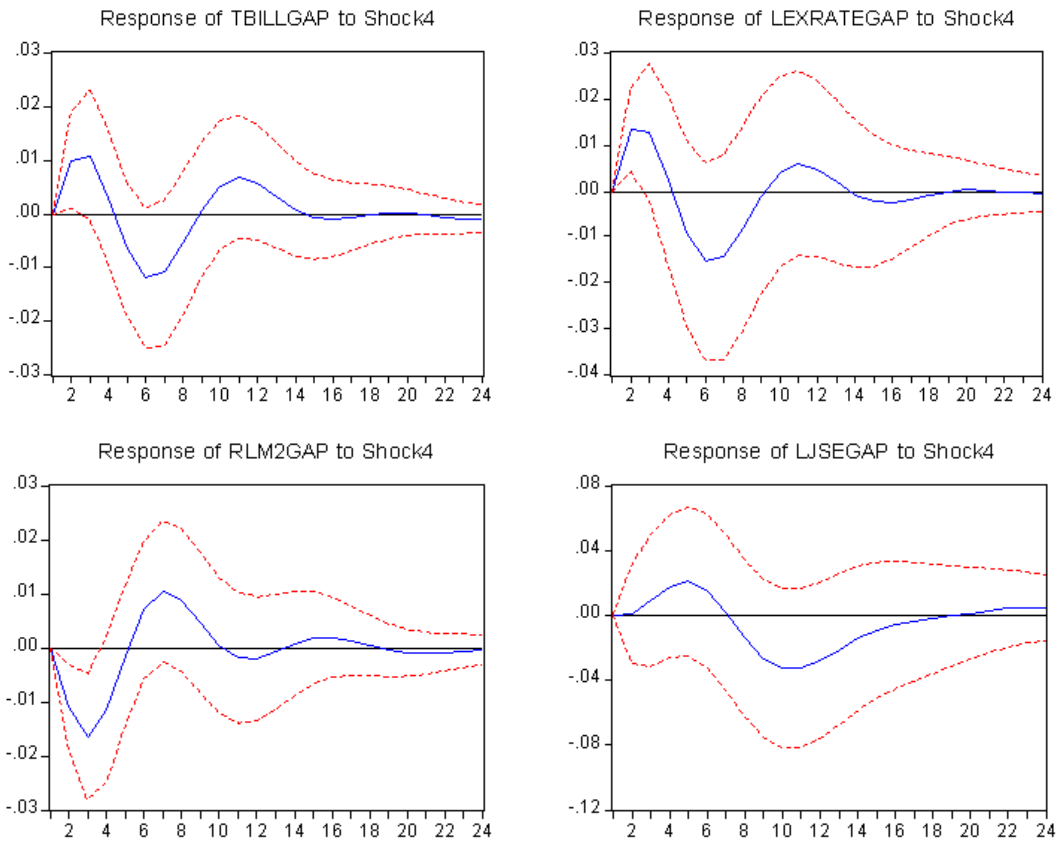
Note: The secondary (right hand side) axis in the first impulse response is for the DJIAGAP

6.4 Foreign Wealth Shock

A positive shock to foreign wealth leads to gradual increases in foreign output and inflation. Foreign nominal interest rates decline marginally, initially before rising to reduce the inflationary impact of the increase in output. The increases in output coupled with low inflation leads to a reduction in both the import and export prices of the domestic country as foreign prices fall and demand for domestic goods decrease. Anticipation of the increases in foreign interest rate and low inflation triggers a depreciation in the domestic currency. Depreciation of the exchange rate results in increases in prices and interest rates while money and wealth decrease. Domestic output falls as a result of the net impact of the import and export prices on the domestic trade balance. Surprisingly, the foreign wealth shock does not benefit the domestic economy.

Figure 7: Response to Foreign Wealth Shock





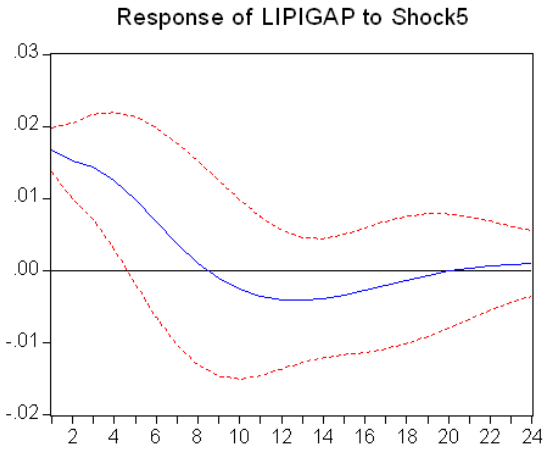
Note: The secondary (right hand side) axis in the first impulse response is for the DJIAGAP

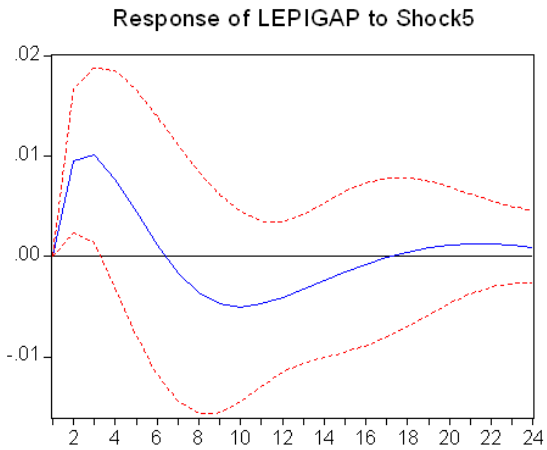
6.5 Import Price Shock

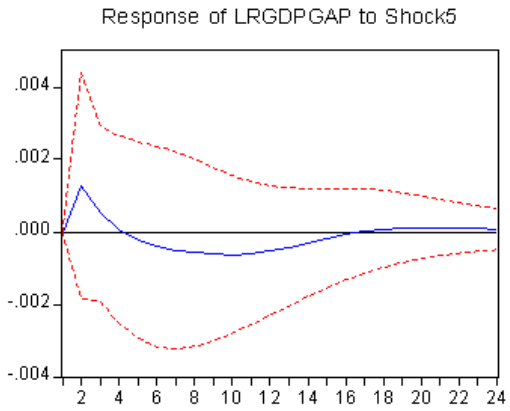
A positive impulse to import prices results in a gradual increase in export prices, which peaks after approximately 4 quarters. This would indicate that the exports of the domestic economy have a high import content. Domestic output increases initially as the initially price changes could have a positive impact on the trade balance. Subsequently, output decreases for approximately 12 quarters before returning to a steady state equilibrium.

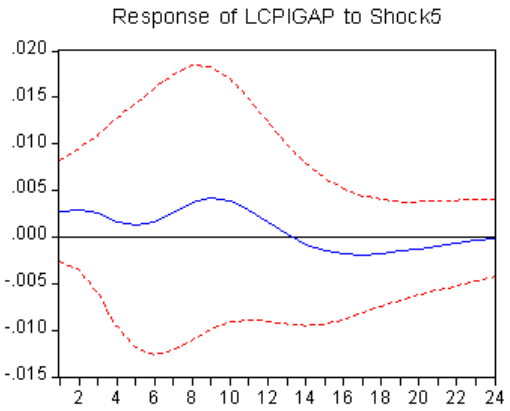
Inflation responds immediately to the import price shock with price increases lasting approximately 13 quarters before a period of price corrections which last for an additional 11 quarters. The exchange rate responds with an initial depreciation followed by a sustained period of appreciation as the current account adjusts to the imbalance created by the changes in import and export prices. Output and inflation increases and the monetary policy response seem pro-cyclical as interest rates decrease. This response may explain the sustained impact on domestic prices.

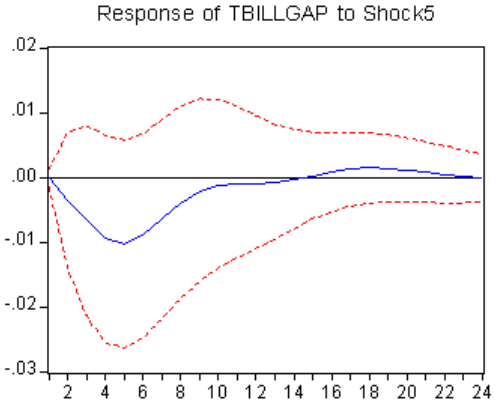
Figure 8: Response to Import Price Shock

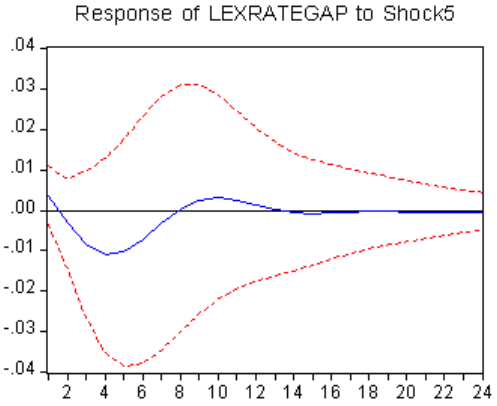


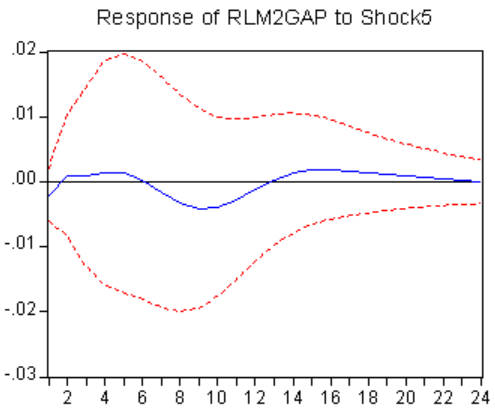


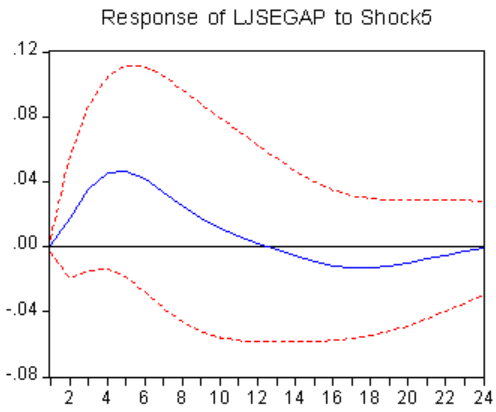








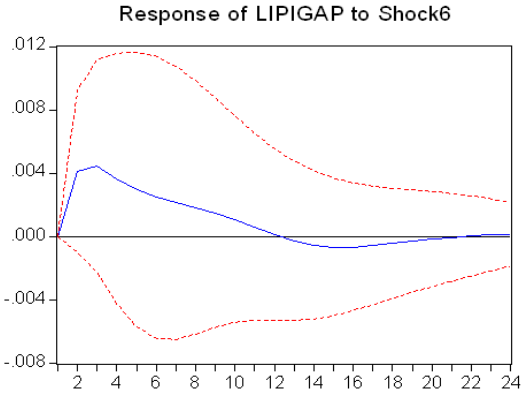


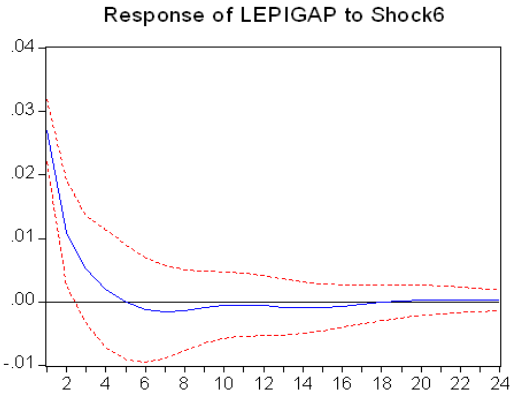


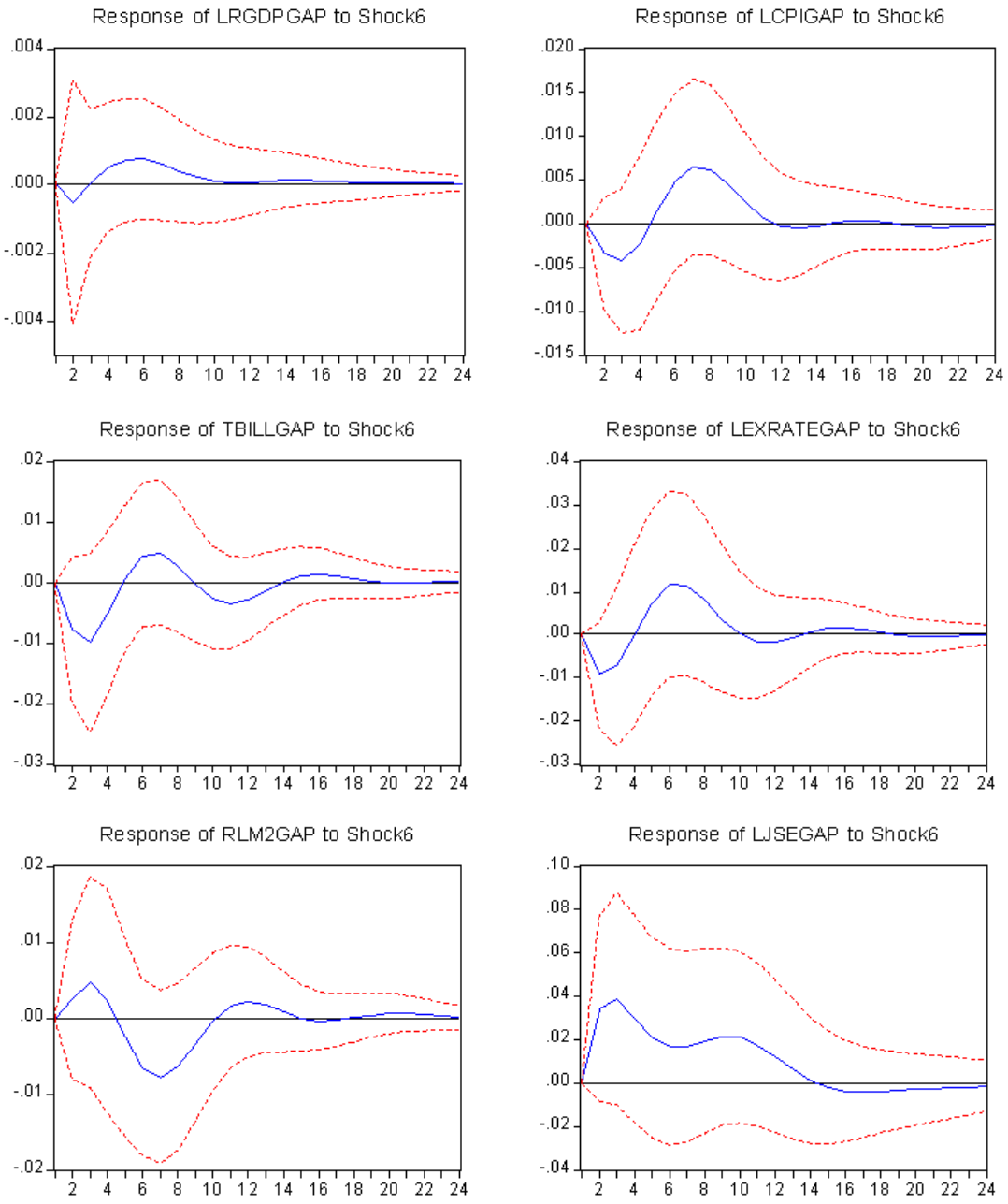
6.6 Export Price Shock

A positive export price impulse results in increases in export prices for approximately 5 quarters. Import prices also increases, but the impact lasts approximately 12 quarters. The net impact of the import and export prices on the trade balance is an initial decrease in output for the first 3 quarters. Output then increases for the next 7 quarters. The output dynamic results in an initial fall in domestic prices over the first 4 quarters followed by price increases for the next 7 quarters. T-bill and exchange rates follow the pattern of price changes, with money demand mirroring these results. Wealth increases for 14 quarters with the rate of increase peaking in the 3rd quarter as a result of the increased earnings from exports, and the substitution effect from the initial interest rate reductions in the first four quarters.

Figure 9: Response to Export Price Shock







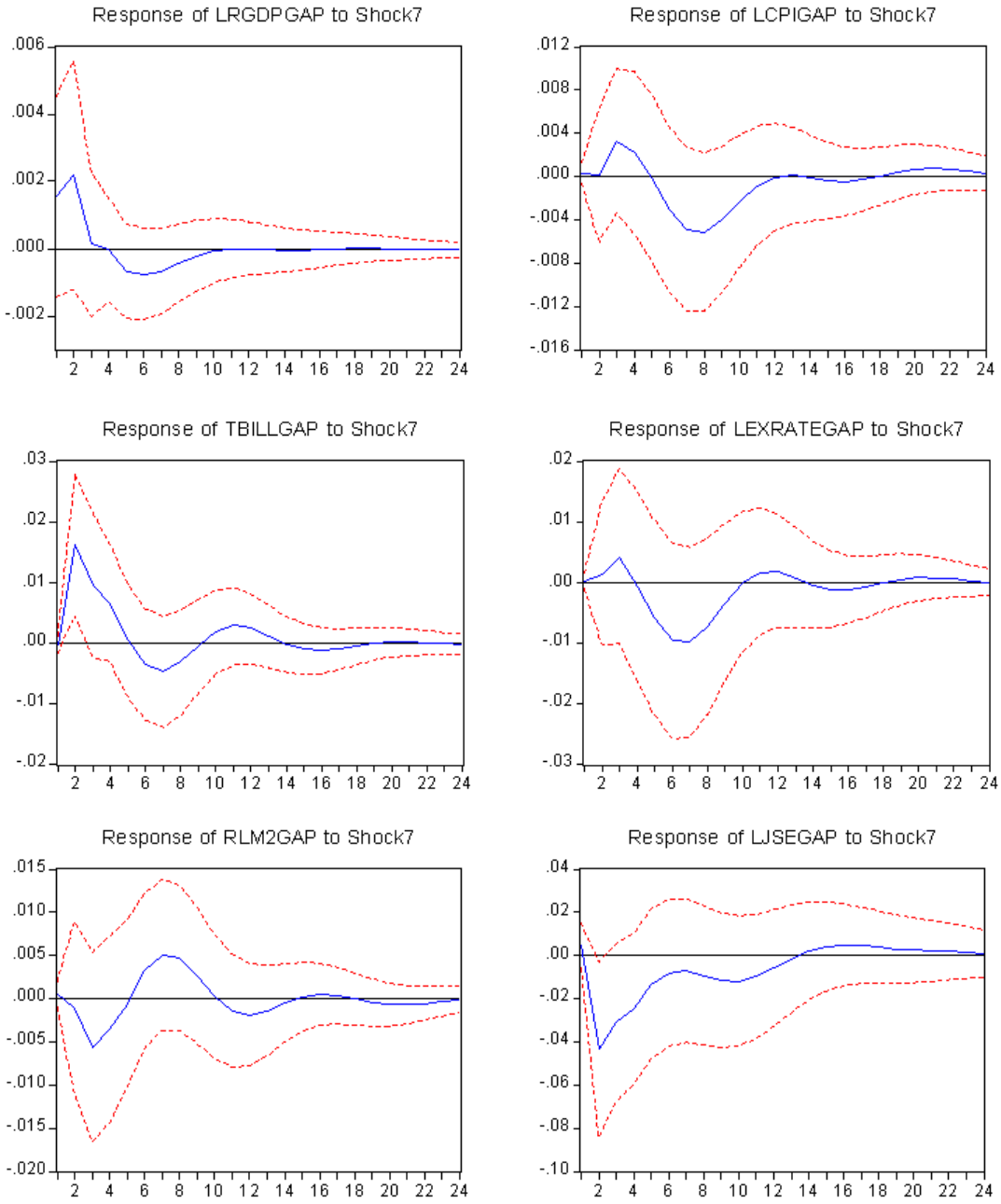
6.7 Weather Shock

The impact of a positive weather impulse on the domestic economy is an immediate increase in output, which peaks after two quarters. [5] This is followed by decreases in output between the 4th and 8th quarters until the economy returns to its long run equilibrium. The impact on prices is lagged as increases begin after 2 quarters and lasts

[5] A positive weather impulse refers to rainfall greater than normal levels. This measure does not abstract from hurricanes and floods, which typically result in initial declines in output but are usually followed by a recovery period of above normal output.

until the 6th quarter. Prices then decline, then gradually returns to a steady to a steady state in the 12th quarter. Monetary policy responds by increasing interest rate in the second quarter to minimize the effect on inflation and exchange rate. In keeping with a priori expectations, the stock market response mirrors the dynamic response of the interest rate.

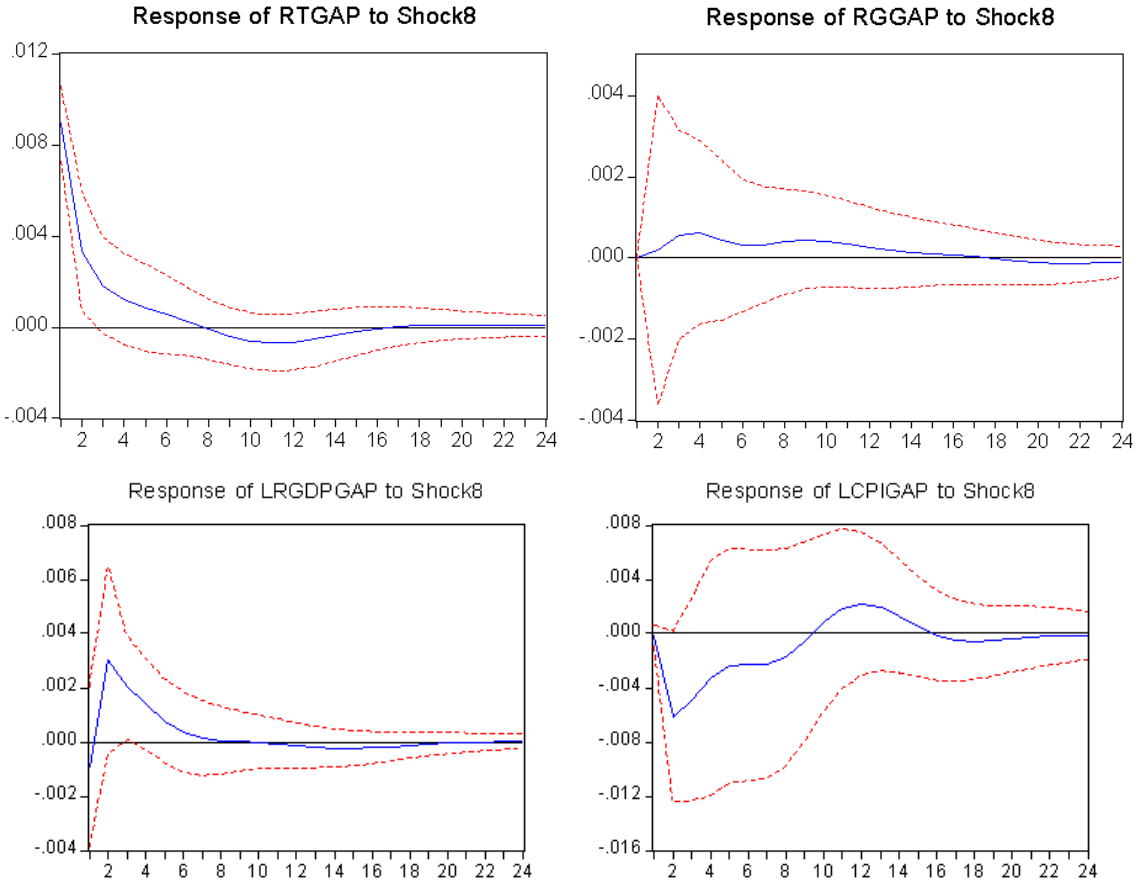
Figure 10: Response to Weather Shock

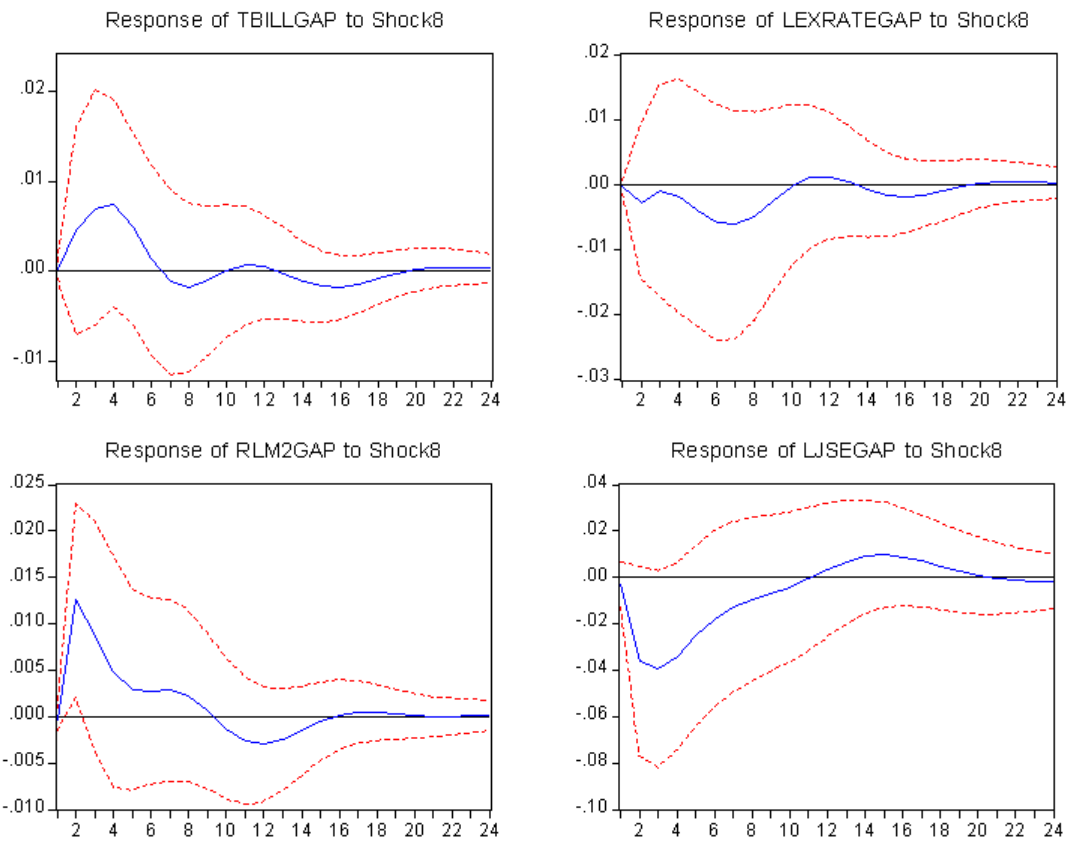


6.8 Tax shock

In keeping with expectations, a positive shock to the tax rate results immediate decreases in output and wealth, with the decline in output lasting only 1 quarter. This results from the sharp reductions in disposable income and therefore output. The tax increase does not result in an immediate increase in spending therefore leading to a sharp improvement in the deficit *(T – G)* position of the government. The initial decline in output triggers a reduction in prices. However, prices do not immediately increase with the subsequent expansion in the economy, which may indicate that the output expansion is supply driven. The price reductions causes an appreciation of the domestic currency, which is supported by increases in the domestic interest rate as the monetary authority seeks to reduce any possible inflationary impact of the output expansion.

Figure 11: Response to Tax Shock

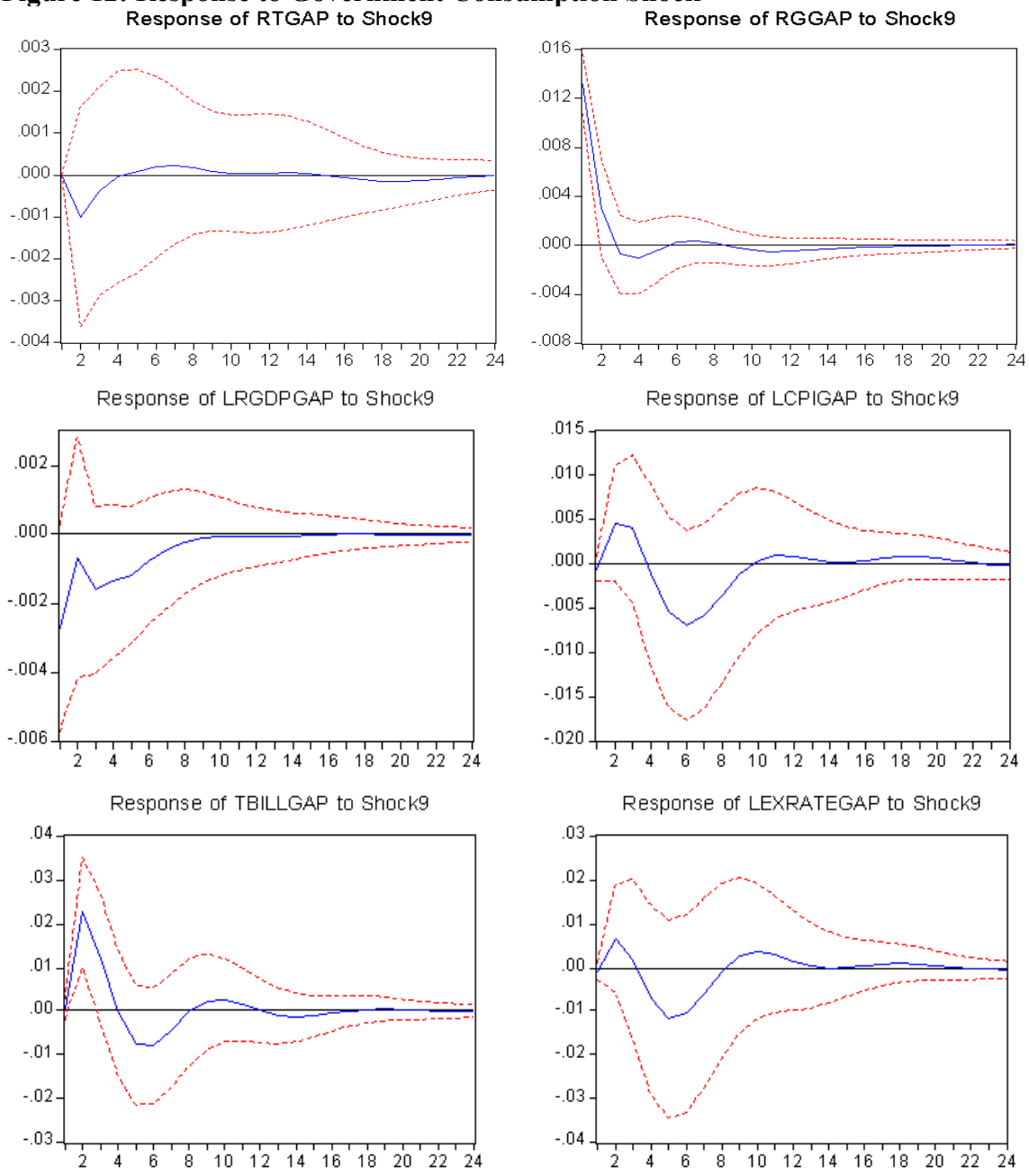


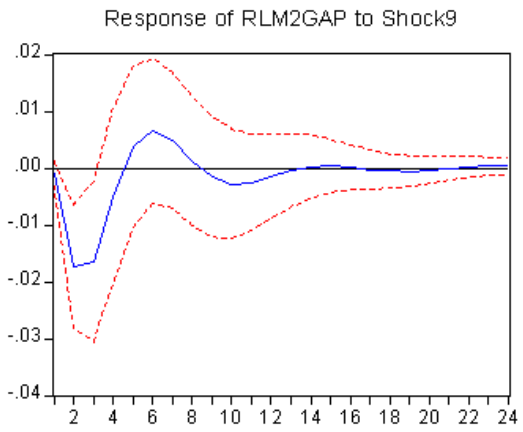


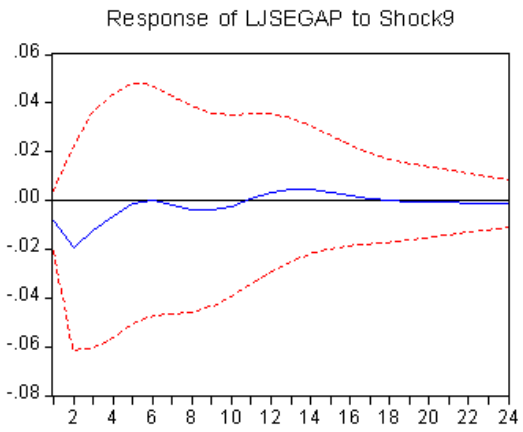
6.9 Government Consumption Shock

A positive shock to government spending, results in immediate reductions in domestic output as domestic investments are crowded out. Following the increased spending, taxes decline as a result of the reduced revenues resulting in a sustained deterioration in the government's fiscal position *(T – G)* for the next 3 quarters. Prices decline marginally as a result of the initial fall in output, but increases for the next 3 quarters during the period of deterioration of the fiscal position. Again the monetary policy response shows an increase in interest rates to reduce the magnitude of the domestic price and exchange rate increases. As with the tax shock, the impact on prices, exchange rates and interest rates lasts more than 20 quarters.

Figure 12: Response to Government Consumption Shock







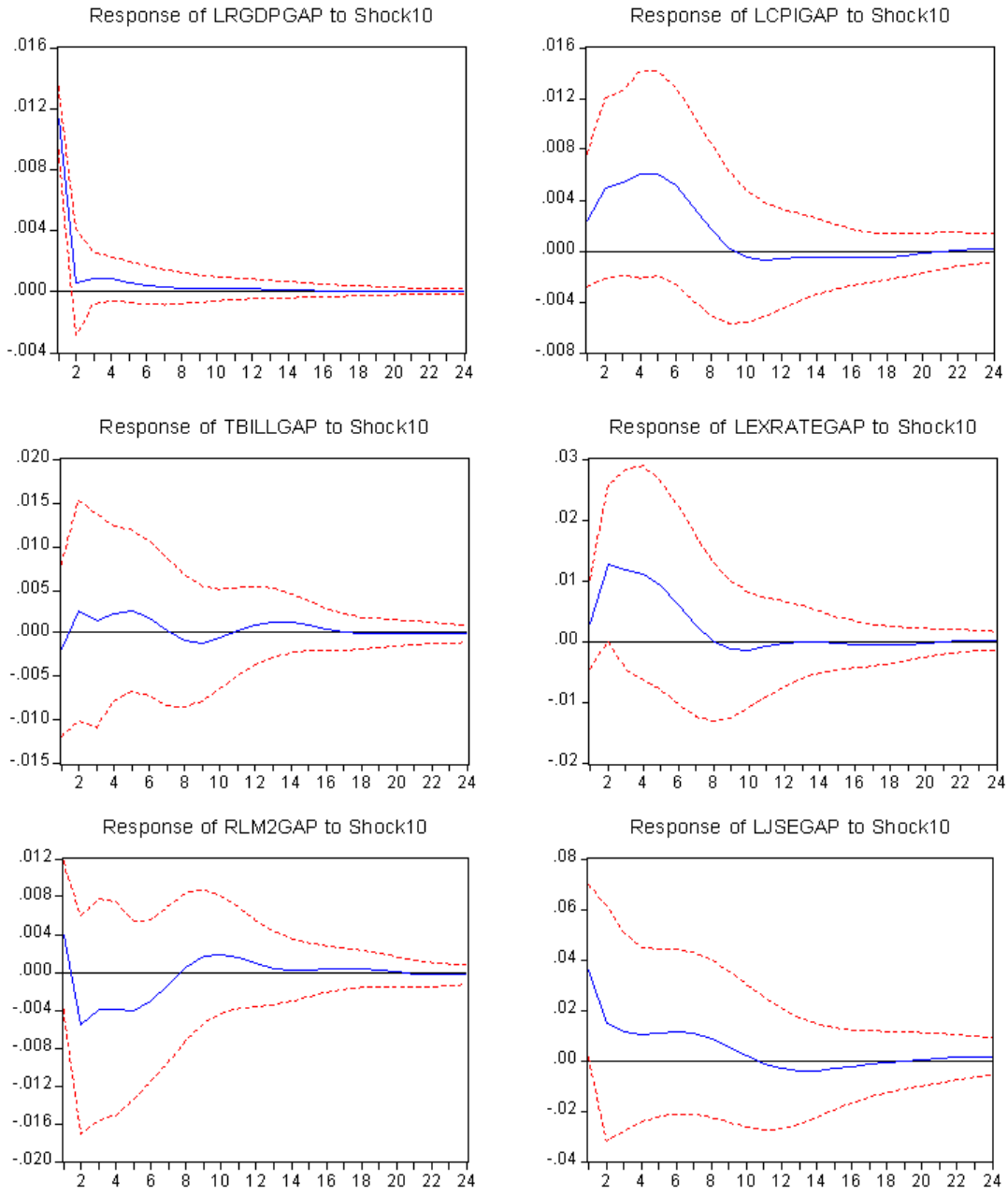
6.10 Domestic Output Shock

A positive domestic output shock is short lived as the impact dissipates almost immediately. The impact on the nominal variables however, is more prolonged as prices and exchange rate increases last for approximately 8 quarters. The monetary policy response seems initially pro-cyclical, as there is an initial decline in interest rates followed by a sustained increase in rates between the 2nd and 7th quarter. This differs significantly from the counter cyclical policy action seen in the foreign economy where interest rates are increased immediately following an output shock to reduce the inflation impulses. The subsequent sustained increase in the rates may be to correct for the increased domestic prices, which may have been magnified by the initial policy action. Wealth responds positively and immediately to the output impulse and the response last for 11 quarters.

The variance decomposition in Table 3 indicates that the main drivers of the domestic output are foreign prices, import prices, taxes, government consumption, the opportunity cost of holding money and money stock. Also important are foreign output, foreign interest rates, export prices and domestic wealth. Interestingly, domestic prices, interest rate and exchange rate are not amongst the leading drivers of the business cycle. From a policy perspective, fiscal policy seems to dominate and has a direct impact on policy whilst the monetary policy impact seems indirect. The domestic interest rate impact is minimal. However, the opportunity cost of money and the changes in the money stock seem to be as dominant as the fiscal variables. Therefore the potential impact of monetary policy may outweigh the dominance of fiscal policy but the challenge for the monetary authority is the accuracy in measuring the policy impact through the numerous indirect channels.

With regards to the relative importance of foreign versus domestic shocks for driving the Jamaican business cycle, foreign factors account for approximately 35% of the output dynamics in the 10th quarter. Thus domestic variables dominate the Jamaican business cycle, but foreign variables do play a major role. It is therefore critical for domestic policy to accurately take account of the foreign variables in all its stabilization policies.

Figure 13: Response to Domestic Output Shock



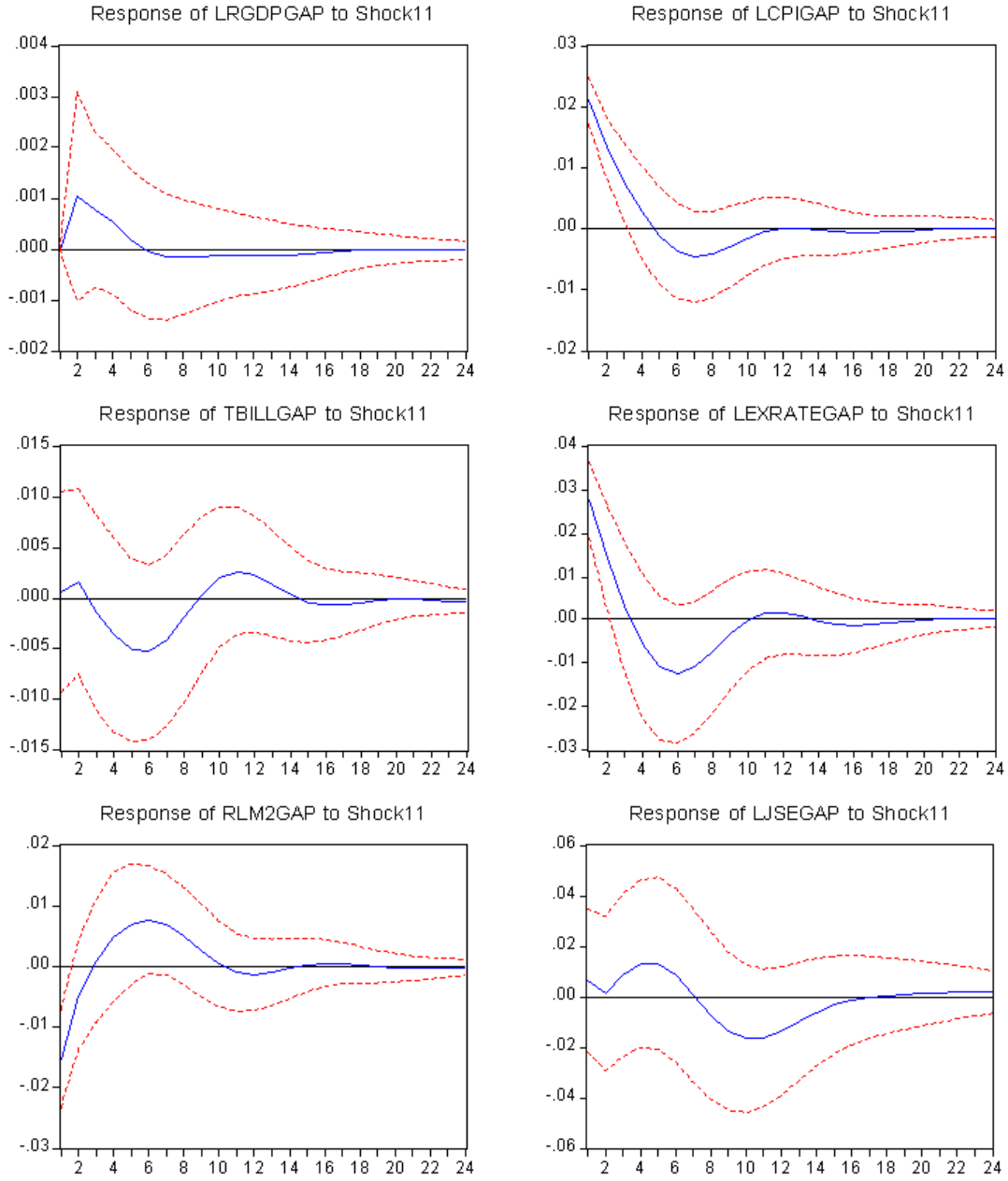
6.11 Domestic Price Shock

A positive domestic price impulse results in a gradual increase in output that peaks after two quarters before the rate of increase dissipates by the 6th quarter. The increased output may be due to the impact of the depreciation, which results from the changes in the foreign and domestic price differential. Interest rates increase for the first two quarters then is followed by a sharp decline as the initial adjustment causes prices to correct sharply in the 5th quarter. The exchange rate and money follow the price dynamic due to the high degree of currency substitution and the high pass-through of prices to exchange

rate and exchange rate to prices. This is consistent with the expectations of a small open economy, which operates a floating exchange rate. As a price taker, the exchange rate adjusts rapidly to any disequilibrium between foreign and domestic prices.

An examination of the variance decomposition in Table 4 indicates that the main drivers of domestic inflation are foreign inflation, exchange rate, money stock and wealth, each accounting for more than 10 per cent of the variance at some point in the 10 quarter horizon. Though the absolute share is not large, imported inflation is the only variable that impacts immediately on domestic inflation.

Figure 14: Response to Domestic Price Shock

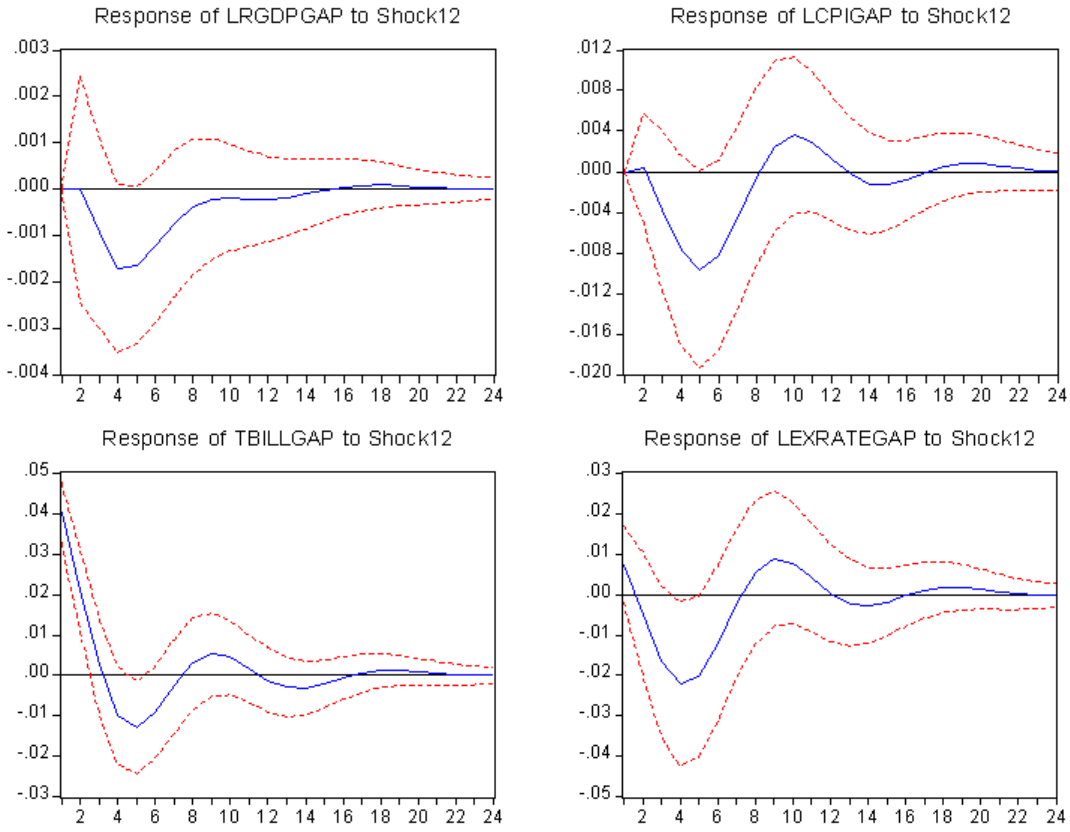


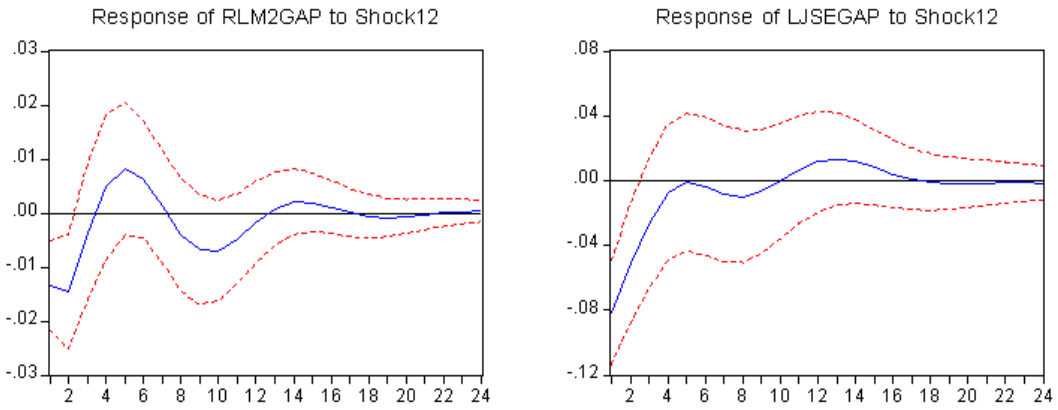
6.12 Domestic Interest Rates Shock

The domestic interest rate impulse is long lived as the impulse last approximately 20 quarters with bouts of rate increases and decreases until the impulse completely dissipates. This response implies the economy's reaction to the impulses is not smooth and necessitates corrective actions of negative and positive rate adjustments before reaching a steady state. Output responds by starting to decline in the 2nd quarter. The fastest rate of reduction is seen in the fourth quarter and the output returns to a steady state by the 16th quarter.

The variance decomposition in Table 6 shows that the initial change in the interest rate is dominated by the influence of money, output, exchange rate and foreign interest rates. Over the 10 quarters, foreign and domestic interest rates, prices, domestic money stock and exchange rate, dominate the interest rate determination. These factors all determine a managed floating exchange rate in a PPP, UIP framework. This illustrates the weight the monetary authority places on the exchange rate and other nominal variables relative to output.

Figure 15: Response to Domestic Interest Rate Shock

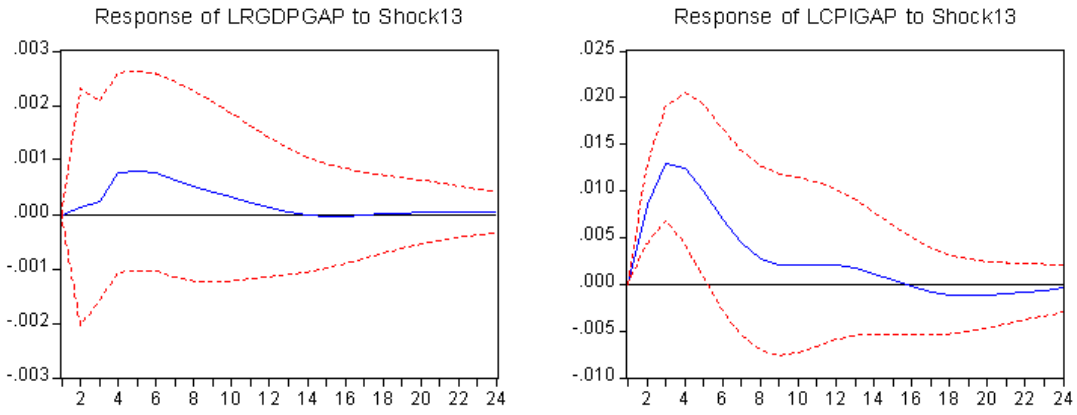


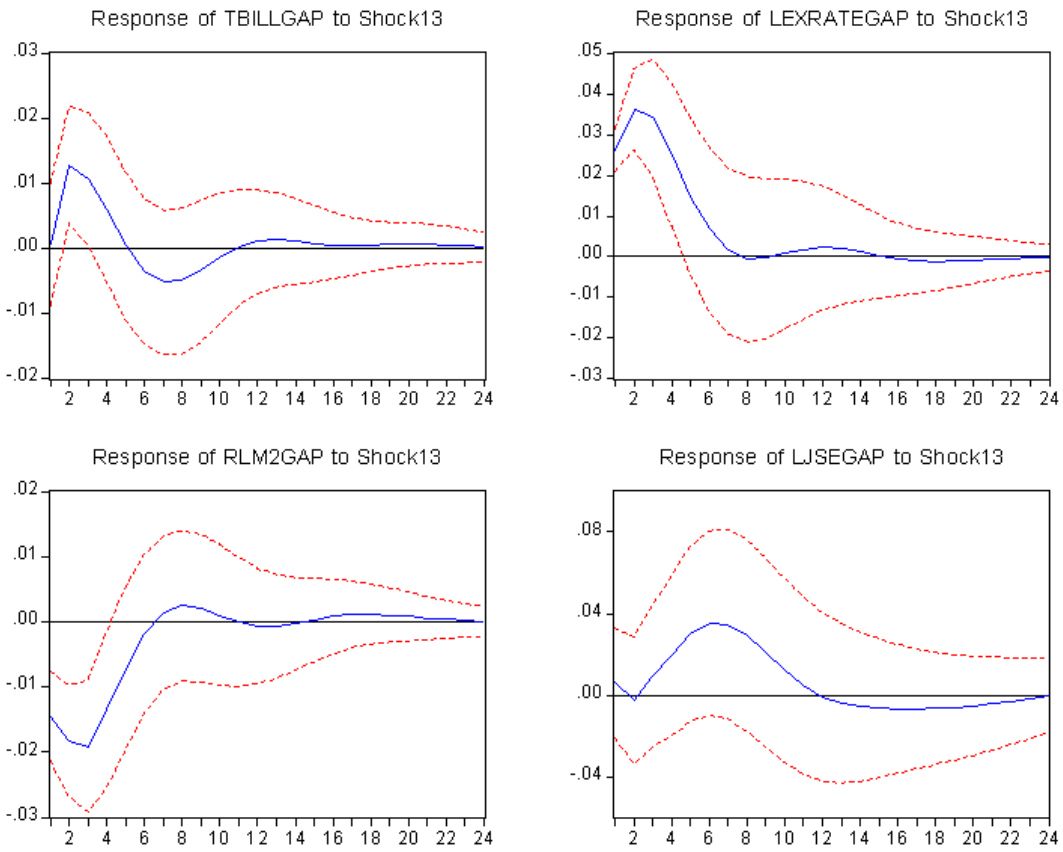


6.13 Domestic Exchange Rate Shock

A positive shock to domestic exchange rate leads to an increase in domestic output that last 14 quarters, with the peak rate of increase in the 4th quarter. This may be as a result of the impact of depreciation on the trade balance. Domestic wealth also increases as a result of the higher net export earnings. In response to the depreciation, the monetary policy response is a gradual increase in domestic interest rates to stabilize the exchange rate and reduce the inflationary impact on the domestic market. Again, the gradual monetary policy response might be the reason for the persistence in the inflationary impact on the economy, which lasts 4 years. The increase depreciation lasts 7 quarters, and there is no negative correction in the rate, thus settling at a higher nominal steady state level.

Figure 16: Response to Domestic Exchange Rate Shock

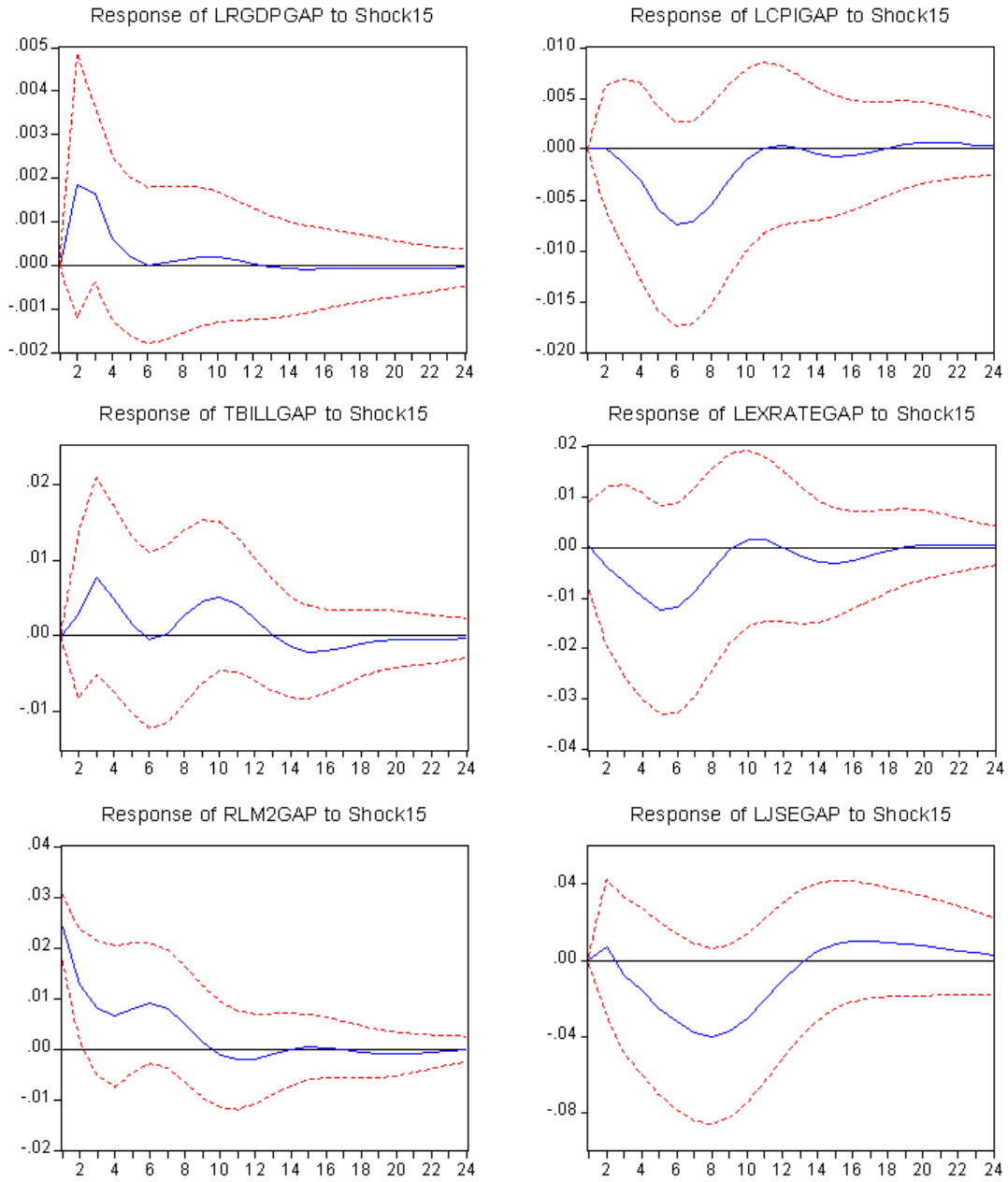




6.14 Domestic Money Shock

The positive money impulse results in an increase in output, which lasts 12 quarters, and the rate of increase is highest in the 2nd quarter. This positive money supply shock is offset by increases in interest rates to reduce the inflationary impact of the monetary expansion. The action seems to over compensate for the monetary expansion and leads to an appreciation of the domestic currency, which results in price reductions. Domestic wealth decreases for 13 quarters and the wealth takes more than 24 quarters to return to a stable long run equilibrium.

Figure 17: Response to Domestic Money Shock



6.15 Domestic Wealth Shock

A positive shock to domestic wealth leads to a decrease in domestic output for 1 quarter, followed by 16 quarters of increased output. The domestic interest rate is increased to reduce the levels of price increase and depreciation of the domestic currency. Though the impact on wealth only lasts 5 quarters, the impact on the real and nominal variables in the economy lasts more than 20 quarters. The pattern of interest rate increases and price and exchange rate dynamics suggests that the stabilization is not smooth and it could be 18 quarters before interest rates are reduced.

Figure 18: Domestic Wealth Shock

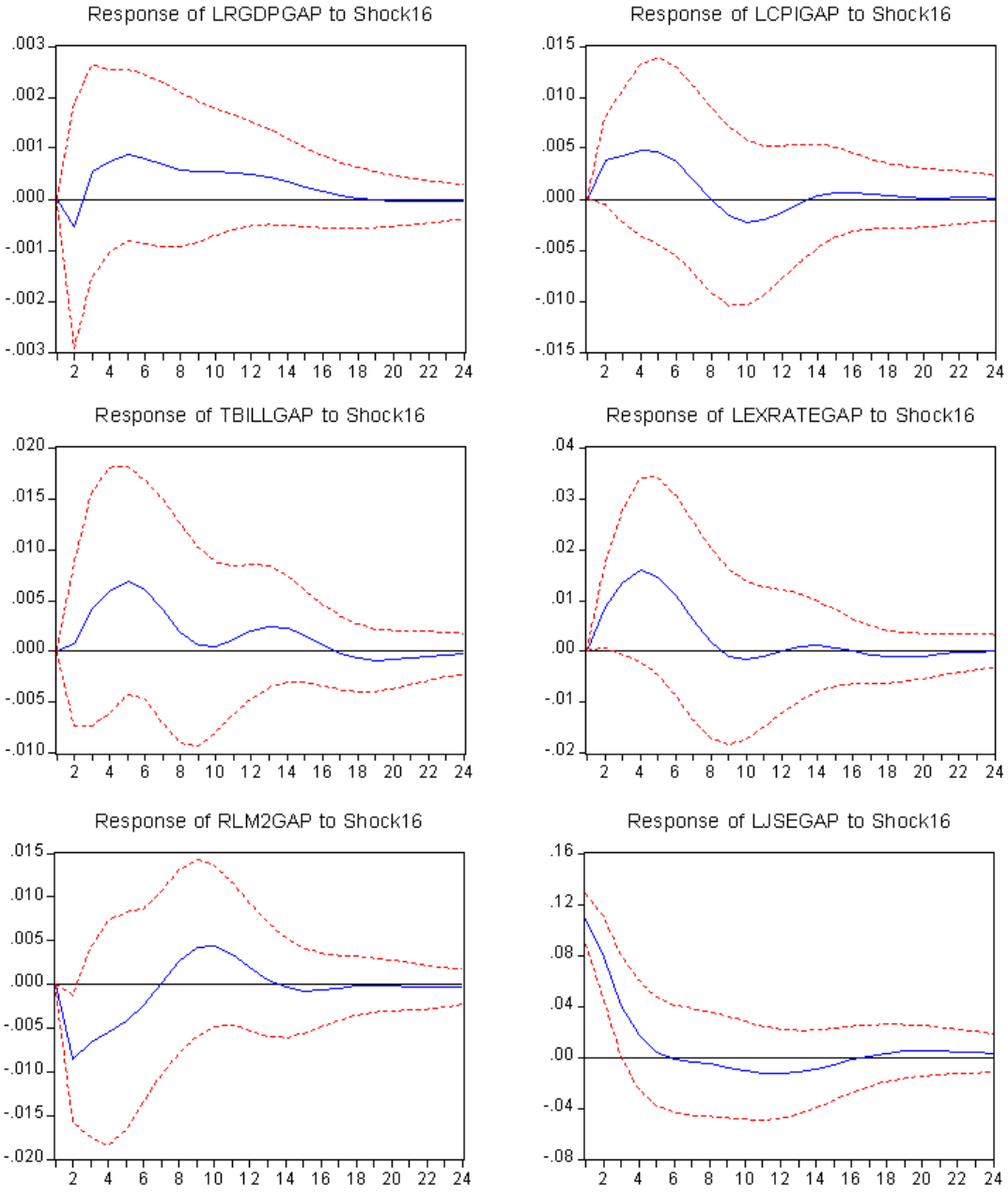


Table 4: Variance Decomposition of Output (y_t)

Period	S.E.	y_t^*	i_t^*	p_t^*	q_t^*	pim_t^*	px_t^*	w_t	T_t	g_t	y_t	p_t	i_t	s_t	$h2_t$	m_t	q_t
1	0.010	1.759	0.000	0.000	0.000	0.000	0.000	0.237	0.252	1.249	96.502	0.000	0.000	0.000	0.000	0.000	0.000
2	0.012	2.043	0.205	2.582	0.767	0.048	0.167	1.299	2.180	4.276	78.002	0.174	0.279	0.160	1.413	6.256	0.149
3	0.015	3.686	0.877	8.571	0.864	4.279	1.146	0.758	8.260	7.680	51.853	0.613	0.198	0.111	6.064	3.632	1.410
4	0.017	3.489	1.318	12.108	0.867	5.534	1.800	0.881	6.835	8.837	45.216	0.574	0.212	0.322	5.069	4.815	2.122
5	0.018	3.152	1.588	11.794	0.802	6.539	2.905	0.790	6.648	8.225	41.354	0.826	0.474	0.993	5.088	6.662	2.157
6	0.018	3.083	2.501	10.933	1.026	6.297	2.693	0.732	6.165	9.124	40.150	0.941	0.536	1.025	4.782	7.588	2.425
7	0.019	2.996	2.649	11.154	0.990	6.201	2.852	0.712	6.559	9.167	38.857	1.209	0.680	1.109	5.038	7.486	2.342
8	0.019	2.829	2.718	11.945	0.956	6.139	2.958	1.062	6.283	9.059	37.425	1.188	0.671	1.134	5.574	7.792	2.267
9	0.020	2.810	2.635	12.865	0.923	6.391	2.892	1.118	6.044	8.738	35.997	1.369	0.747	1.115	5.572	8.522	2.261
10	0.020	2.763	2.631	14.138	0.950	6.405	2.977	1.111	6.058	8.648	35.055	1.404	0.731	1.174	5.388	8.280	2.287

Table 5:Variance decomposition of p_t

Period	S.E.	y_t^*	i_t^*	p_t^*	q_t^*	pim_t^*	px_t^*	w_t	T_t	g_t	y_t	p_t	i_t	s_t	$h2_t$	m_t	q_t
1	0.016	0.000	0.000	0.000	0.000	1.855	0.000	0.000	0.000	0.000	0.001	98.144	0.000	0.000	0.000	0.000	0.000
2	0.027	2.151	1.010	0.642	0.008	2.450	0.055	1.934	5.456	0.457	2.191	59.487	0.113	9.697	1.703	10.860	1.786
3	0.039	1.585	0.506	3.891	0.324	1.208	0.199	0.925	2.997	2.077	1.047	57.280	1.843	8.434	0.839	13.517	3.328
4	0.048	1.015	0.644	2.940	0.289	1.620	0.577	1.570	1.935	2.689	0.872	48.957	1.696	11.400	0.620	13.319	9.856
5	0.054	1.678	0.665	5.630	0.411	1.301	0.828	1.259	1.746	3.624	0.801	45.415	2.241	10.221	0.649	11.352	12.180
6	0.058	1.986	0.585	7.692	0.978	1.149	2.875	1.156	1.893	4.678	0.801	40.219	1.979	9.995	0.673	9.968	13.372
7	0.061	3.023	0.585	10.461	1.947	1.623	3.641	1.486	1.825	4.810	0.889	36.270	1.828	9.248	0.746	9.511	12.108
8	0.064	3.518	0.632	12.247	2.648	1.834	4.997	1.474	1.779	4.634	0.825	33.769	1.688	8.852	0.813	9.033	11.257
9	0.065	3.731	0.625	12.561	3.010	1.967	4.969	1.654	1.744	4.475	0.815	32.892	1.681	8.742	0.798	8.739	11.598
10	0.065	3.696	0.626	12.451	2.984	1.951	4.908	1.637	1.825	4.446	0.899	32.599	1.709	8.672	0.823	8.792	11.982

Table 6: Variance decomposition of i_t

Period	S.E.	y_t^*	i_t^*	p_t^*	q_t^*	pim_t^*	px_t^*	w_t	T_t	g_t	y_t	p_t	i_t	s_t	$h2_t$	m_t	q_t
1	0.032	0.049	5.849	0.504	0.000	0.137	0.000	0.044	0.047	0.234	18.055	7.229	13.417	17.151	2.308	34.975	0.000
2	0.046	2.070	5.581	4.874	0.623	1.025	0.034	3.817	1.539	7.359	8.989	8.128	6.575	13.074	8.306	27.105	0.900

3	0.054	2.085	4.925	4.882	0.635	0.963	0.998	2.777	1.473	5.775	9.292	6.690	4.837	9.751	7.504	34.867	2.547
4	0.060	2.179	7.979	4.645	1.533	0.915	2.675	3.060	1.339	5.206	7.683	5.744	6.289	9.923	6.698	29.173	4.958
5	0.067	1.841	9.551	4.263	2.603	0.802	2.571	2.632	3.381	4.429	6.694	6.041	5.190	11.665	7.831	24.924	5.582
6	0.073	1.985	9.822	4.351	2.203	0.668	2.312	2.345	3.734	4.533	7.142	8.096	4.415	12.152	6.957	24.622	4.664
7	0.077	2.076	9.085	4.248	2.224	1.032	2.320	2.167	3.372	4.153	6.891	10.212	4.244	11.436	6.416	25.752	4.371
8	0.082	2.216	8.133	7.739	2.212	3.465	2.591	2.271	3.326	4.105	6.105	10.307	3.763	10.258	5.759	23.137	4.611
9	0.086	2.208	7.815	11.108	2.018	4.513	2.551	2.278	3.206	4.164	5.614	9.406	3.563	9.694	5.259	21.961	4.643
10	0.089	2.126	7.643	11.307	2.193	4.274	2.612	2.154	3.034	4.440	5.459	9.195	3.706	9.633	5.013	22.817	4.394

6.16 Projection Results

VAR models have been noted for their usefulness as projection or forecasting models. The model was checked to ascertain its usefulness as a projection model for key variables in the domestic economy. One important difference between this model and other projection models of the economy is that no assumptions are needed since all variables could be assumed endogenous and projected by the model. The system of equations in (2) is used to project each variable's transitory movement. The permanent movement of each variable is then projected as

$$\hat{y}_t^p = \gamma_1 + \gamma_2 T_t + \gamma_3 y_{t-1}^p + \gamma_4 y_{t-2}^p \qquad (5)$$

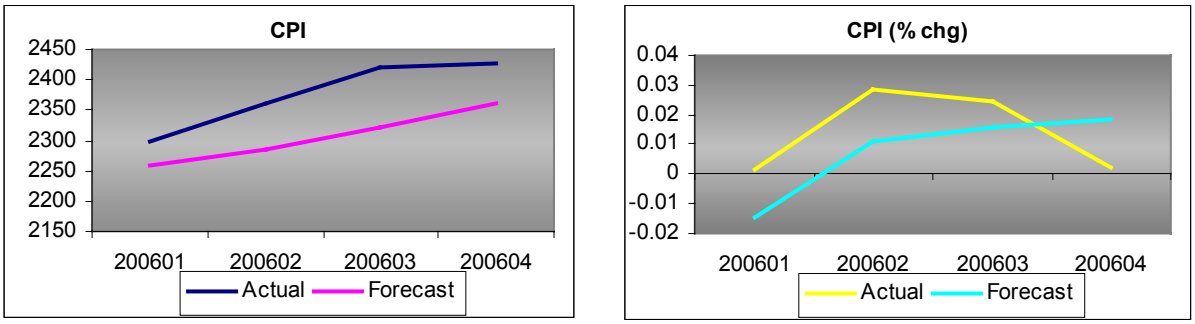
Therefore the projections for the vector y_t is calculated as

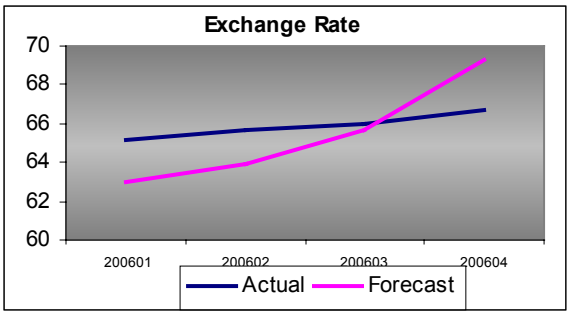
$$\hat{y}_t = \hat{y}_t^t + \hat{y}_t^p \qquad (6)$$

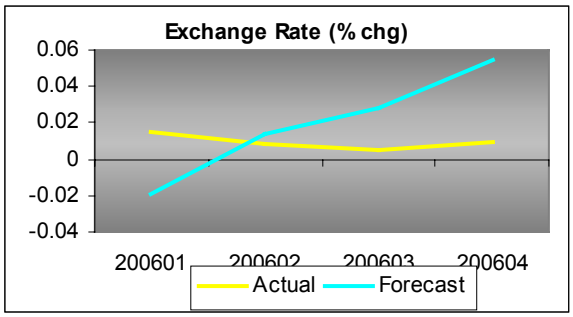
Each variable is then adjusted for seasonality and then compared to the first and second moments for the actual outturn.

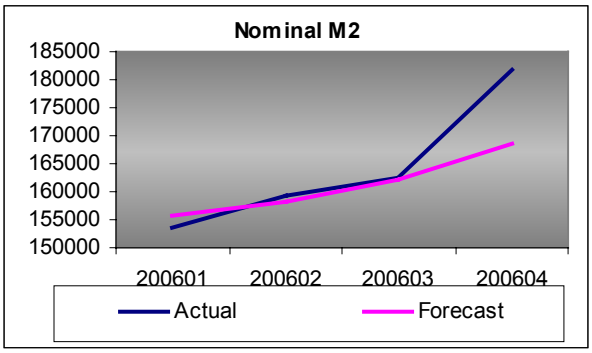
The model produces good out-of-sample forecasts for most of the domestic variables, with the exception being the exchange rate forecast. As the model is for the business cycle, it is not surprising that it does a good job at forecasting output. The forecast for money stock is also very accurate in picking the magnitude and direction of the changes in the equilibrium money stock. The forecast of inflation, though not as accurate, picks the turning points for the price changes. The exchange rate forecast is the least accurate. This may be due to the fact that the forecasts of its main determinants, foreign and domestic interest rates, differ from the path chosen by policy makers in both economies.

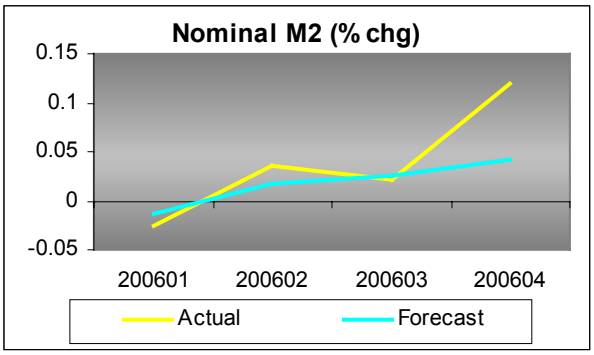
Figure 19: Forecast Performance for Selected Domestic Variables

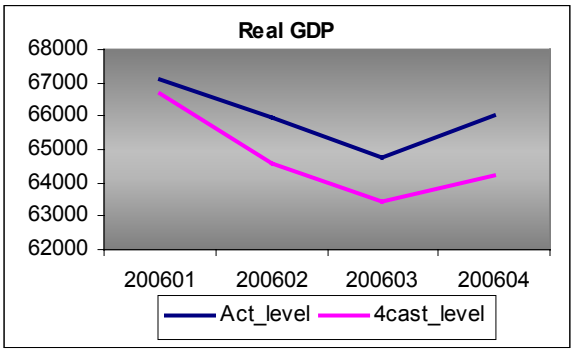


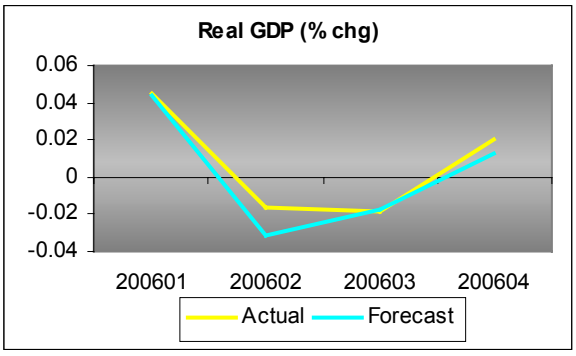












7.0 Conclusions

The model produced some interesting insights of the main drivers of the Jamaican business cycle. It identified the monetary transmission channels and highlighted the current central bank strategies in stabilizing the business cycle. Also, the projection exercise illustrates the usefulness of such a model as an additional forecasting tool of many of the main macroeconomic indicators in the economy, particularly output.

The findings indicate that the main drivers of the Jamaican business cycle are foreign prices, import prices, taxes, government consumption, the opportunity cost of holding money and money stock. Also important are foreign output, foreign interest rates, export prices and domestic wealth. Interestingly, domestic prices, interest rate and exchange rate are not amongst the leading drivers of the real business cycle. Weather is an important determinant, but is currently not among the main drivers of output. This result

is supported by the fact that the impact of hurricanes during the sample period did not result in recessions in the economy.

Examining the monetary transmission mechanism, changes in the target interest rate have been shown to have another key channel of transmission than those identified in Figure 1. Changes in the target rate have an immediate impact on money demand, exchange rate and wealth as proxied by the stock market index. This wealth channel is consistent with the findings of Mitchell (2005), which highlighted its importance as a target for monetary policy.

The domestic monetary policy responses to the business cycle and its determinants seem less precise than the response in the foreign economy. In some cases, the interest rate response could be pro-cyclical. In some cases, in which the responses were counter-cyclical, the responses seem reactive to the impulses and hence the impact on the nominal variables seemed to be propagated over a long horizon. There is some evidence that the initial policy response to some shocks were larger than required as these responses typically necessitate corrective measures following the initial policy action. This would also result in persistence in the shocks in particular to the nominal domestic variables. One challenge faced by monetary policy is its limited direct but significant indirect impact on output and prices. These channels have a significant international component, posing further challenges for domestic monetary policy. The relative importance of the terms of trade on the Jamaican business cycle ensures that the exchange rate and its determinants are the primary focus of monetary policy to achieve its desired business cycle and inflation outcomes.

The test of the models usefulness as a forecasting tool, illustrated its potential for use in projecting key macroeconomic indicators. The forecast of real GDP and money supply seemed particularly accurate and could therefore prove to be a useful addition to the suite of models currently utilized in analysing monetary policy and forecasting the main macroeconomic indicators in the Jamaican economy. The dynamic modelling of the external sector should provide more consistent simulations of the different international policy scenarios than the traditional static approach. Additionally, as all variables are endogenous, this model allows for a comparison of actual data outturn versus some notion of an inherent equilibrium path.

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