Working Paper

A Structural Approach to Modelling the Jamaican Business Cycle

Roger McLeod†

Research and Economic Programming Division

Bank of Jamaica

August 2016

Abstract

This paper develops a small structural model of the Jamaican business cycle using two approaches, namely, a Structural Vector Autoregressive (SVAR) framework as well as a Vector Error Correction (VEC) approach. The main aim of this study is to consolidate the central bank's macroeconomic forecasting function with alternative VAR models producing unconditional forecasts of variables that have a strong theoretical and empirical importance in the Jamaican business cycle. This paper also serves as an extension to Murray (2007). Key differences to the SVAR estimated in that study is the use of a Kalman filter when converting variables to gap deviation form, as well as the addition of important dummy variables and a few changes to the identification of the model. In addition to providing accurate short term forecasts and simulations, the estimated SVAR model can be used to assess the efficacy of monetary policy over different time periods using estimated impulse response functions derived from the structural factorization of the model. An estimated VEC model on the other hand takes advantage of the long term component of the macroeconomic relationships between the variables. The identification approach of the model is similar to that of Fisher, Huh, and Pagan (2013) Dungey and Vehbi (2011), and Pagan and Pesaran (2008) where cointegration analysis is used to distinguish between permanent shocks and temporary shocks, and stationary variables are added in the form of a pseudo-cointegrating vector. We then assess the out-of-sample performance of both models.

Keywords: Business Cycle, Structural VAR, Error Correction, Permanent shocks

JEL Classifications: E31, E32, E37, C31

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†Dr. Roger McLeod is a Senior Economist in the Research Services Department, Research and Economic Programming Division, in the Bank of Jamaica. The views expressed in this paper are not necessarily those of the Bank.

1 Introduction

In this paper, we estimate two small structural empirical models of the Jamaican business cycle in the form of a Structural Vector Autoregressive (SVAR) model and a Vector Error Correction (VEC) model. The models we develop in this paper serves as an extension to Murray (2007), while their main use will be the provision of unconditional forecasts of endogenously[1] determined macroeconomic variables as well as to aid in the Bank's monetary policy assessment. Essentially, the paper will be used as a check against the conditional forecasts of the Bank's monetary model (Mon-Mod). This therefore dictates the kind of model I wish to estimate and the identification approach to be used. The main focus is to ensure the models are structural and tractable. Structural in the sense that shocks (or variable relationships) have a direct economic meaning or interpretation and tractable in the sense that the model is adequately small but well specified to the extent that one can easily trace the impact of shocks when investigating particular results or scenarios.

For completeness as well as to ensure all the dynamism and information emanating from the variables relationships are exploited, two models will be estimated. The SVAR model should be quite good as a one step ahead forecast model, while the VEC model should do better over the longer horizon. Also, the VEC model serves as the next stage in the evolution of the VAR suite of models, following the estimated SVAR model in Murray (2007). Jamaica has frequently experienced several short lived recessions over the sample period, and it is our challenge to develop models that can adequately disaggregate and identify the different shocks at play which drive the business cycle. Given that Jamaica is a small open economy, several international linkages and shocks (to the extent that the model should not be forecasting shocks but rather the path of the variable if no significant shocks occur) have to be considered. Essentially, to improve on the work in Murray (2007), one would need to use a more precise measure of variables in gap-deviation form, better balance the trade-off between the number of parameters and the predictive power of the SVAR model by carefully dropping some variables, as well as develop a cointegrated – VAR model (VECM) that utilizes long term equilibrium relationships. In this paper, we focus on these three main modifications and present the findings.

[1] Note that the models developed augments, but do not replace the Bank's main forecasting model which in addition to being a larger model that incorporates more variables, also utilizes future assumptions of key variables to produce conditional macroeconomic forecasts. Therefore, our unconditional forecasts generated from the estimated SVAR and VEC models serves as an important unconditional forecast alternative.

1.1 Jamaican Economy

During the 1980s and early 1990s, many Caribbean and Latin American economies were plagued by either excessively high inflation or hyperinflation. Over the past two decades, however, central banks in the respective regions have become more pragmatic and restrictive in their approach to price stability. This has resulted in single digit inflation or significantly lower inflation relative to the 1990s, for most of these economies. Stable and low inflation that accompanies economic growth has therefore become increasingly important to Jamaica as its trading partners have become more macro-economically stable. Jamaica is a relatively small open economy that specializes mainly in the production and export of primary goods as well as tourism. Production and by extension exports, therefore depend heavily on the price of energy which is determined on the international market. Production demands imports to produce exports and is therefore vulnerable to external shocks and terms of trade transmitted through the exchange rate. However, the inability to stabilize a post liberalized foreign exchange market in Jamaica has inevitably resulted in low or negative economic growth, and at the same time higher inflation rates than most of its trading partners. While Jamaica has seen recent reductions in inflation rates, the potential transition towards Inflation targeting necessitates the estimation of models that can accurately estimate and predict business cycle oscillations so as to keep inflation low and more importantly, stable, despite the inevitable external shocks.

Monetary policy in Jamaica is centred on the use of interest rates to exert both a direct (through the real economy) and indirect control (through asset prices such as the exchange rate) over inflation in a free floating exchange rate system which is periodically managed using international reserves. To adequately prepare for stability engendering policies, it is important to estimate an accurate VAR model with relatively good predictive power in the form of unconditional forecasts that acts as both an augmentation and a check of the Bank's main macroeconomic forecasting tool. It is also important to develop a cointegrated VAR model (VEC model) which does not separate variables into different components but rather seeks to establish and identify common stochastic trends between these non-stationary variables in order to provide an empirical counterpart to a Dynamic Stochastic General Equilibrium model that will be developed in short order.

1.2 Evolution of Literature

Prior to the seminal work of Sims (1980), multivariate simultaneous equations models were used extensively for performing forecasts. As macroeconomic variables' time series became more readily available with higher frequency, and the need to describe the dynamism between macro variables became more important, VAR models were developed for this sole purpose and have been widely used for

performing forecasts and policy analysis ever since. A key innovation in VAR modelling was that all variables were treated a priori as endogenous, consequently circumventing the highly debated and controversial issue of exogeneity of some variables. VAR models are excellent at giving short term forecasts given that the current values of a set of variables are partly explained by past values of all variables. Policy analysis can also be aided by VAR analysis assuming that the model is predicated on the proper data generating mechanism of the variables involved. This can be ensured by developing a structural VAR, where the 'structure' is based on a particular theoretically reasonable identification of the shocks in the system. By placing restrictions on the contemporaneous interactions between variables (as proposed by Sims (1986) and Bernanke (1986)), or restrictions on the long run relationship between variables (as proposed by Blanchard and Quah (1989)), or restrictions on both short and long run relationships (see Bjornland (2009) and Krusec (2010) for details), then one can identify the shocks of the system in line with economic theory and direct economic interpretation, to produce impulse response functions that are able to conduct credible policy analysis.

Murray (2007) estimated a 16 variable SVAR model of the Jamaican business cycle using identifying restrictions on the contemporaneous relationships between variables. The identification approach relies on several economic theories governing the evolution of each variable with no major puzzles in the results. There are however important modifications to make to this framework which can potentially improve its forecast performance and policy analysis. These modifications include firstly, the use of a Kalman filter as opposed to a Hodrick-Prescott (HP) filter when measuring variables in gap deviation form. Secondly, the dropping of irrelevant variables to better balance the trade-off between the number of parameters and the predictive power of the model (with respect to the main macro-variables), and lastly, to include important dummy variables to account for events that may have caused a structural break in the sample period.

The importance of stochastic trends in time series is one potential drawback of SVAR models given that they can only be applied to stationary time series. As such, the VECM framework which separates long run and short-run components of the data generation process offers an important augmentation to VAR models following the work in Granger (1981), Engle and Granger (1987), and Johansen (1995). A key modification of VEC models however, which this paper utilizes, is the use of cointegration to distinguish temporary shocks from permanent shocks, then using this information to identify the structure of the model. Dhar, Pain and Thomas (2000) is one of the earlier central bank research papers using this approach. The authors estimate a structural empirical model of the UK monetary transmission mechanism. Cointegration is used to distinguish between temporary and permanent shocks and

identifying assumptions are then used to estimate a structural VEC model. Although not explicitly stated by the authors, all variables are I(1) given that they formed a conventional cointegrating vector.

In Pagan and Pesaran (2008), the paper goes a step further in trying to show exactly what identifying information is provided by the knowledge of what shocks are permanent or transitory. This was previously studied in Blanchard and Quah (1989) who used a two variable model with one variable being ascribed with a permanent shock and the other with a temporary or transitory effect. Other research papers such as Fisher (2006), and others, then built on this approach by adding more permanent or transitory shocks (variables) to the system. The main addition to the literature and understanding of SVEC models provided by Pagan and Pesran (2008) however, is the finding that identification would be vastly improved in terms of estimating unobserved structural relationships, if the researcher knew the parameter values (loading coefficients) of the error correction terms in the structural equations. Specifically, it is shown that these values will be zero in the structural equations for the variables that are known to have permanent shocks. Additionally, Pagan and Pesaran (2008) shows that this approach can be applied in a model consisting of both I(1) and I(0) variables.

This result is then built on in Dungey and Vehbi (2011) whom estimated a Structural VEC model of the UK economy and its term premium. Fisher, Huh and Pagan (2013) then goes a step further to show that when both I(1) and I(0) variables are mixed in a Structural VEC model setting, then it is necessary to identify whether the added stationary variable(s) has a permanent or transitory shock and what that means for the identification approach used. In particular it is shown that the addition of stationary variables in a VECM of I(1) variables can be done using the pseudo-cointegration approach, if and only if the I(0) variable(s) is assumed to be a transitory shock. It is shown that a violation of this condition results in an inaccurate estimation of the cointegrating vector of the I(1) variables. This result therefore builds on the finding in Pagan and Pesaran (2008) and the authors uses several papers to show how various puzzles appear (or reappear) when this condition is violated. The authors also show how to identify a model when the additional I(0) variables are permanent shocks. Taking the above into consideration, our estimated VEC model will similar incorporate psuedo cointegrating vectors, a separation of temporary and permanent shocks, as well as a recursive-type structural ordering of the variables which serves as a structural identification of the VEC model, without having to place further restrictions on Γ_0 in equation (1.9).

The remainder of this paper is organized as follows. In section 2 we detail how the data was constructed and will be utilized, after which we describe the methodology to be employed, in both the SVAR and VEC models. We then show how each model is identified and the key assumptions and relationships

driving the models. In section 3 we estimate the models and show the results. Impulse response functions, as well as a variance decomposition of output are shown, after which we show the models forecast performance using simulated out-of-sample forecasts between 2014Q2 and 2016Q1. In section 4, we make concluding remarks and give some policy recommendations.

2 Data and Methodology

2.1 Structural VAR Model

Our aim is to provide analytically, and quantitatively, a SVAR model which is able to accurately estimate business cycles in the Jamaican economy so as to simulate effects in the monetary transmission mechanism and provide reasonable forecasts for the macro fundamentals.

Starting from a reduced form representation;

$$A(L)z_t = \varepsilon_t \sim N(0, \Sigma) \qquad 1.1$$

Where, $A(L)$ is a nth-order[2] 12 by 12 matrix polynomial, z_t is a vector (of length 12) of the selected variables, ε_t is the error term which has an independent multivariate normal distribution with zero mean so; $E(\varepsilon_t) = 0$, where its covariance matrix is positive definite and is given by; $E(\varepsilon_t \varepsilon_t') = \Sigma$, $for\ det(\Sigma) \neq 0$[3] and $E(\varepsilon_t \varepsilon_t') = 0, for\ t \neq$ s.

To structurally identify the shocks in this model, we need to convert this reduced form representation into a SVAR representation. This is done following Amisano and Giannini (1997) where the class of SVAR models that we estimate is a special case of the AB model, where A is used as an identity matrix.[4] This specific class of model uses the following transformation;

$$\varepsilon_t = Bu_t \qquad 1.2$$

Where, u_t is a vector of length 12, and is the unobserved structural shocks. ε_t is the error term from equation (1.1). B is an invertible 12 by 12 matrix to be estimated. Therefore, it is the estimation of the B matrix using restrictions, which governs the identification of the structural shocks in the system. Note that

[2] Where n is equal to the number of lags used in the VAR estimation.
[3] "det" refers to the determinant.
[4] This is referred to as the C model in Amisano and Giannini (1997) or the B model in Lutkepohl and Markus (2004).

this is a special case of the general AB model that is written as $A\varepsilon_t = Bu_t$, which translates to equation (1.2) when A is an identity matrix.

To convert our reduced form representation in equation (1.1), we pre-multiply equation (1.1) by A to get;

$$AA(L)z_t = A\varepsilon_t \qquad 1.3$$

Where, $\varepsilon_t = Bu_t$. Note that the unobserved structural shocks, u_t, has zero mean ie. $E(u_t) = 0$, and is assumed to be orthonormal (as such its covariance matrix is an identity matrix), so $E(u_t u_t') = I_{12}$. Note also that it is now possible to model explicitly the relationship among the selected variables, and the impact of the orthonormal shocks hitting the system. The error vector, ε_t, from equation (1.1) is transformed by generating linear combinations (through the B matrix) of 12 independent (orthonormal) disturbances, we refer to as u_t. Therefore, the identification of the matrix B should be governed by the structural relationships of the variables in our system.

Note that from equation 1.2, we also get;

$$\varepsilon_t \varepsilon_t' = Bu_t u_t' B \qquad 1.4a$$

Where, the assumption of orthonormal structural innovations in u_t, imposes restrictions on the matrix B. This is shown when we take expectations of equation (1.4a), to get;

$$\Sigma = BB' \qquad 1.4b$$

For Σ known (where, $E(\varepsilon_t \varepsilon_t') = \Sigma$), the derivation of equation 1.4b imposes $k(k+1)/2$ restrictions on the $2k^2$ unknown elements in the A and B matrices, where k is the number of endogenous variables (therefore k = 12). Given that A was used as the identity matrix this has already placed 144 restrictions in matrix A. This leaves $2k^2 - k(k+1)/2 - 144 = 66$ free elements in the B matrix. So, to identify B we need to place at least 66 restrictions on this matrix.

2.1.1 Structural VAR Data

The SVAR includes 12 variables over the time span 1990Q1 to 2016Q1. These variables are deemed appropriate and sufficient to accurately estimate business cycles in the Jamaican economy. The domestic variables used account for output, relative prices, monetary policy and fiscal policy. Foreign pressures are captured using oil prices, US output, US inflation and import prices (US to Jamaica). All variables are measured in gap-deviation form, via a Kalman filter in a state-space model estimated using Maximum

Likelihood. As expected for variables in gap deviation form, all twelve constructed variables were found to be stationary at both the 1.0 per cent and 5.0 per cent level of significance.

Table 1.0 SVAR variable symbols and description

Symbol	Variable (measured as the deviation from its long run trend)
v_t^*	Oil Price (WTI)
y_t^*	Foreign Real GDP (US)
i_t^*	Foreign Interest Rate (US)
p_t^*	Foreign Consumer Price Index (US)
Im_t	Import Prices
g_t	Government Expenditure/GDP
y_t	Domestic Real GDP
p_t	Domestic Consumer Price Index
i_t	Domestic Interest Rate
s_t	Nominal Exchange Rate
m_t	Real Money Balances
T_t	Tax Revenue/GDP

2.1.2 Structural VAR Data Decomposition

As noted previously, we separate the trend component from the cyclical component using a Kalman filter in a linear state space model. The SVAR model then models and forecasts the cyclical component, while the trend component is forecasted using a simple regression with trend. The cyclical and trend components are then added to re-construct variable forecasts back into their original form. The Kalman filter uses the following general specification, which is slightly tweaked for individual variables using Maximum Likelihood estimation method. A linear state space representation of the dynamics of each n x 1 vector or variable is as follows;

$$\omega = a_t + b_t \qquad 1.5a$$

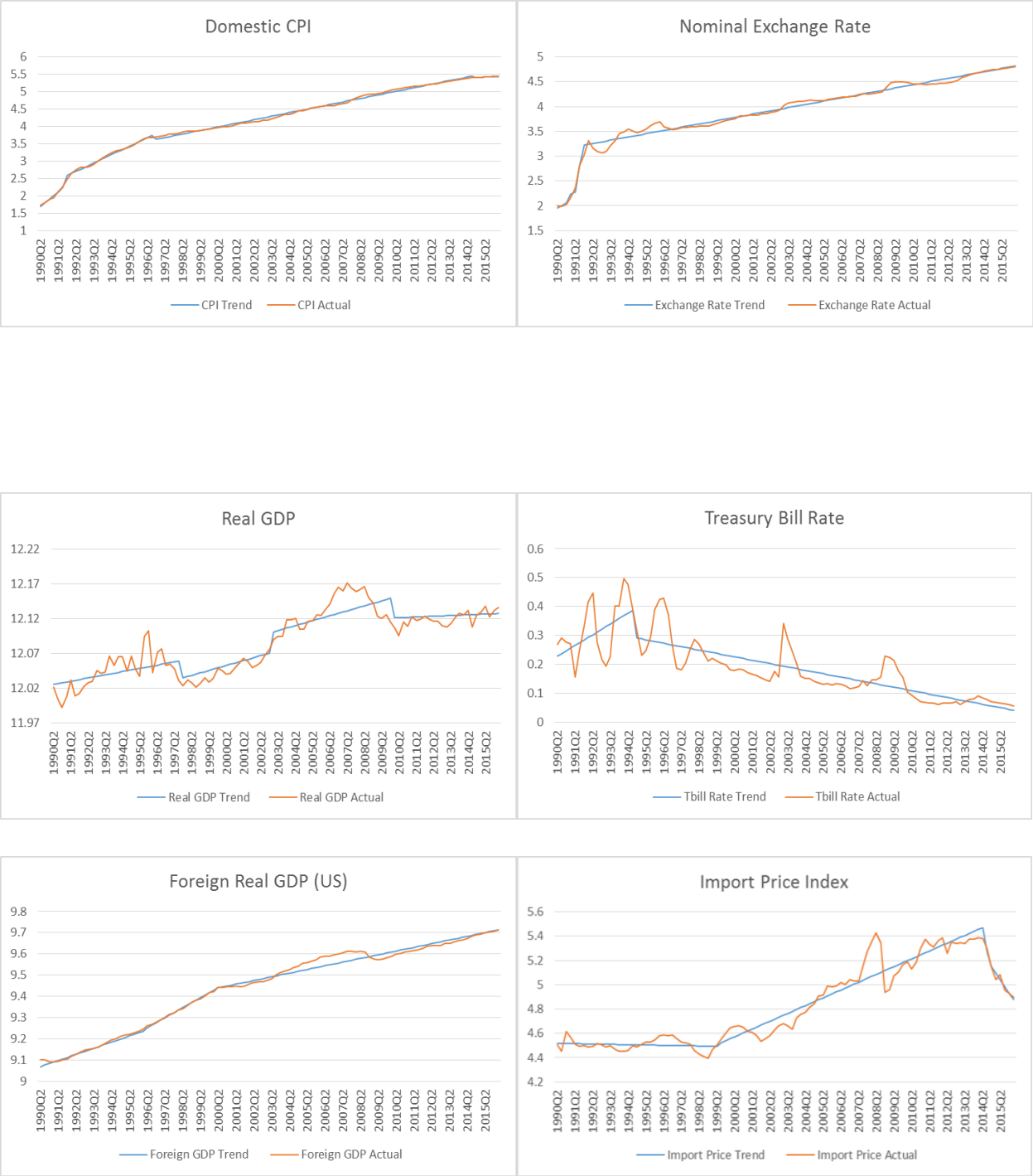
$$a_t = \beta + c_t + d_t + \epsilon_t \qquad 1.5b$$

$$b_t = (L)\delta b_{t-1} + u_t \qquad 1.5c$$

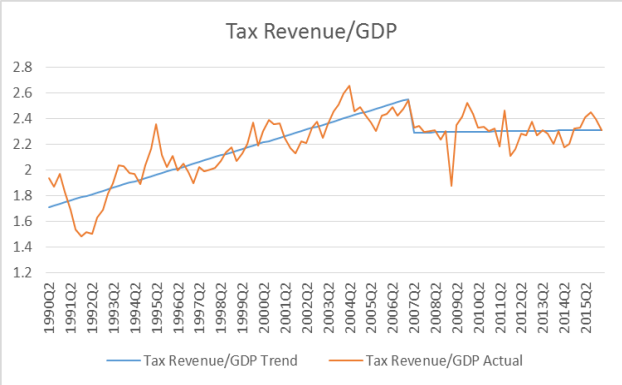
Where, equation (1.5a) is the signal equation and (1.5b) and (1.5c) are the state equations. The trend and cyclical components are denoted as a_t and b_t, respectively, while ω is the respective selected variable to be decomposed. Note that β is the constant for the signal equation, while c_t and d_t are the intercept and trend dummies and (L) represents the lag operator. Also, ϵ_t and u_t are vectors of mean zero with

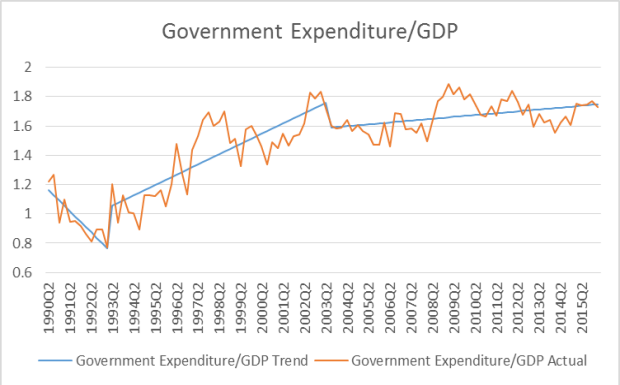
Gaussian disturbances. Each variable was decomposed into their trend and cyclical components using the above framework, with the results displayed graphically in Figure 1.0.

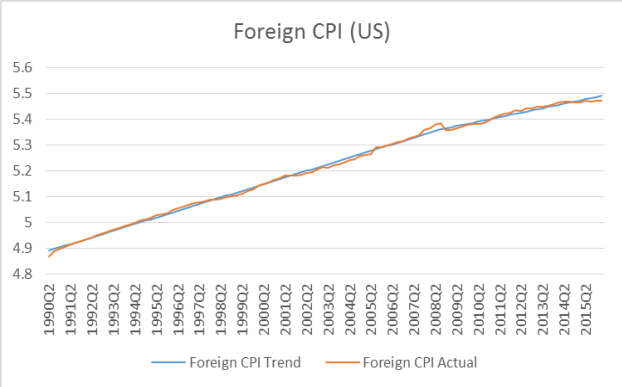
Figure 1.0 Actual and trend component for selected variables.[5]

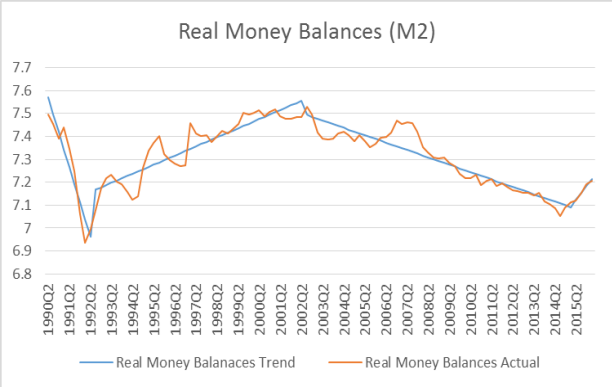


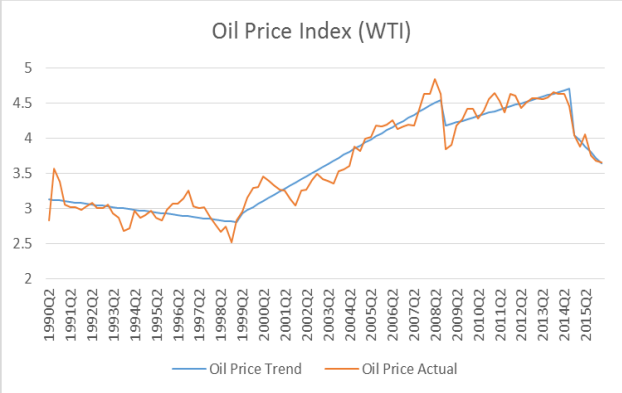
[5] Note that 'actual' reflects seasonally adjusted data

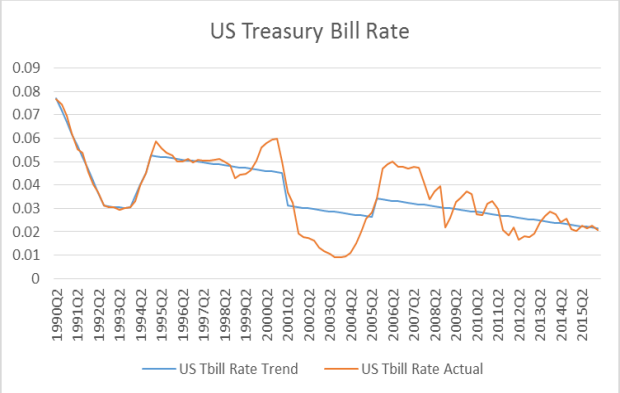












As can be seen form the graphs, the foreign variables are markedly less volatile (with the exception of oil prices) than the domestic counterparts. As a result, structural breaks were necessary features to incorporate in the construction of many of the domestic gap variables. As with any filtering methods, the end points are a challenging element to accurately estimate due to the unknown future points in the data. To ensure accuracy we have checked to ascertain whether alternative end point estimates (for variable such as real money balances, import prices and oil prices) result in significantly different parameter estimates, impulses responses or forecasts. Given we did not find it significantly varying results, we

proceeded using the conventional practice of choosing end points that follow the trend of the raw variables.

2.1.3 Structural VAR Identification and Estimation

As we alluded to earlier, short run restrictions (restrictions on the contemporaneous relationship between variables), long run restrictions (accumulated responses which reflect the relationship between variables in the long run) or a combination of both can be used to identify the B matrix. For this paper and for simplicity, we use short run restriction (only) predicated on economic theory and reasoning.

Table 1.1 Identification Matrix

	v_t^*	y_t^*	i_t^*	p_t^*	Im_t	g_t	y_t	p_t	i_t	s_t	m_t	T_t
v_t^*	■											
y_t^*	■	■										
i_t^*	■	■	■									
p_t^*	■	■	■	■								
Im_t				■	■							
g_t						■						
y_t		■				■	■					
p_t							■	■		■	■	
i_t								■	■	■		
s_t			■						■	■		
m_t							■			■	■	
T_t												■

Identification is derived via block erogeneity restrictions. The first block is the foreign variables block where the first four variables in that block follows a recursive (Cholesky) type of matrix of responses. So, the most exogenous foreign variable enters first, ie. oil price gap, and does not react contemporaneously to any other foreign or domestic variable. In addition, no domestic variable is allowed to impact upon foreign variables contemporaneously, in line with a small open economy specification for the next three foreign variables. Import prices gap is the last foreign variable in the foreign block of variables, and only US inflation gap is allowed to impact upon this variable contemporaneously. The second block of variables relate to fiscal measures (scaled by GDP). These variables are 'partially exogenous'[6] and are also scaled by GDP, hence making the impact of the gap deviations of inflation or GDP on these variables

[6] This is in the sense that fiscal variable movements are subjected to pressures that are not captured by domestic or foreign variables, such as the changes in tax compliance or new tax packages as well as new fiscal programmes from regional or international lending agencies, amongst other influences.

redundant. As such these fiscal measures are restricted to not react to domestic (or foreign) variables contemporaneously.

The third set of variables could be referred to as the monetary authorities' control variables, ie., variables of which the monetary authorities have a direct impact. The nominal exchange rate gap is determined by the usual Uncovered Interest Parity (UIP) condition. For the case of Jamaica, this would normally be accompanied by a risk premium measure, however we allow this to be captured in the error term, with the assumption that its long run value is stable and constant. Domestic output gap is determined by foreign output gap and government expenditure gap. Interest rates rules are derived from a backward looking Taylor rule[7], augmented by the nominal exchange rate gap which is a reasonable assumption for the central bank reaction function. Real money balances gap are given by the usual real money demand function which incorporates transaction and portfolio motives. The price function is given by a backward looking open economy Phillips curve augmented by real money balances. This translates to the price level (in gap deviation form) reacting contemporaneously to output gap, as well as exchange rate and money balances gap.

The restrictions are in the form of exclusion restrictions which translates to placing zeros in the identification matrix, which is illustrated in Table 2.0. The shaded regions are non-zero elements, while the non-shaded regions are zero restrictions. As we alluded to earlier, 66 restrictions were needed to just-identify the model, while 114 restrictions were applied, making the model over-identified. This is important given that the accurate results of an over-identified model acts a further step in verifying if the structural model is the appropriate model for which the observed reduced from relationships were derived. Note that we incorporate a mixture of real and nominal variables, which is suitable given that identification restrictions were based on short run relationships only. We assume in the long run however, that the relations between real and nominal variables evaporates as adjustments take place in relative prices and monetary policy no longer has an impact on output. In terms of lag specification, this was informed by the Schwartz Criterion to be optimal at one. Additionally, given that only 103 observations were used (after adjustments), this is a plausible choice to maintain parsimony and better balance information content with parameter estimation accuracy. We also added a dummy variables to the model, representing the financial crises over the data span. Three other dummies, accounting for the impact of the IMF, the Jamaica Debt Exchange (JDX) and National Debt Exchange (NDX) were not found to be significant and were not included. For SVAR estimation, impulse responses and back-casting results, see

[7] The output gap is however dropped from the Taylor rule, as previous attempts have shown this variable to be insignificant in the central bank reaction function.

results in section 3.1. Note however that the SVAR forecasts are done using the reduced from version of the model.

2.2 VEC Model and Data

With regards to the data that will be used in the VECM, all twelve variables in Table 1.0 will be used as done in the SVAR with the exception of the nominal US/JMD exchange rate, which will be changed to the bi-lateral US/JMD real exchange rate. This is done so as to incorporate accurate long-run equilibrium relationships in the cointegrating vector that I identify and estimate. The variables will all be used in their original level form and not in gap deviation form which is stationary. Given that almost all our macro-variables in their original level forms have a unit root, it is useful to augment the macro-forecasting framework using a VEC model. The question therefore is, how do we handle the variables that are stationary in level form? This will be answered shortly, for now we proceed to the model set up. Unlike the SVAR specification, this model takes into account both the short and long term components of the relationships amongst the variables. Given that economic theory/reasoning is used to identify SVAR models and these theories are based on long run equilibrium relationships, it is useful to use cointegration to aid identification in line with the Davidson (1994, 1998) approach and estimate a VEC model as an alternative. Thus one must aim to identify irreducible cointegrating (IC) relationships when estimating the VECM, similar to a system of equations in structural equation modelling.

Our aim is to produce a VECM model of the form:

$$\Gamma_0 \Delta z_t = \alpha[\beta' : \eta'] \begin{bmatrix} z_{t-1} \\ D_t^{co} \end{bmatrix} + \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_p \Delta z_{t-p} + B_0 x_t + \ldots + B_q x_{t-q} + C D_t x_t + u_t \qquad 1.6$$

where, $z_t = (z_{1t}, \ldots, z_{Kt})'$ is a vector of Kobservable endogenous variables, $x_t = (x_{1t}, \ldots, x_{Mt})'$ is a vector of M observable exogenous variables, D_t^{co} is a vector of deterministic terms (dummies) included in the cointegration relations and D_t contains all remaining deterministic variables. The residual vector, u_t, is assumed to be a K dimensional unobservable zero mean white noise process with positive definite covariance matrix, $E(u_t u_t') = \Sigma_u$. The parameter matrices α and β are $(K \times r)$ dimensional matrices where r is the cointegrating rank, α and β represents the loading coefficients and the matrix with the cointegrating relations, respectively.

To estimate a model of the form depicted in equation (1.6), we start from a unrestricted VAR(1) model of the form:

$$A_0 z_t = A_1 z_{t-1} + e_t \qquad 1.7$$

where, A_i are $(n \times n)$ matrices, A_0 is non-singular by assumption, e_t , is a $(n \times 1)$ vector of reduced form shocks with zero mean and covariance matrix, Σ_n. We use a one lagged model, for two reasons; firstly, this was informed by the Schwartz Criterion in a VAR model of all variables in their original level form and secondly, to be consistent with the SVAR model. Now, let us return to the issue of stationarity of some of the twelve variables in their original level form. We initially start with the I(1) variables only to construct the 'true' cointegrating vector. Of the twelve variables in their original level form, only two variables, the domestic and foreign Treasury Bill rates are stationary, while all others are I(1). Hence, the ten I(1) variables enter the 'true' cointegrating space. As done in the SVAR, we also a crisis dummy variable to the model. We have an option of including this dummy into the cointegrating space (or estimating with dummies outside of the cointegrating space) which we have opted for, given that we expect the events of the various domestic crises to impact the dynamic relations between domestic and foreign variables during these important moments. Notwithstanding this, we still checked whether the number of cointegrating equations would significantly change if the dummy variables are modelled outside of the cointegrating space and this did not materialize. We then add the two stationary variables at a later stage after identifying the 'true' cointegrating space. The steps will be shown in the identification of the model in section 2.2.1.

2.2.1 Identification of VEC Model

Of the ten I(1) variables, 6 cointegrating equations were found. Restrictions to identify the 6 cointegrating equations were based on three considerations, namely, irreducibility from Davidson (1994, 1998), economic theory and Likelihood Ratio (LR) test to test for binding restrictions and the identification of equations. The identification of the cointegrating space will then determine which shocks are transitory and permanent. Irreducibility from Davidson (1994, 1998) broadly implies that if a set of I(1) variables are cointegrated, then this does not necessarily mean the relationships are structural. Also, if an irrelevant variable is added to a cointegrated space, then its coefficient does not converge to zero as in the case of a stationary regression – therefore relationships with irrelevant variables added are no longer structural. What we need are irreducible cointergated (IC) relations where generally there is no way or little room to drop a variable without losing cointegration of the remaining set. Essentially, cointegration has to be identified by the rank condition. The use of over identification restrictions also removes unwanted effects and ensure solved forms are a function of identified structural vectors. Generally speaking, the fewer variables an IC relation contains, then the better chance it is structural and not a solved form. Also, one must minimize the extent to which one variable enters different IC relations. The next step involves adding the stationary or I(0) variables to the model using the pseudo-cointegrating equations, that is, variables 'cointegrating with themselves' approach (see Fisher et al. (2014) for details on this approach).

The complete vector of variables can be classified as, $z_t = (z_{jt}, z_{wt}, z_{qt})'$, where z_{jt}, z_{wt}, z_{qt} are respectively, the $j \times 1$ vector of I(1) variables with permanent shocks, the $w \times 1$ vector of I(1) variables with transitory shocks, and the $q \times 1$ vector of I(0) variables with transitory shocks by assumption. The resulting cointegration matrix of parameters, β, which is of dimension $K \times (w + q)$ is then of the form;

$$\beta = \begin{pmatrix} \beta_j & 0 \\ \beta_w & 0 \\ 0 & I_q \end{pmatrix} \tag{1.8}$$

Where K is the total number of variables in the model. Given that we have twelve in total, ten I(1) variables (with four being permanent shocks and six with transitory effects)[8], as well as two I(0) variables (not including the dummy variable), then $j = 4$, $w = 6$, $q = 2$, and $K = j + w + q = 12$. The first two rows of β are associated with the 'true cointegrating' relations, while the third row is associated with the 'pseudo – cointegrating' variables.

The final estimated model is as follows;

$$\Gamma_0 \Delta z_t = \alpha[\beta' : \eta'] \begin{bmatrix} z_{t-1} \\ D_t^{co} \end{bmatrix} + \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_p \Delta z_{t-p} + u_t \tag{1.9}$$

The actual restrictions used to identify the 'true' six cointegrating equations and the two 'pseudo – cointegrating' equations, totaling eight cointegrating equations, can be seen in Table 1.2. The first six equations (C1 to C6) are the 'true' cointegrating relations, while the final two (C7 and C8) are 'pseudo – cointegrating' relations. The non-shaded regions are zero restrictions, while the shaded regions are free elements. For each equation, a one is placed within one of the shaded regions to indicate that we have normalized the cointegrating equations to that variable. As can be seen from Table 1.2, our restrictions are based on economic theory and reasoning. Domestic output is driven by foreign demand, money demand is determined by the exchange rate through a positive 'transactionary' effect rather than a negative portfolio effect. We could the assumption that government balances its budget in the long run therefore expenditure equals revenues (scaled by GDP), however given the long history of fiscal deficits, we simple restrict expenditure to follow receipts. Domestic inflation is driven by import prices and import prices are driven by foreign inflation. Both interest rates are stationary variables added as 'pseudo-cointegrating' terms in C7 and C8. All cointegrating equations are accompanied by a deterministic constant and a trend in the specification, with the exception of C4 and C6 which do not use a trend.

[8] This is informed from the cointegration test results of six equations, which implies that we can have at most four variables with permanent effects.

Table 1.2 Restricted Cointegration Matrix (restricted VEC model)

	C1	C2	C3	C4	C5	C6	C7	C8
v_t^*					*			
y_t^*	*				1			
i_t^*								1
p_t^*						*		
Im_t				*		1		
g_t			1					
y_t	1							
p_t				1				
i_t							1	
s_t		*						
m_t		1						
T_t			*					

Consistent with the SVAR model, the VEC model forecasts are provided by the reduced form version of the respective models (that is, without structural restrictions on the contemporaneous or short run relationship (Γ_0) or the loading/adjustment coefficients (α)). To identify the impulse response function however, we need to insert such structural restrictions. With respect to the identification of shocks in the long run, we distinguish which variables are allowed to have permanent effects by placing restrictions on the adjustment coefficients in the model. Note however that the identification of the cointegration matrix in section 2.2.1 has already placed 81 zero restrictions on the long run relationships between the variables. For clarity, as long as a variable has an impact on any other variable in the long run, then it is a permanent shock. Based on the statistical significance of the various error correction terms in the short run adjustment equations for all variables, we have designated foreign output, foreign inflation, import prices and real money balances as having permanent effects. The remaining I(1) and stationary variables are transitory shocks to the system.[9] So, if the estimated loading coefficients' matrix, $\tilde{\alpha}$, is of the form;

$$\tilde{\alpha} = \begin{pmatrix} \tilde{\alpha}_1 & \tilde{\delta}_1 \\ \tilde{\alpha}_2 & \tilde{\delta}_2 \\ \tilde{\alpha}_3 & \tilde{\delta}_3 \end{pmatrix} \qquad 1.10$$

[9] Note that we are using the 'pseudo-cointegration' approach for the stationary variables in the model and as such by assumption, the stationary variables are transitory effects (See Fisher et al. (2010) for further details). The statistical significance of the error correction terms however confirms the validity of this assumption.

Where, $\tilde{\alpha}_1$, $\tilde{\alpha}_2$ and $\tilde{\alpha}_3$ are of dimension j x w, w x w and q x w, respectively. While, $\tilde{\delta}_1$, $\tilde{\delta}_2$ and $\tilde{\delta}_3$ are of dimension j x q, w x q and q x q, respectively. Now to use the pseudo cointegration approach for our stationary variables, we must have assumed as well as impose the restriction that $\tilde{\alpha}_1 = 0$ and $\tilde{\delta}_1 = 0$. This ensures that the structural equations with permanent shocks do not contain the lagged 'true' error correction terms and likewise, do not contain the lagged 'psuedo' error corrections terms. This has been shown to be the appropriate approach (see Pagan and Pesaran (2008) as well as Fisher et al. (2013)) when adding stationary variables (that do not have a long run impact on any of the selected I(1) variables) to a VEC model.

Regarding the identification of shocks in the short run (for the VECM Impulse Response function), we use a Cholesky (lower triangle matrix) decomposition with a particular casual ordering of our domestic and foreign variables. We could also place zero restrictions on some cell elements and structurally identify Γ_0 in equation (1.6), however our intention is to utilize the long run restrictions of the model to guide the evolution of the variables while allowing for the data to determine the short run dynamics of the business cycle. The casual ordering of our variables is oil prices, foreign output, foreign interest rate, foreign inflation, import prices, government consumption, tax revenue, real exchange rate, domestic output, domestic interest rate, real money balances and domestic inflation. This was shown to the appropriate choice based on a review of the impulse responses of all variables.

3 Results

In this section, we present the impulse responses and the simulated out-of-sample forecasts (or back-casting) results for both models. For simplicity and the need to conserve space, we only present in the text the impulse responses of all the central banks control variables to a monetary policy shock, as well as the response of output to a shock in all variables. I can also confirm the absence of price and exchange rate puzzles which have frequented the literature. For the simulated out-of-sample forecasts or back-casting results, both models are run using data up to 2014Q1, after which forecasts are done over the sample period 2014Q2 to 2016Q1.

3.1 SVAR Impulse Responses and Variance Decomposition

All impulse responses were largely in line with *a priori* expectations. With respect to the domestic interest rate shock, the responses of domestic output, domestic inflation and real money balances were declines as expected which dies out after roughly 20 quarters. There is an initial increase in domestic

output in the first quarter only but this is quickly ‘corrected’ with a significant decline thereafter in the subsequent quarters. This could be attributed to the sharp reduction in inflation in the first quarter, whereas it is typically the case for Jamaica, that a monetary policy contraction does not impact economic activity until the third quarter. The response of the nominal exchange rate is an immediate appreciation which dies out after 12 quarters. As such, there are no price or exchange rate puzzles in the results which serves as a further check of the specification validity.

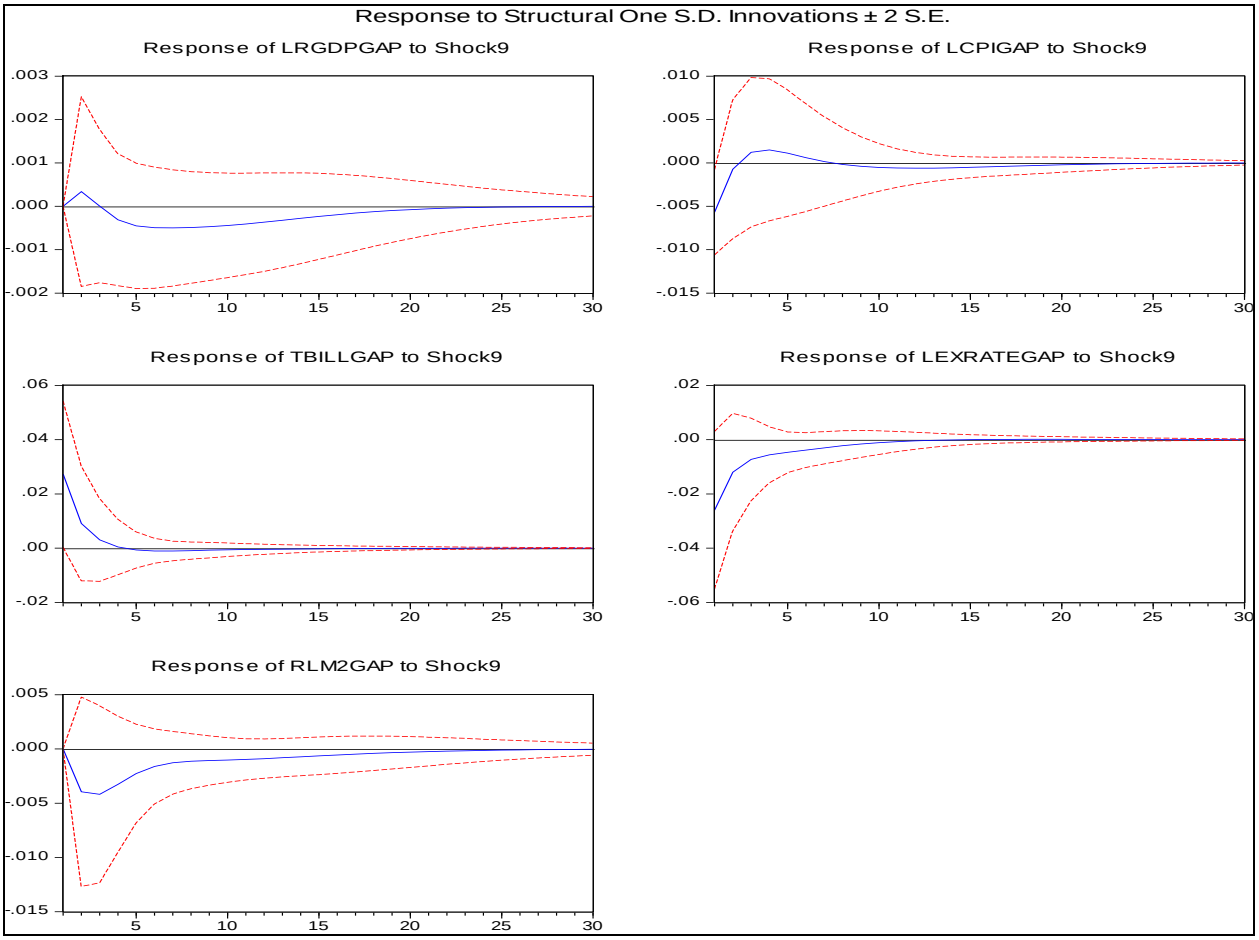
With respect to the responses of real GDP to all shocks (placed in Figure 1.2), the results are in line with *a priori* expectations. Oil prices tend to increase output initially (first quarter) due to the immediate increase in the price of imports which reduces import demand, however this effect turns negative in the following periods as the high import input and energy component of manufactured exports takes effect, resulting in reduced demand for higher priced exports and an overall effect which is closer to a accumulative zero impact. The impact of import prices on GDP is however more pronounced, where after a similar immediate increase in real GDP due to the immediate price impact on import demand, this quickly gives way to a reduction in real GDP, due to the reduction in demand for higher priced exports. In terms of the other foreign variable effects, as expected US real GDP has a very significant positive impact that lasts for roughly 24 quarters, while the positive impact from US inflation lasts only 8 quarters. The latter impact occurs due to the competiveness effect on Jamaican exports emanating from higher US inflation. US monetary policy has no impact on domestic GDP.

With regards to the response of real GDP to domestic variables, government consumption tends to impede growth consistent with the crowding-out effect, while domestic inflation and interest rate reduces real GDP over the 24 quarters. Shocks to real money balances or money supply, firstly increase real GDP up to quarter 5, after which real GDP is reduced in the following quarters leading to an accumulative zero impact. This is exactly in line with what is expected in first the short run, then the long run, of a monetary supply shock on real GDP. There is also the result that suggests the absence of the usual competiveness effect following a shock to the nominal exchange rate. However, in addition to the fact that only the real exchange rate should be used in such a case to truly assess the competiveness effect, the high import content of exports ensures that one has to do further investigation to assess whether the conventional competiveness is actually present anyway. This will be assessed in the VEC model which uses the bilateral real exchange rate. What is for certain however, is that nominal exchange rate depreciation does not lead to real GDP growth. Also from the results, a tax shock increases real GDP, which may seem incorrect given that this should tend to reduce real GDP, however if the data span covers periods where tax increases were a part of fiscal deficit containing or fiscal reform programmes (which is the case for Jamaica), then tax shocks may show real GDP growth in impulse responses. This is because deficit-driven

tax increases may have important expansionary effects through expectations and long-term interest rates, or through confidence (see Romer and Romer (2007) for further details). Diagnostically, the model residuals fall largely within the specified 95.0 per cent interval bands and the inverse roots of AR characteristic polynomial lie within the unit circle.

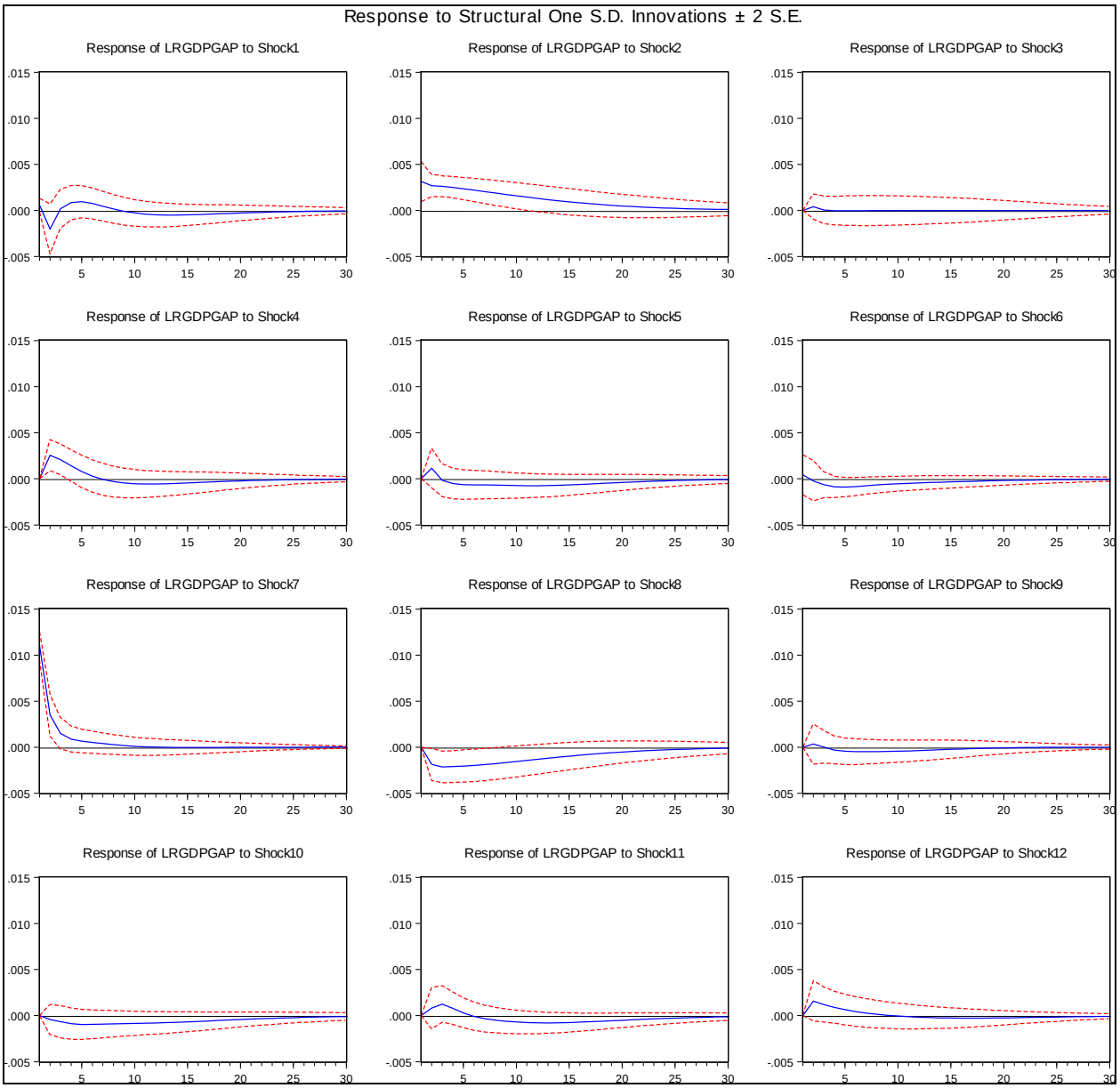
With regards to the variance decomposition of domestic output gap, about half the variation is explained by itself (shock 7) over a two year horizon, after which this falls to about 43.0 per cent after 6 years. Foreign output gap (shock 2) is the next leading determinant of output gap variation with roughly 20.0 per cent. This is followed by the inflation gap with 14.0 per cent, with US inflation gap and the exchange rate gap with 5.0 and 4.0 per cent, respectively. Overall this suggests that foreign shocks are the most important and influential on domestic output gap, whereby the competitiveness effect only accounts for a minimal amount of output gap variation. The model also indicates that monetary policy cannot account for any significant variation in the output gap.

Figure 1.1 SVAR Model Domestic Interest Rate Shock



Notes: Shock 9 is an interest rate shock or monetary policy shock. LRGDPGAP is output gap, LCPIGAP is consumer prices gap, RLM2 is real money balances gap, LEXRATE is nominal exchange rate gap and TBILLGAP is interest rate gap.

Figure 1.2 SVAR Model Impulse Response of Real GDP to all shocks



Notes: LRGDPGAP is output gap. Shock 1 is oil price shock. Shock 2 is foreign output shock. Shock 3 is foreign interest rate shock. Shock 4 is foreign inflation shock. Shock 5 is import price shock. Shock 6 is government consumption shock. Shock 7 is domestic demand/output shock. Shock 8 is domestic inflation shock. Shock 9 is domestic interest rate/monetary policy shock. Shock 10 is nominal exchange rate shock. Shock 11 is real money balances shock. Shock 12 is tax revenue shock.

Figure 1.3 SVAR Variance Decomposition of Output Gap.

Period	S.E.	Shock1	Shock2	Shock3	Shock4	Shock5	Shock6	Shock7	Shock8	Shock9	Shock10	Shock11	Shock12
1	0.133	0.241	7.418	0.000	0.000	0.000	0.144	92.197	0.000	0.000	0.000	0.000	0.000
4	0.158	2.469	14.330	0.077	6.126	0.783	0.686	65.115	6.034	0.101	0.676	1.349	2.253
8	0.162	2.668	18.805	0.065	5.327	1.318	1.560	53.691	10.798	0.448	1.918	1.279	2.124
12	0.164	2.571	20.148	0.059	5.192	1.951	1.780	48.262	12.899	0.653	2.696	1.863	1.926
16	0.164	2.752	20.299	0.056	5.198	2.443	1.840	45.491	13.603	0.705	3.191	2.524	1.898
20	0.164	2.849	20.238	0.054	5.176	2.678	1.862	44.330	13.814	0.705	3.440	2.915	1.940
24	0.164	2.876	20.195	0.054	5.158	2.759	1.870	43.922	13.874	0.700	3.539	3.077	1.975

3.1.1 VEC Model Impulse Responses and Variable Decomposition

As with the SVAR model, the complete set of shocks and response are largely in line with *a priori* expectations, however we only impulse responses relevant to our assessment. With respect to the domestic interest rate shock, we see very similar results with the SVAR model which bodes well for the specification accuracy of both models. Domestic output, domestic inflation and real money balances declines due to the shock as expected and dies out after roughly 25 quarters with the exception of real money balances which takes much longer to dissipate. There is an initial increase in domestic output in the first quarter only (likewise with the SVAR model) but this is quickly corrected with a significant decline thereafter in the subsequent quarters. Again, this could be attributed to the sharp reduction in inflation in the first quarter, whereas the monetary policy contraction does not impact output until the third quarter. With respect to the real exchange rate response, there is an immediate appreciation of the exchange rate with no significant overshooting which dies out after 22 quarters. Generally, the VEC model results tends to show a slightly more prolonged estimated relationship between the variables. This could be the consequence of using the cointegration of I(1) variables as well as other long run restrictions, rather than an estimation of the relationship between the cyclical component of the variables as done in the SVAR.

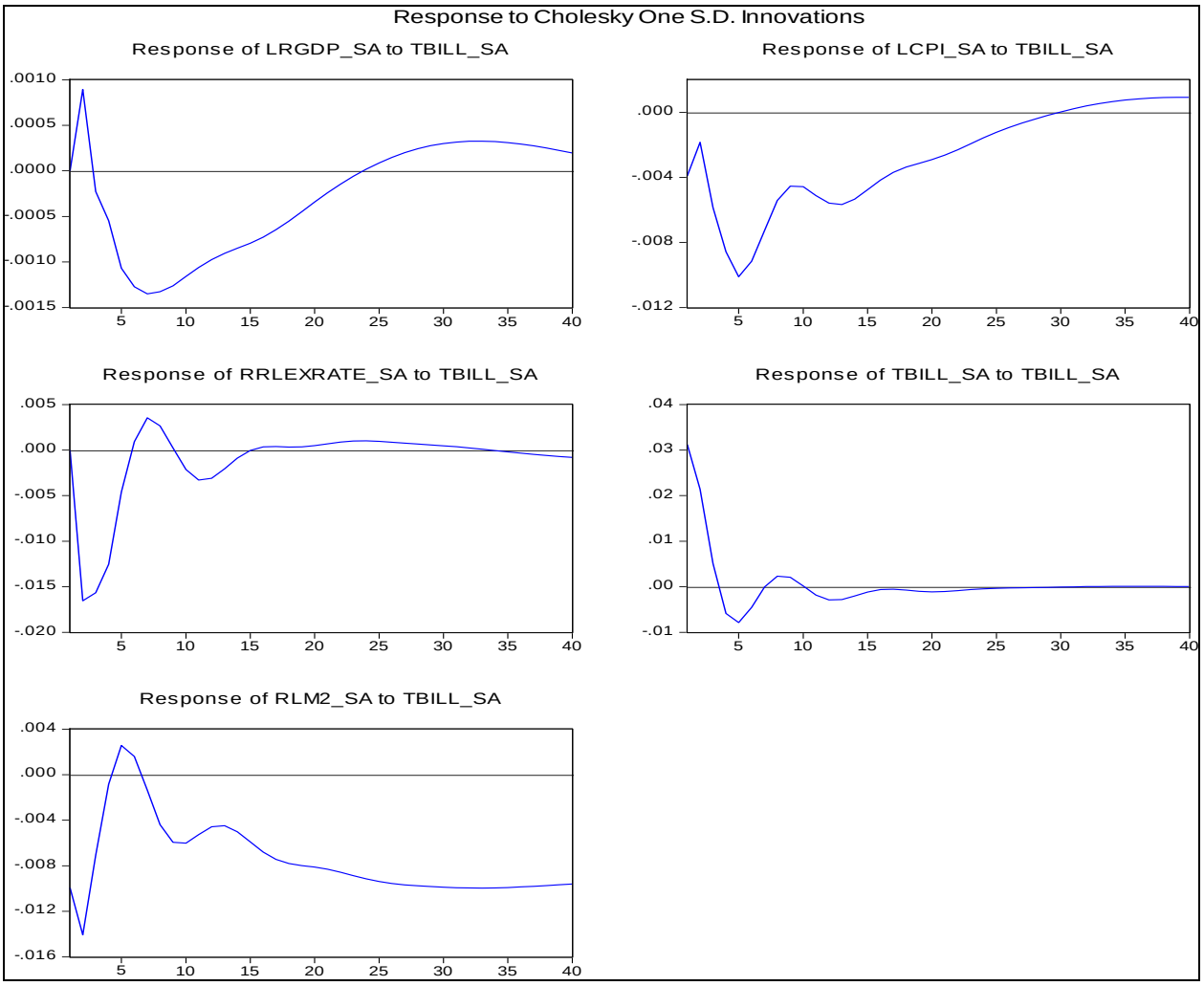
With respect to the response of domestic real GDP to all shocks, these are largely in line with the SVAR impulse responses, but they are a few key differences to highlight. Firstly, the use of the real exchange rate in the VEC model as opposed to the nominal exchange rate used in the SVAR, has resulted in a clear depiction of the competiveness effect that was not seen in the SVAR. This effect lasts for about 18 quarters. With respect to the response of real GDP to shocks in the foreign variables, all responses are in line with the SVAR responses. With respect to import price shock, the increase in GDP brought about by the subsequent decrease in the trade balance is now strong and sustained until quarter 8 then dissipates after, as opposed to the short lived increase, then subsequent decrease, seen in the SVAR.

With respect to the response of real GDP to the domestic variable shocks, the responses of real GDP are relatively in line with the SVAR results. Of note however, the crowing out effect is slightly less pronounced (given that after 15 quarters this effect is reversed suggesting that the long run impact of GDP consumption may be different to its short run crowding out impact), and the response to a tax shock results in an immediate output decline, then subsequent increase as opposed to the absence of an immediate reduction in the SVAR results. The actual reduction in real GDP due to the tax shock is not seen until after 18 quarters and is still not enough to induce an accumulative decline. Other important differences are seen in the time it takes for the impact of the shock to dissipate, where shocks to real money balances, domestic inflation and fiscal measures takes a longer time to die out, hence our need to extend the graphs to 40 quarters rather the previous 24. It should also be noted that we have specified certain variables[10] to have permanent effects, which has extended the adjustment period of variables in the VEC model.

With regards to the variance decomposition, while the results are similar, there are key differences for some variables in comparison the variance decomposition in the SVAR model, albeit the SVAR model uses variables in gap deviation form. After two years, half of the output variation is explained by itself and after six years this reduces to 33.0 per cent which is slightly lower than the SVAR. Foreign output accounts for 20.0 per cent after two years which is in line with the SVAR but 44.0 per cent after six years, which is much higher than the SVAR results at six years. This could be influenced by the strong long run relationship between foreign and domestic output as well as the fact that these are variables with unit processes as opposed to variables measured in gap deviation form. Also, the real exchange rate accounts for a larger percentage of the variation in the VEC model with roughly 10.0 per cent. Again, this could be de the competiveness effect being a long run phenomenon, thus inhibiting strong evidence of its significance in determining output when using variables in gap deviation form. All other variables accounted for only a small amount of output variation.

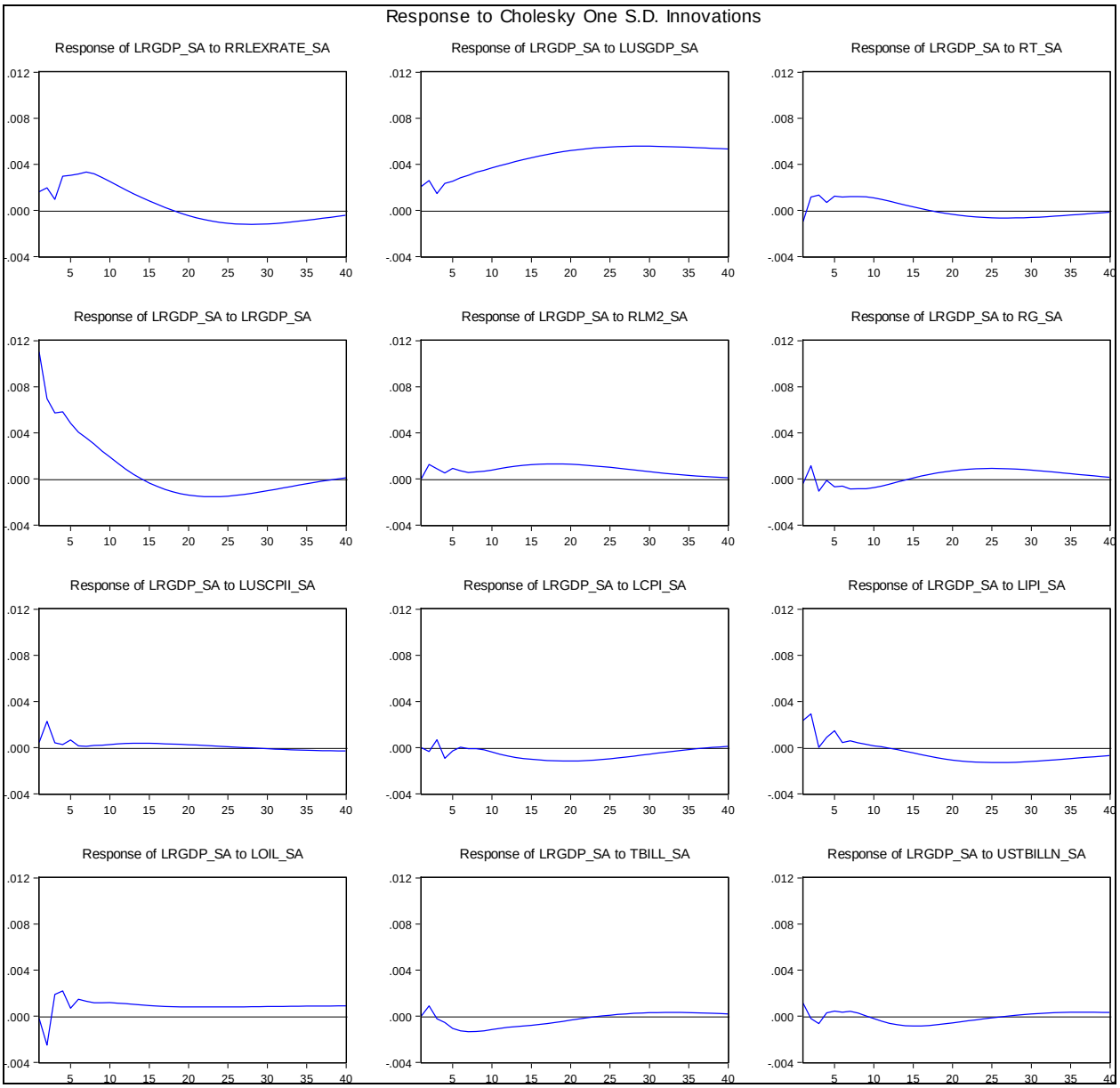
[10] These are oil prices, US real GDP, real money balances and US inflation.

Figure 1.4 VEC Model Domestic Interest Rate Shock



Notes: LRGDP_SA is domestic output (log real GDP), LCPI_SA is log consumer price index, RLM2_SA is log real money balances, RRLEXRATE_SA is log real exchange rate and TBILL_SA is domestic interest rate.

Figure 1.5 VEC Model Impulse Response of Real GDP to all shocks



LOIL_SA is log oil price index. LUSGDP_SA is log US real GDP. USTBILLN_SA is US Treasury Bill rate. LUSCPII_SA is log US consumer price index. LIPI_SA is log import price index. RG_SA is government consumption (scaled by GDP). LRGDP_SA is log domestic real GDP. LCPI_SA is log domestic consumer price index. TBILL_SA is domestic Treasury Bill rate. RRLEXRATE_SA is log real exchange rate. RLM2_SA is log real money balances. RT_SA is tax revenue (scaled by GDP).

Figure 1.6 VEC Model Variance Decomposition of Output Gap.

Period	S.E.	RRLEXRATE_SA	LUSGDP_SA	RT_SA	LRGDP_SA	RLM2_SA	RG_SA	LUSCPII_SA	LCPI_SA	LIPI_SA	LOIL_SA	TBILL_SA	USTBILLN_SA
1	0.039	1.912	3.188	0.690	88.922	0.000	0.112	0.153	0.000	4.064	0.028	0.000	0.932
4	0.083	5.058	5.833	1.424	73.703	0.823	0.805	1.753	0.452	4.656	4.574	0.358	0.562
8	0.094	11.729	11.057	2.146	61.582	0.963	1.016	1.267	0.320	3.676	4.207	1.547	0.490
12	0.107	13.244	18.563	2.433	51.959	1.261	1.142	1.088	0.430	2.999	4.291	2.092	0.498
16	0.120	11.864	27.201	2.169	44.213	1.884	0.990	1.003	0.903	2.647	4.161	2.160	0.804
20	0.132	10.050	35.103	1.853	37.984	2.392	0.990	0.888	1.395	2.648	3.834	1.946	0.916
24	0.142	8.806	41.461	1.681	33.082	2.570	1.133	0.764	1.667	2.847	3.502	1.655	0.832

LOIL_SA is log oil price index. LUSGDP_SA is log US real GDP. USTBILLN_SA is US Treasury Bill rate. LUSCPII_SA is log US consumer price index. LIPI_SA is log import price index. RG_SA is government consumption (scaled by GDP). LRGDP_SA is log domestic real GDP. LCPI_SA is log domestic consumer price index. TBILL_SA is domestic Treasury Bill rate. RRLEXRATE_SA is log real exchange rate. RLM2_SA is log real money balances. RT_SA is tax revenue (scaled by GDP).

3.2 Simulated Out-of-Sample Forecasting Results

In this section, we run each model using data up to 2014Q1, then forecast the main domestic macroeconomic variables up to 2016Q1, for which there is data to compare. Therefore we produce 'simulated' out-of-sample forecasts for domestic output, inflation, the nominal exchange rate and real money balances. Importantly, we do not allow data after 2014Q1 in this estimated model, as including this data will result in forecasts that are 'in-sample' giving an overly optimistic view of the models forecasting accuracy. Also, note that for the VEC model (which uses the real exchange rate as opposed to the nominal exchange rate as done in the SVAR) we use the forecasts of domestic inflation, foreign inflation and the real exchange rate, to re-calculate the forecasts for the nominal exchange rate. Both models do not incorporate any assumptions of variable paths in the future as all variables are treated as endogenous in the model. The SVAR model forecasts the cyclical components of each variable as shown above, while the trend components is forecasted using trend regressions. The actual variable forecasts we show in the SVAR section are therefore constructed by adding the trend forecasts to the SVAR cyclical forecast for each variable. Note also that for both models, the variables were initially seasonally adjusted, so in order to compare our results to actual data up to 2016Q1, the variables are re-adjusted to their raw form using the seasonal factors.

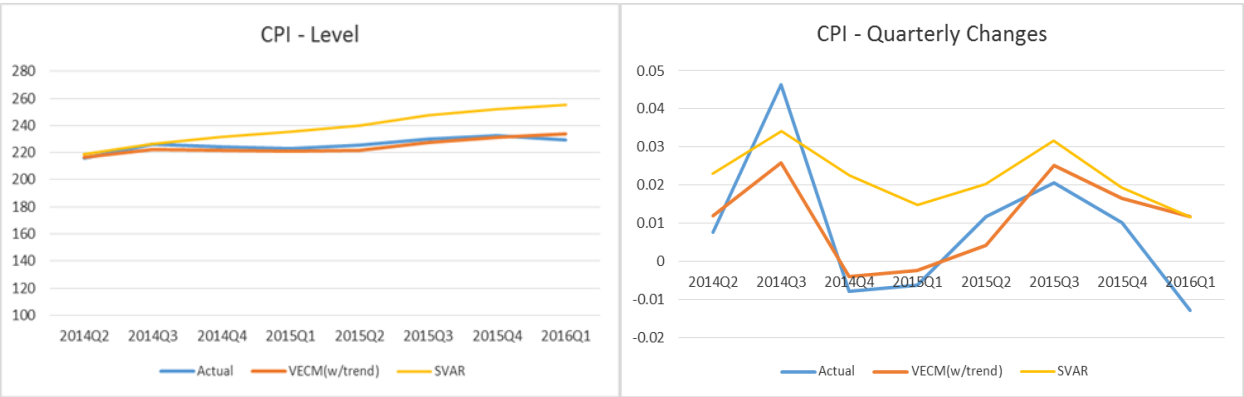
In terms of the results, both models do quite well in forecasting output and real money balances. Output is forecasted best which is in line with expectations given that variable inclusions and relationships built into the model were solely predicated on capturing business cycles. The VEC model is slightly better both at the short and longer term horizons in the prediction of the level, direction and turning points in real GDP. In terms of real money balances, both models one step ahead prediction is overestimated which results in a trajectory that is slightly higher than the actual outturn. The models however do a very good

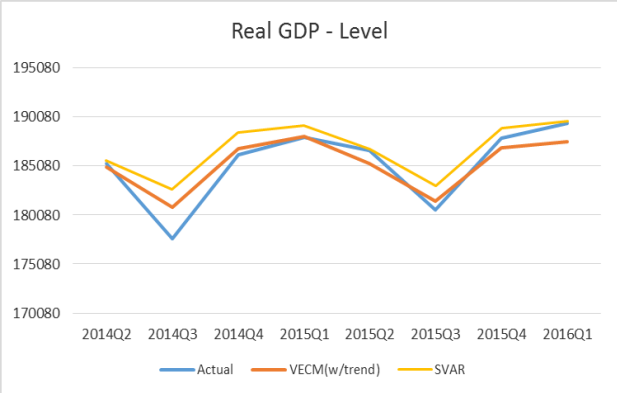
job in predicting the magnitude and turning points (direction) of real money balances, ensuring that the trajectory of the forecast stays in line with the actual outturn for the two year horizon. The forecasting power in relation to output and money is therefore very good for both models.

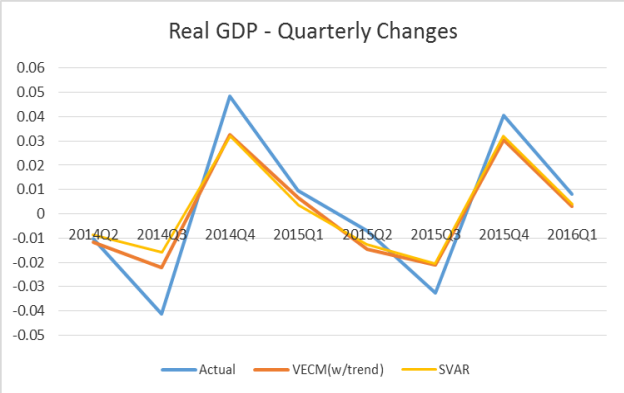
With respect to inflation, the VEC model also does remarkably well in predicting future inflation and represents an area where the VEC model significantly outperforms the SVAR model. While the turning points are predicted well by both models, the greater accuracy of this in the VEC model results in a near perfect tracking of future CPI levels. The SVAR on the other hand tends to overstate inflation beyond a one year horizon. With respect to the nominal exchange rate, both models do not predict the exchange rate with significant accuracy. This is not a surprise however, given that the exchange rate is a variable which is notoriously difficult to predict in models that are not built primarily for that purpose.

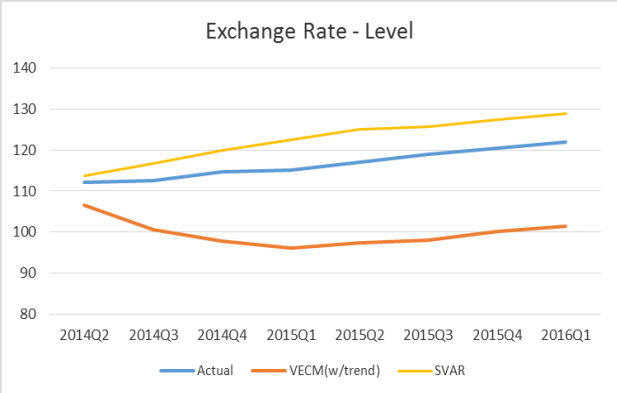
It should be noted that while the SVAR does a better job at predicting the exchange rate, the forecasts of the SVAR do not need a forecast of domestic and US inflation to be computed. This is as opposed to the VEC model which forecasts the real exchange rate which we then convert to the nominal exchange rate using domestic and US inflation forecast. This results in an increased potential for forecasting error which may have materialized in the VEC model overstating the appreciation (and significant slowdown in the rate of depreciation) in 2014 following the recent IMF arrangement. Note however that the turning points are always consistent and the magnitude of changes becomes more accurate beyond the one year horizon resulting in a trajectory that converges with the actual outturn after one year. A future version of this paper will include variables such as an order flow proxy variable and another variable that predicts the exchange rate and US inflation in the short run reasonably well.

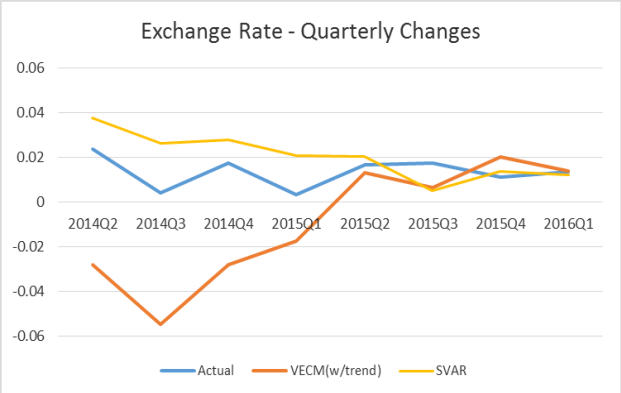
Figure 1.7 Simulated Out-of-Sample Forecasts

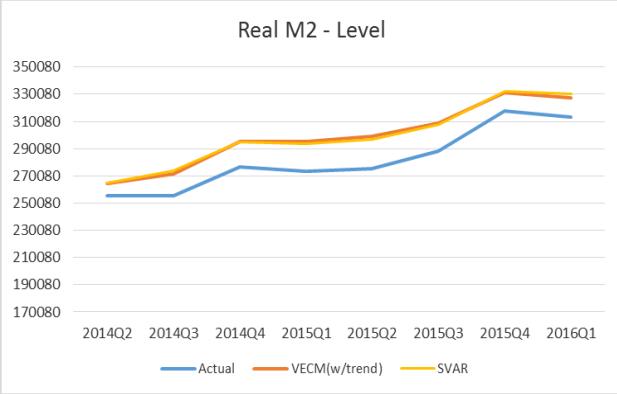


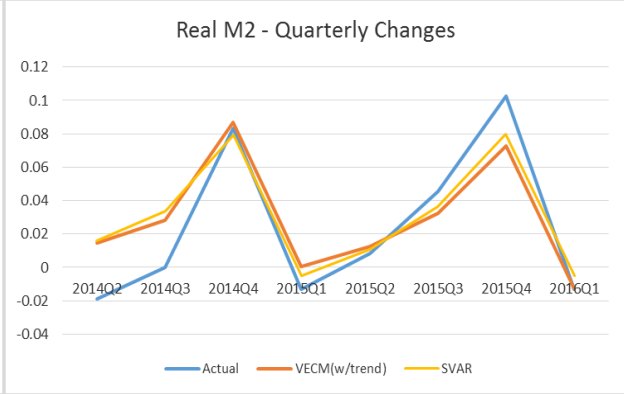












4 Conclusion

In this paper, we developed two small structural models of the Jamaican business cycle using SVAR and VEC frameworks. The main aim of the models is the provision of unconditional forecasts of variables that have a strong theoretical and empirical importance in the Jamaican business cycle, thus serving as an extension to Murray (2007). The SVAR model variables were constructed using a Kalman filter to

determine the trend after which they are transformed into gap deviation form. A crisis dummy variable and the model is identified using short term zero restrictions based on economic intuition and theory. A VEC model is also produced taking advantage of the long term component of the macroeconomic relationships between the variables. The identification approach of the model is similar to that of Fisher, Huh, and Pagan (2013) Dungey and Vehbi (2011), and Pagan and Pesaran (2008) where cointegration analysis is used to distinguish between permanent shocks and temporary shocks, and two stationary variables (domestic and foreign interest rates) are added in the form of a pseudo-cointegrating vector. Impulse responses of both models were shown to be reasonable impersonators of the actual structural relationships in the economy given that they were derived from the structural factorization of the model (in the case of the SVAR) or reasonable approximations of the structural relationships using adjustment coefficients (in the case of the VEC model) without any puzzles or results against economic reasoning and theory.

The main focus was to ensure the models are structural and tractable. Structural in the sense that shocks (or variable relationships) have a direct economic meaning or interpretation and tractable in the sense that the model is adequately small but well specified to the extent that one can easily trace the impact of shocks when investigating particular results. Both models tended to show consistent results in terms of magnitude and direction of the responses to respective shocks. One key difference which is seen between models however, is that some of the responses to shocks in the VEC model are longer lived or more persistent, emanating from the designation of some permanent shocks in the VEC system. Importantly however, there are no monetary policy, price or exchange rate puzzles in the results which have frequented the literature of models identified using short term structural restrictions. We mainly found that foreign shocks are the main drivers of the business cycle, with foreign prices, output and the real exchange rate being key determinants of both output variation and its level.

Simulated-out-of-sample forecasts for both models proved to be a strong indicator of the models usefulness and accuracy. The VEC model does a remarkably good job at forecasting inflation and real GDP. While the SVAR does well at forecasting output as expected, its inflation forecasts tends to be slightly overstated. Real money balances are also forecasted fairly well and in equal measure by both models. The forecast performance of both models is very good, with the exception of the exchange rate which is less accurate. A key modification of this paper will be the addition of variables that improves the accuracy of exchange rate unconditional forecasts.

The main policy recommendation emanating from this study is that given that foreign shocks appear to be significantly more important to output determination, the monetary authorities should focus heavily on

the external sector and clearly and routinely define the equilibrium path for output as derived by an external sector evaluation. Using monetary policy to direct the business cycle may be very problematic, given that most domestic variables have a significant foreign component. Notwithstanding, the real exchange rate could be a key control variable for the central bank in this regard, however the extent to which this can be used to manipulate business cycles is often questioned, with no significant investment in export goods capable of reaping significant benefits from increased competiveness. The effect is statistically present as the model suggests, but the potential for a much larger impact is currently not being harnessed, which would incidentally be a key pathway to greater central bank control over business cycles in the economy.

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