ECCB STAFF RESEARCH PAPER

INSPECTING THE MECHANISM: EXTERNAL SHOCKS AND THE ECCU

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GARFIELD RILEY

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ABSTRACT

This paper documents detailed evidence on the influence of external shocks on macroeconomic fluctuations in the Eastern Caribbean Currency Union. Using a Bayesian VAR model, it finds that almost half of the variation in ECCU growth over the 1977 – 2008 period can be explained by external shocks. Of these, US demand shocks exert the greatest influence, followed by world interest rate shocks. An increase in US real GDP growth (interest rates) is expansionary (contractionary). Conditional forecasts, based on likely scenarios of the evolution of key external variables, highlight the sensitivity of the ECCU to renewed concerns about US growth and increases in oil prices.

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1.0 Introduction

The study of the international transmission of nominal and real shocks continues to be an active research area, despite a fairly long history. A possible reason for such longevity is the ambiguity in both theoretical prescriptions and the empirical evidence gathered on the issue. For example, traditional open economy models predict a worsening of the foreign trade balance and output in response to a domestic monetary expansion, through an expenditure switching effect[1]. However, the reduction in foreign output may be attenuated or even be reversed if the foreign trade balance improves through an income absorption effect. More modern approaches, such as the inter-temporal model of the current account also entail an expenditure reducing effect on foreign output. A fall in the world real interest rate as a result of a monetary expansion – particularly if the home country is economically large – may however increase world aggregate demand. Foreign output may thus expand as a result.

The small open economies of the Eastern Caribbean Currency Union (ECCU) provide a fertile testing ground for examining the international transmission of nominal and real shocks. By virtue of their size, plausible identifying assumptions can be made about the sources of these shocks, propagation mechanisms, and ultimate impact on the domestic economy. It is difficult to argue with the conjecture that macroeconomic developments in the ECCU are highly contingent on external developments. To date however, little is known, in a *quantitative* sense, of the magnitude and relevance of these shocks and the adjustment path of the ECCU economy in response to these external events.

An assessment of the sources and magnitude of external disturbances and their effects on the ECCU is important for several reasons. An identification of such disturbances enhances the understanding of macroeconomic fluctuations in the ECCU. Of even more import from a policy perspective, an understanding of these shocks can inform policy design and practice. A more nuanced discussion can then be conducted, for example, on

[1] We have in mind here the Mundel-Fleming-Dornbusch open economy model; see Stockman and Obstfeld (1985) and chapter 9 of Obstfeld and Rogoff (1996) for a basic exposition.

whether to accommodate external shocks, or to try to insulate the domestic economy from such shocks. Obviously, policy reaction functions depend to a large extent on how much external events drive macroeconomic fluctuations. The policy space will be curtailed if foreign factors are the major component of business cycle fluctuations. Even in this case, however, an understanding of the sources and effects of these shocks will be quite important.

Macroeconomic outcomes in the ECCU over the period 2003-2007 were quite favourable. Real output expanded by 5.0 per cent, the longest such expansion since the 1980s. Although an improvement in domestic policy – such as fiscal consolidation and improved debt management in some countries – undoubtedly played a role, the external environment was also extra-ordinary, with high global growth and easy access to financing resulting in a rapid increase in private capital inflows. This leads to the main empirical questions of this paper. Can the growth gains achieved over the last five years be sustained in a less benign external environment? What has been the influence of external factors on macroeconomic outcomes in the ECCU? How has the time path of the domestic economy been altered by such factors?

This paper proposes to address these issues using a Bayesian VAR (BVAR) model in a block recursive formulation. More precisely, the model contains two blocks – a foreign block and a domestic block. This strategy exploits the small open economy assumption in that foreign variables are completely exogenous to the domestic economy, thus resolving the identification problems endemic in studies of the transmission of monetary and real shocks. Standard VAR tools, such as variance decompositions and impulse response analysis, are utilized to assess both the quantitative relevance of foreign shocks and the dynamic adjustment path of the ECCU economy in response to such shocks. The use of a BVAR offers some advantages, both in helping to overcome the deficiencies of traditional VARs, and in scenario forecasting.

This strategy has been previously used in the literature on the international transmission of shocks. The ones closest to this paper are Osterholm and Zettelmeyer (2008) and

Abrego and Osterholm (2008). The empirical literature in this area is vast, and a comprehensive survey is outside the realms of the present study. For developing countries see Canova (2005); Kose and Rebucci (2005); Sosa (2008); Izquierdo, Romero and Talvi (2008) examine the effect of external factors on growth in Latin America; Berg (2003) and Cushman and Zha (1997) focus their efforts, inter alia, on Hong Kong, Brazil and Korea, while Cashin and Sosa (2009) examine the six independent members of the ECCU.

To preview the main results:

- External shocks – demand shocks, monetary policy shocks and oil price shocks – explain almost half of the forecast error variance of the growth of ECCU real GDP at standard medium-term horizons. Of these shocks, US demand shocks turn out to be the most important, accounting for well over half of the contribution of external shocks.
- The impulse responses confirm popular notions of the impact of the shocks considered on ECCU growth. Demand shocks are expansionary, and persistent, with effects lasting for 3 years. A monetary tightening (stricter financing conditions) presages a contraction in ECCU growth. Similarly, increases in oil prices lead to a deterioration in economic activity within the ECCU.
- Conditional forecasts suggest that ECCU growth would not be resilient to a contraction in the United States, or an increase in oil prices. Either of these two scenarios implies that domestic output would contract, or be significantly reduced, depending on the parameterization used for the shocks.

The paper proceeds in the following manner. Section 2 sets out the econometric approach, including model specification and testing procedures. Section 3 contains the empirical results; section 4 conducts scenario forecasting analyses, and section 5 concludes.

2.0 Econometric Method

The point of departure in assessing the role of external factors on macroeconomic fluctuations in the ECCU is a Bayesian VAR with block exogeneity restrictions. VAR models have become a key tool in modern macroeconometrics, for several reasons: they impose relatively few restrictions on the data generating process and perform relatively well in forecasting. The cost of this flexibility, however, is 'over-fitting' of the model by using generous lag lengths. This over-parameterisation problem is potentially catastrophic in small samples, leading to imprecision of estimated parameters and large out of sample forecast errors. Constructing decision rules to choose an 'optimal' lag length is one way to address this. A more efficient way out of this impasse is to employ Bayesian VAR modeling, which reduces the over-parameterisation problem by making judicious use of extra-sample information. As a general rule, this results in a first order improvement in forecasting performance relative to traditional VARs. Thus, the analysis proceeds by employing a Bayesian VAR.

2.1 Methodology

To fix ideas, consider a small open economy such that developments in the rest of the world can be considered strictly exogenous. The structural model of such an economy can be denoted as:

$$G(L)x_t = \mu + \eta_t \tag{1}$$

Where *G (L)* is a lag polynomial of order *p*, x_t is an *nx1* vector of macro variables (domestic and external), μ is a vector of 1,s and η_t is an *nx1* vector of normally distributed error terms. Note however, that the structural model cannot be directly estimated; to recover the structural parameters in *G*, we must first estimate a reduced form model of the type:

$$A(L)x_t = \delta + v_t \tag{2}$$

Where *A (L)* is a lag polynomial of order *p*, such that $A(L)=(A_0)^{-1}G(L)$ with $A_0=I$ and v_t an *nx1* vector of normally distributed reduced form errors satisfying $v_t=(G_0^{-1})\eta_t$. The relation between structural and reduced form is then used to recover the structural model, i.e. recover the parameters in G_0. In order to achieve identification, however, at least $n(n-1)/2$ restrictions must be imposed on the system; these restrictions are given in the G_0 matrix. The standard way to identify such a system is to orthoganilise the reduced form errors by Choleski decomposition. A natural way to conduct such an orthogonalisation, in the context of this study, is to use the small open economy assumption in specifying that the external variables are causally prior to domestic variables in matrix *G*. This ordering implies that foreign variables do not respond contemporaneously to shocks in ECCU variables, but ECCU variables may be affected (by construction) by innovations in external variables.

It is important to note however, that the Choleski factorization imposes restrictions on the *contemporaneous* relationships between the variables in the system. In principle, lagged ECCU variables can still impact external variables. Most authors impose *complete* exogeneity of the external variables by an additional restriction that lagged values of domestic variables should not appear in the equations for external variables (Sosa 2008; Cashin and Sosa 2009; Cushman and Zha 1997 and Genberg 2003). A practical way to do this is to separate the model into two blocks of equations: one external block and one domestic economy block.

Given that some of the equations in the VAR specified above have different regressors, (denoted a "near-VAR" in the literature) the usual practice of estimating VARs by least squares may be inefficient. A potential remedy is to estimate the system using SUR (Seemingly Unrelated Regressions) techniques. The standard results in the SUR versus OLS debate imply that there will be gains in efficiency if the residuals are correlated across equations. If residual correlation is low, the gains in efficiency might be small. Moreover, feasible GLS procedures like SUR can introduce bias and inflate variances, so the cost of using this strategy may even be higher.

A complementary approach is to estimate the system using Bayesian techniques. This offers several advantages; most appropriate for the purposes of this paper is that it offers more precise estimation of the parameters, and provides a model consistent measure of forecast uncertainty, in a sense to be made explicit below. Although the Bayesian approach was introduced into VAR modeling to circumvent the 'over-fitting' problem of standard VARs, it has also proven amenable to policy analysis (see Osterholm 2008; Villani and Warne 2003; Smets and Wouters 2003). Bayesian analysis solves the over-fitting problem without necessarily imposing exact zero restrictions on the coefficients. It also does not impose complete exogeneity of the external variables with probability one as in the near-VAR approach. In other words, the subjective prior belief of exogeneity can be assumed, but if the data rejects it the Bayesian approach flexibly updates this prior belief and amends the estimates accordingly.

The starting point of many Bayesian VARs is the so-called "Minnesota (or Litterman) prior". To obtain a prior that could be implemented without undue computational burdens , Doan, Litterman and Sims (1984) assume that the prior distributions on the lags of endogenous variables are independently normal, and the means of the prior distributions for all coefficients are zero. An exception is the first own lag of the dependent variable in each equation, which is given a prior mean of one by default. This relies on the assumption that most macroeconomic time series can be reasonably described as random walk processes. These assumptions reduce the information required in specifying the prior to a few "hyper-parameters", which are governed by the expression:

$$S(i,j,l) = \frac{\{\gamma g(l) f(i,j)\} s_i}{s_j} \quad ; \qquad f(i,i) = g(l) = 1.0 \tag{3}$$

Where γ is the standard deviation on the first own lag, measuring the overall 'tightness' of the prior; $g(l)$ measures the tightness on lag l relative to lag 1 in equation i; $f(i,j)$ represents the tightness on variable j in equation i relative to variable i, and s_i is the standard error of a univariate auto-regression on equation i. The prior is scaled by the standard error to correct for different units of measurement for the variables in the system. The Minnesota prior thus allows individual prior variances to be determined by a small set of hyper-parameters. Note that depending on the value of these hyper-parameters, a Bayesian VAR model could collapse into a traditional VAR, a random walk, or a univariate auto-regression.

2.2 Empirical Implementation

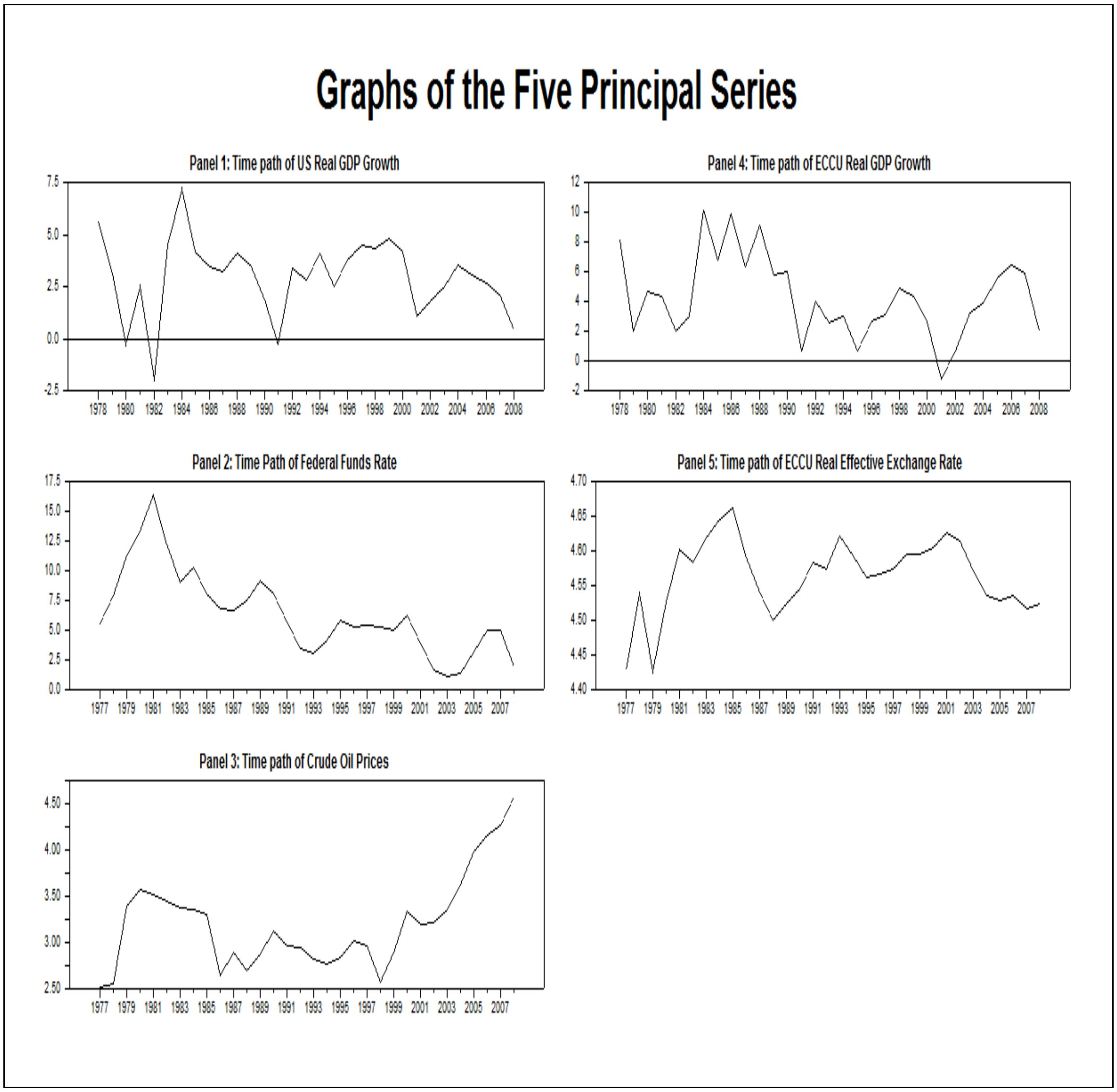
Relevant external factors that might impinge on macroeconomic fluctuations in the ECCU comprise three sets of factors: foreign demand, oil prices, and global financial conditions. In the model, external demand conditions is proxied by real GDP growth of the United States. Oil prices are measured as the average of three crude oil prices (Brent, West Texas Intermediate and Dubai Fateh) in US dollars per barrel. Global financial conditions are measured by world real interest rate, the US real interest rate and the Federal Funds rate.

The world interest rate is computed using the six-month LIBOR and the CPI inflation rate of industrial countries, while the US real interest rate is calculated as the three month t-bill rate deflated by the CPI. The domestic block of the model includes real GDP and the real effective exchange rate. In some variants, the model was extended to include the total value of credit extended by the commercial banking system. Hence, the full vector of variables is constructed as:

$$x_t = (\Delta y_t^{US} \quad i_t^{US} \quad \Delta c_t \quad \Delta y_t^{ECCU} \quad \Delta q_t) \tag{4}$$

Where y_t^{US} is the logarithm of US GDP; i_t^{US} is the US interest rate; c_t the logarithm of oil prices; y_t^{ECCU} is the logarithm of ECCU GDP, while q_t is the real effective exchange rate. In this set-up, US GDP, world interest rate and oil prices are treated as block exogenous with respect to the ECCU variables. This was accomplished by shrinking the prior means on the parameters on y_t^{ECCU} and q_t in the equations for y_t^{US}, i_t^{US} and c_t towards zero (see Osterholm and Zettelmeyer (2008) and Villani and Warne (2003) for details). This approach amounts to imposing a tight prior distribution centred on zero for the affected variables, a somewhat less restrictive assumption than imposing exogeneity directly. Intuitively, this set-up allows for a non-zero posterior if the data strongly disagrees with the prior. The model was estimated using annual data from 1977 to 2008. Standard unit root tests reveal that the selected variables are integrated of order one, thus the model was estimated in first differences. Figure 1 shows the data used.

Figure 1: Data



3.0 Empirical Results

The standard practice in the VAR literature of using a Choleski decomposition of the variance-covariance matrix to identify standard normal shocks, ε_t, from the estimated reduced form shocks was followed[2]. This utilizes the relationship $\sum = GG'$, where G is a lower triangular matrix, and $\varepsilon_t = G^{-1}\eta_t$. With the variables ordered as in equation (3) above, the maintained assumption is that US growth is independent of all shocks except its own; the federal funds rate is assumed to contemporaneously depend only on US GDP shocks and federal funds rate shocks, and so on[3]. Figure 2 shows the response of ECCU growth to various shocks. The impulse responses appear sensible:

- Increases in external demand – proxied by real GDP growth in the US – have large and quite persistent effects on ECCU real GDP. Output growth increases on impact, and declines asymptotically to a positive level after three years.
- The response of ECCU growth to US interest rates is more muted; growth rises on impact, then subsequently turns negative after one year. The VAR run with the world real interest rate and the US real interest rate shows a similar pattern, though the decline is somewhat smaller.
- Given the small open nature of the ECCU economies, and the fact that they are net importers of energy, oil price shocks should play a significant role in the evolution of economic growth. Indeed, this is the case, as oil price increases are shown to have a substantial and persistent negative impact on ECCU growth.

The full set of impulse responses are shown in figure A1 in the Appendix. Note that the six impulse response functions in the upper right-hand quadrant of the figure are flat, reflecting block exogeneity of the foreign variables.

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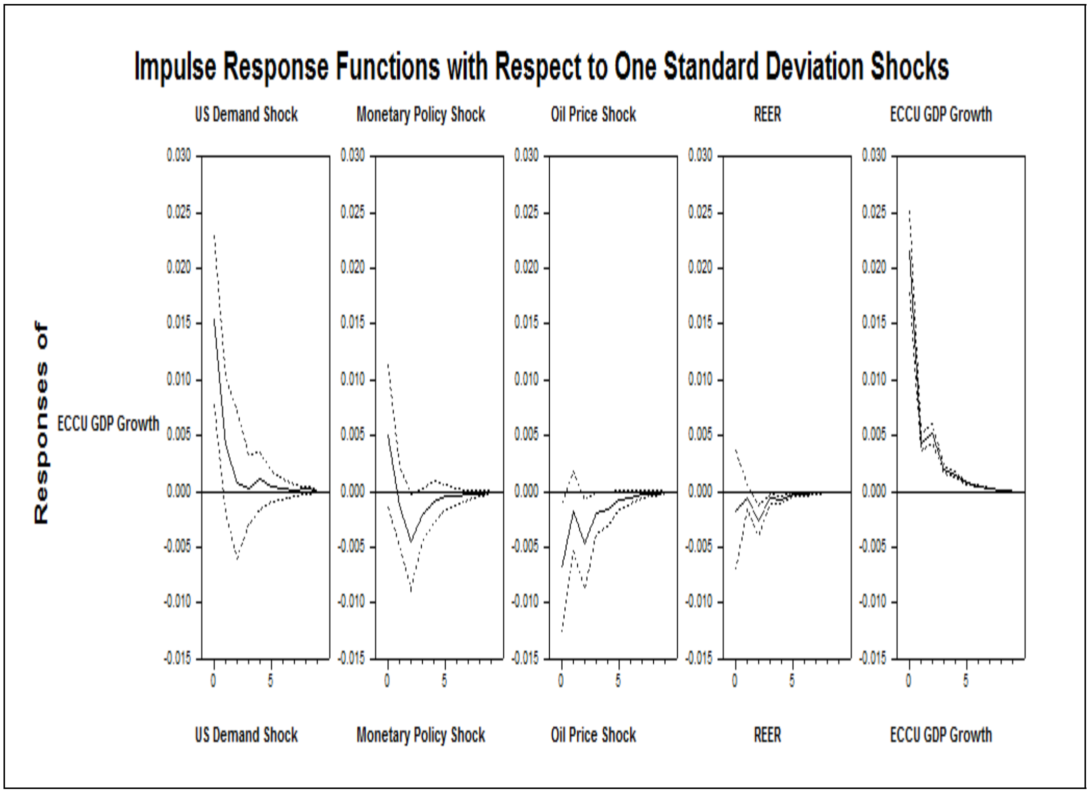
[2] It is important to note, however, that factorizing the variance-covariance matrix in this way, while standard, might be less plausible with annual data.

[3] Switching the ordering between US GDP shocks and shocks emanating from the federal funds rate did not materially affect the results.

Figure 2: Impulse Responses of ECCU GDP to External Shocks



Note: Solid lines are the point estimates of the Impulse-Response mean. Dotted lines are the 16th and 84th percentiles from Monte Carlo simulations based on 1000 replications.

Variance decompositions for ECCU growth are shown in table 1. External shocks play an important role in explaining output fluctuations; almost half of the medium-term (3 -5 year horizon) forecast error variance is explained by external factors, though the relative importance of the factors varies. US demand shocks account for 29.0 per cent of fluctuations in ECCU real GDP; oil price shocks contribute 9.8 per cent, while shocks to the federal funds rate accounts for 9.3 per cent of the forecast error variance.

Table 1: Variance Decomposition of ECCU Real GDP

Horizon	US Demand Shock	Oil Price Shock	Monetary Policy Shock
1	27.4	5.1	3.7
2	29.4	6.1	5.3
3	28.7	8.1	8.5
4	28.8	8.6	9.1
5	29.0	9.8	9.3

To ascertain the robustness of the results, various transformations of the base model were carried out. Specifically, the real GDP growth of industrial countries was used as a proxy for external demand. This extension appears logical, as there are extensive trade linkages between the ECCU and industrial countries. Figure A2 in the appendix displays the impulse responses with US real GDP replaced by real GDP of industrial countries. As can be seen, there does not appear to be important departures from the results above; the most significant change being that the world demand shock is more persistent than the US shock.

Bayesian VARs were introduced into the econometrics literature by Litterman (1980) as a solution to the 'over-fitting' problem in conventional VARs. Conventional VARs were found to perform very poorly in out of sample forecasts against a naïve random-walk alternative. In addition to the impulse responses and variance decompositions just computed, the model will be put through its paces in a conditional forecasting exercise to further examine the effects of external influences on ECCU growth. It therefore behooves us to first examine how well the model performs versus other models. Specifically, this is achieved by comparing the out of sample forecast performance of the Bayesian VAR with a benchmark random walk model and a conventional VAR.

It is straightforward to obtain forecasts of the two models considered. In a first step, the model is estimated over the period 1977 – 2004, leaving 2005 – 2008 for the forecast evaluation. The parameters of each model are then recursively estimated by updating the information set as the forecasts moves forward in time, much like in a real-time forecasting procedure.[4] Thus the model is estimated over the period 1977 – 2004, and a one-step ahead forecast is generated for 2005. Moving ahead one period, the model is re-estimated with data ending 2005. This iterative process continues until the end of the data set in 2008. Note that we forecast over successively shorter periods as we near the end of the dataset. The forecasting performance of the three models is then compared using the horizon t root mean square error (RMSE) criterion, given by:

$$RMSE = \sqrt{\left(N_h^{-1} \sum_{i=1}^{N} \left[x_{t+h} - x_{t+h,t} \right] \right)^2} \tag{5}$$

Where x_{t+h} is the *actual* value of variable *x* at time $t+h$ and $x_{t+h,t}$ is the *h*-step ahead forecast of *x* generated at time *t*. Table A1 shows the RMSE's as well as the Theil U statistic of the three models. The Theil U statistic is a unit-free metric of forecasting performance, as opposed to the RMSE which is not scale invariant. The Theil U also does a relative ranking of the BVAR and the conventional-VAR against a random walk alternative. Values above unity are disadvantageous, as it implies that the particular model does worse than the random walk.

Table A1 in the appendix displays the forecast evaluation of the models. The table shows the RMSE for each variable as well as Theil U's. Three features deserve comment. First, both the VAR and BVAR have a hard time beating a random walk with respect to oil prices, signified by Theil U statistic's above unity. Second, an unrestricted VAR performs poorly. Third, the Bayesian VAR generally performs better than the traditional

[4] This can be done in a variety of ways. Probably the most straightforward, and the approach used in the paper, is the Kalman filter.

VAR: for three out of the five variables, it produces smaller root mean squared errors and lower Theil U's at almost all horizons.

4.0 Conditional Forecasts and Scenario Analysis

To further assess the implications of external variables for ECCU macroeconomic dynamics, the Bayesian VAR will be used as a laboratory to make conditional forecasts. Conditional forecasts are forecasts whereby values of certain endogenous variables are constrained to a particular interval or a fixed number. The former are normally referred to as *soft conditions*, while the latter, in which future values of variables are fixed at single points are termed *hard conditions*, using the terminology of Waggoner and Zha (1999). Applications of this approach can be found in Sims (1982) and Leeper and Zha (2003). Conditional forecasting is of great value in empirical policy analysis, as it permits consideration of questions such as, "how would the forecasts of ECCU GDP change if the time path of the federal funds rate was altered?"; "what would be the effect if oil prices rise by more than forecast?" These types of questions cannot be readily answered using the unconditional forecasts of section 3.0.

However, there are two issues that must be addressed. The first is how to treat the variable that is being constrained. Using the federal funds rate example, it is reasonable to suppose that changes in the rate are endogenous responses to the dynamic state of the economy, thus it should be cast as an endogenous variable within the system of equations. This issue is addressed in the current system by the nature of the block exogeneity assumption, as the US monetary authorities do not react to changes in the ECCU economy. However, the federal funds rate is left endogenous, given that the system includes US real GDP growth. The second issue is that ascertaining the impact of conditional forecasts may be more complicated than unconditional forecasts, particularly h - horizons ahead. Consider for example, the error in the h-step ahead forecast:

$$\sum_{s=0}^{h-1} \psi_s u_{t-s} \tag{6}$$

A conditional forecast, in effect, picks a value for this forecast error, as subtracting the unconstrained forecast from the constrained forecast gives the error of the forecast. One step ahead, this procedure is not that complicated, as the forecast error in a variable consists of just one innovation. Two steps ahead, a variable's forecast error depends upon the first step innovations in *all* of the variables in the system, plus its own second step. Thus, there is an identification problem: we have a single constraint on a linear combination of $N + 1$ variables. This can be handled by orthoganilising the residuals, re-writing the forecast errors in (6) as:

$$\sum_{s=0}^{h-1} \psi_s G v_{t-s} \qquad (7)$$

Where G is a (Choleski) factor of the Variance-Covariance matrix from the VAR. The constraints on the process can be written in vector form as:

$$RV = r \qquad (8)$$

To proceed, the conditional forecasts are made by first computing the V vector that minimizes $V'V$ subject to the constraint. The solution to the minimization problem is:

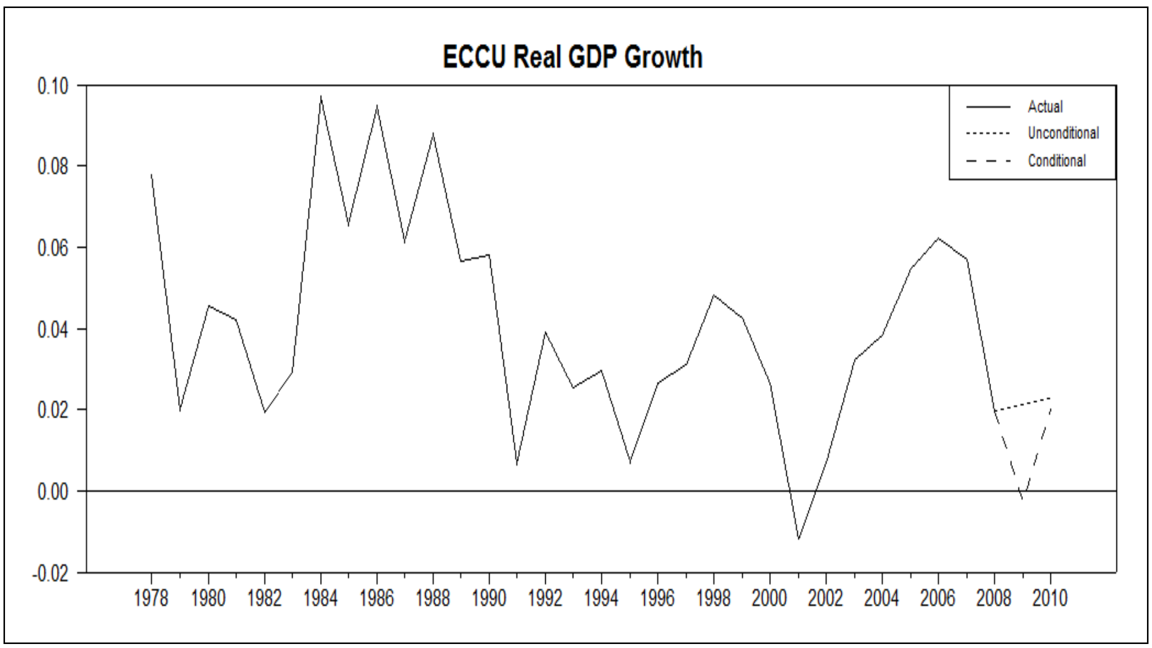
$$V^* = R'(RR')^{-1} r \qquad (9)$$

The V's are then translated into non-orthoganilised shocks and the model is forecast with these added shocks.

How are these shocks used? As described, the objective is to generate future paths of the endogenous variables. This is done by using the historical data and the orthoganilised shocks to draw successively from the distribution with these shocks imposed, thus generating the future data. The difference with the unconditional forecasting exercise, is that only the orthogonal shocks belonging to a subset of the endogenous variables are created randomly, while the entire vector of orthogonal shocks is generated in the unconditional case. At each forecast horizon, the generated orthogonal shocks of the “free” variables, as well as the given path of the conditional variables are generated sequentially, one horizon at a time.

Figure 3 below depicts the outcome of such an exercise for ECCU real GDP growth. In the “baseline” scenario, it is assumed that US real GDP will contract by 2.7 per cent in 2009, recovering to 1.5 per cent in 2010[5]. The figure shows the unconditional forecasts and the conditional forecasts. The conditional forecasts are the simulated values, where future values are drawn from the distribution constrained to the suggested time path of US growth[6]. The other variables in the system are allowed to adjust endogenously; that is, their future time path was not constrained.

Figure 3: Effects of a US Recession on ECCU Growth



The ECCU is projected to expand by 2.2 per cent in 2009 and by 2.3 per cent in 2010 respectively, after declining to 2.0 per cent in 2008. Note that these are unconditional forecasts based on the past correlations in the data series. The imposition of the

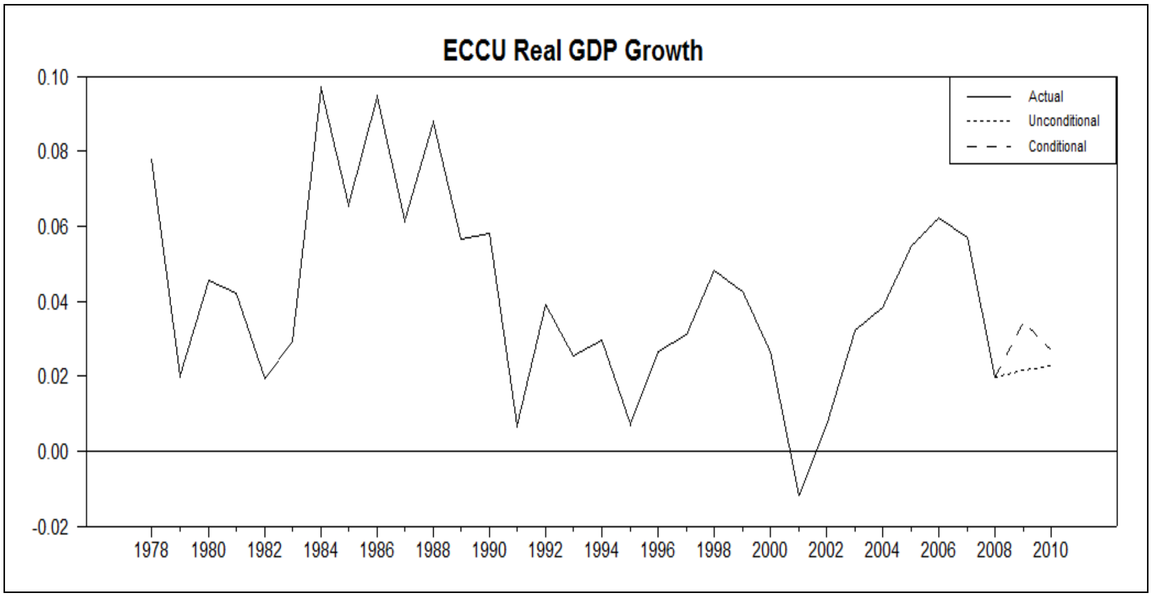
[5] All “baseline” forecasts for the conditioned variables are taken from the IMF’s World Economic Outlook database, updated October 2009.

[6] This draws 10,000 values, with 1000 burn-in draws at each forecast horizon.

constrained time path for US growth has a dramatic effect on the projections. Specifically, the US recession leads to a contraction in ECCU real GDP growth of 0.03 per cent in 2009, increasing to 2.1 per cent in 2010, when the US economy is assumed to expand by 1.5 per cent. Relative to the "baseline", this is a fall of 2.2 percentage points in 2009 and 0.02 percentage point in 2010. Given the results derived previously, the fact that a US contraction leads to a recession in the ECCU is not surprising; however, the magnitude of the decline is noteworthy. Various other scenarios (not shown) were conducted. For example, it was assumed that the contraction in the US was deeper and more persistent than previously projected, possibly as a result of a relapse in financial conditions. Thus the US economy would contract by 3.5 percent in 2009 and by 1.0 per cent in 2010. Under this scenario, ECCU Real GDP will contract by 0.07 per cent in 2009, and would remain flat in 2010.

As discussed, fluctuations in crude oil prices constitute another significant vulnerability for the ECCU economies. It would be of interest to examine how projected changes in oil prices would influence the time path of growth in the ECCU. As in the case with the assumptions on US growth, oil price projections were obtained from the IMF's WEO database. The IMF is projecting a contraction in oil prices of 36.6 per cent from their 2008 levels in 2009, and an increase of 24.3 per cent in 2010. Given these conditional forecasts, the model predicts that growth in 2009 will increase to 3.4 per cent, falling to 2.7 per cent in 2010. This compares with baseline (unconditional) projections of 2.2 per cent and 2.3 per cent in 2009 and 2010 respectively. These results are shown in figure 4 below.

Figure 4: Effects of a Reduction in Oil Prices on ECCU growth



A reduction (increase) in crude oil prices is unambiguously positive (negative) for growth in the ECCU. If oil prices decline by only 10.0 per cent in 2009, while increasing by 35.0 per cent in 2010, ECCU real GDP growth would only increase by 2.9 per cent and 2.3 per cent respectively. Note that in all of the scenarios, the other variables are allowed to adjust endogenously.

Conclusion

This paper presented a Bayesian VAR model to dis-entangle the effects of external events on macroeconomic fluctuations in the ECCU, and for scenario analyses. In accordance with the literature on the international transmission mechanism in developing countries, the model exhibited block exogeneity restrictions of the foreign variables. The exogeneity assumption was flexibly imposed by adapting the standard Minnesota prior in two directions. First, the prior distribution of domestic variables in equations where the dependent variable was an external variable was shrunk towards zero; secondly, the prior mean on all coefficients was set equal to zero, given that the model was estimated in first differences.

Standard VAR tools – such as impulse response analysis and variance decompositions – were used to assess the influence of external factors on macroeconomic outcomes in the ECCU, and to examine how the time path of the domestic economy has been altered by such factors. Re-assuringly, the results confirm the supposition that the ECCU economies are highly vulnerable to the vagaries of the international economy, in that almost half of the variance of real GDP growth can be explained by external shocks. Of these, US demand and monetary policy shocks are the most virulent, accounting for 29.0 per cent and 9.3 per cent of the medium-term variance of domestic GDP growth respectively. US demand shocks are expansionary, with effects lasting for around three years. A positive shock to the federal funds rate is contractionary, leading to a reduction in ECCU output growth within a year. Likewise, positive oil price shocks result in adverse movements in ECCU real output.

The significance of these external factors was also evident in the scenario analyses conducted. Unconditional forecasts for 2009 and 2010 predict that growth in the ECCU will average 2.2 per cent and 2.3 per cent respectively. Conditional forecasts, whereby time paths of a subset of the external variables were imposed over the projection period, led to this result being overturned. Using projections from the October 2009 edition of the IMF's World Economic Outlook, a contraction of 2.7 per cent in US growth in 2009 precipitated a contraction in domestic growth of 0.03 per cent. If it is assumed that the contraction in the US is sharper and more persistent, domestic growth will decline by 0.07 per cent in 2009, and will be flat in 2010. Similarly, assumptions on the future time path of crude oil prices highlight the sensitivity of domestic output to external conditions.

While cognizant of the vulnerabilities highlighted in this paper, it is apparent that the economies of the ECCU will remain exposed to external shocks, given their small and highly open nature. One should not be nihilistic, however: the region can perhaps lessen these vulnerabilities to some extent by strengthening policy frameworks. This includes policies that lower public debt, and those that induce more dynamism in fiscal budgets. These are important objectives in their own right, but of more import for the present work is that they will allow more headroom for deficits to rise in states of declining economic activity, so as to cushion the expected contractionary effects on output and consumption. A diversification of export structures will positively contribute to reducing vulnerabilities. Improved risk-sharing mechanisms can also serve to attenuate adverse shocks. In this regard, the OECS economic union project is particularly cogent, as it provides scope to pool resources, and more generally can be utilized as a mechanism for resource transfers over varying states of nature.

The ideas and analysis in this paper can be improved upon in several directions. First, a longer dataset may be required so that better information can be gleaned from the estimates. Second, a consideration of other activity variables, such as money and credit aggregates, and the inclusion of a policy variable may also be useful. Third, country-specific Bayesian VAR models can be constructed, so as to determine the extent of any departures from the average responses produced in this paper. Thus, while the results presented here are suggestive, a degree of caution is warranted on the interpretation, given the shortness of the data sample and the uncertainty inherent in the estimates. Future work will consider a wider range of external influences, and will impart more structure, so that a clearer causal interpretation can be examined

Appendix

Data Sources:

World GDP: World Bank's World Development Indicators (WDI) on-line database**.**

US GDP: Bureau of Economic Analysis.

US three-month Treasury bill rate: Board of Governors of the Federal Reserve System.

US CPI: Bureau of Labour Statistics.

Six-month LIBOR rate and CPI inflation rates of Industrial countries: IMF, International Financial Statistics.

ECCU Real GDP and Real Effective Exchange Rate: Eastern Caribbean Central Bank database, back-filled in the case of the REER by the World Bank's World Development Indicators on-line database.

Table A1: Unit Root Tests

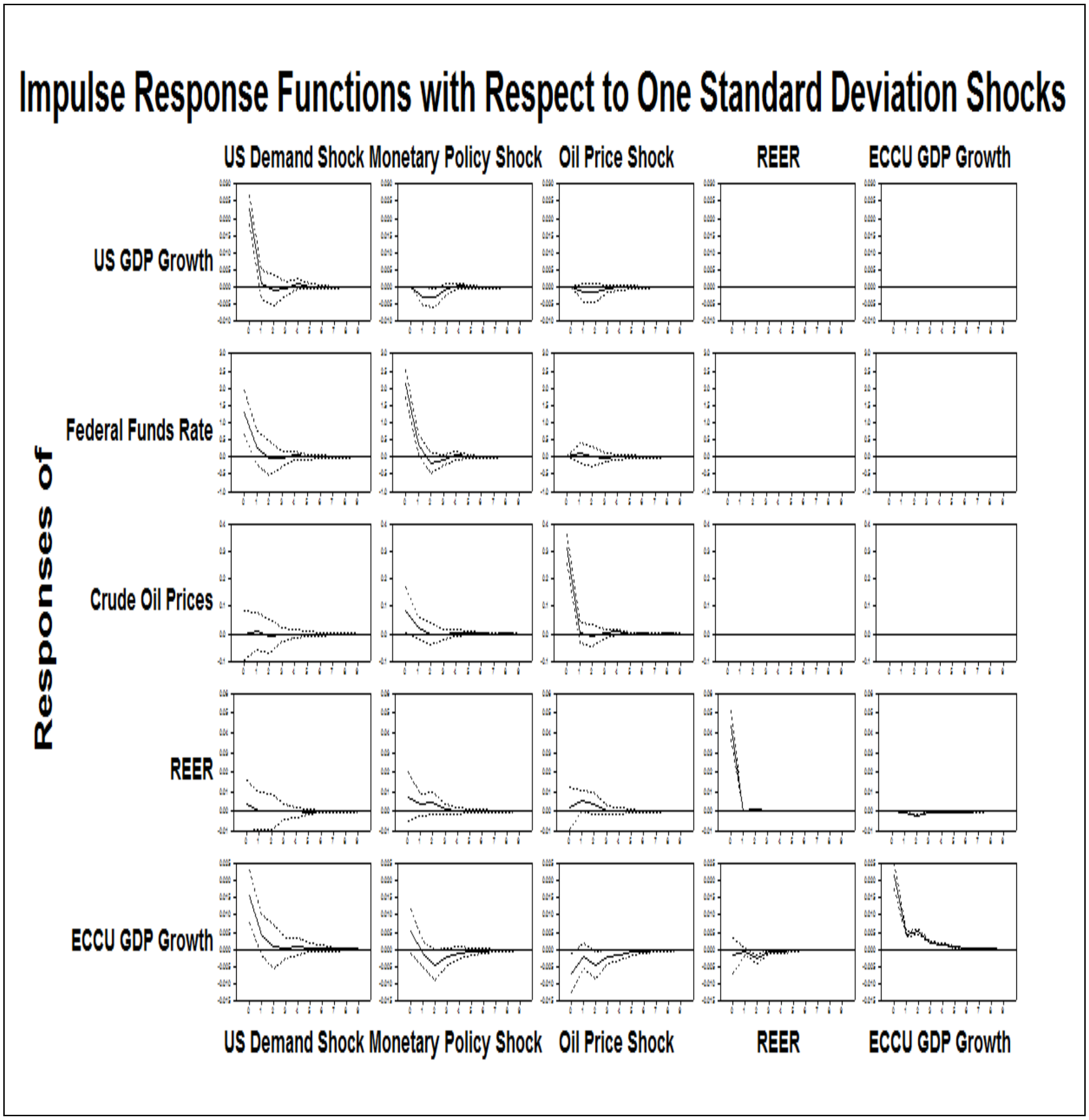
Variables	Level		First Difference	
	ADF	Phillips-Perron	ADF	Phillips-Perron
lyus	-0.633	-0.642	-4.283*	-4.22*
Federal funds rate	-1.223	-1.553	-3.965*	-4.145*
loil	-0.567	-0.683	-5.062*	-5.067*
lyec	-1.820	-1.592	-2.520	-3.526*
lreer	-2.21	-3.441	-4.783*	-6.847*

Note: a * indicates rejection of the null hypothesis at the 5 percent significance level

Table A2: Forecast Comparison

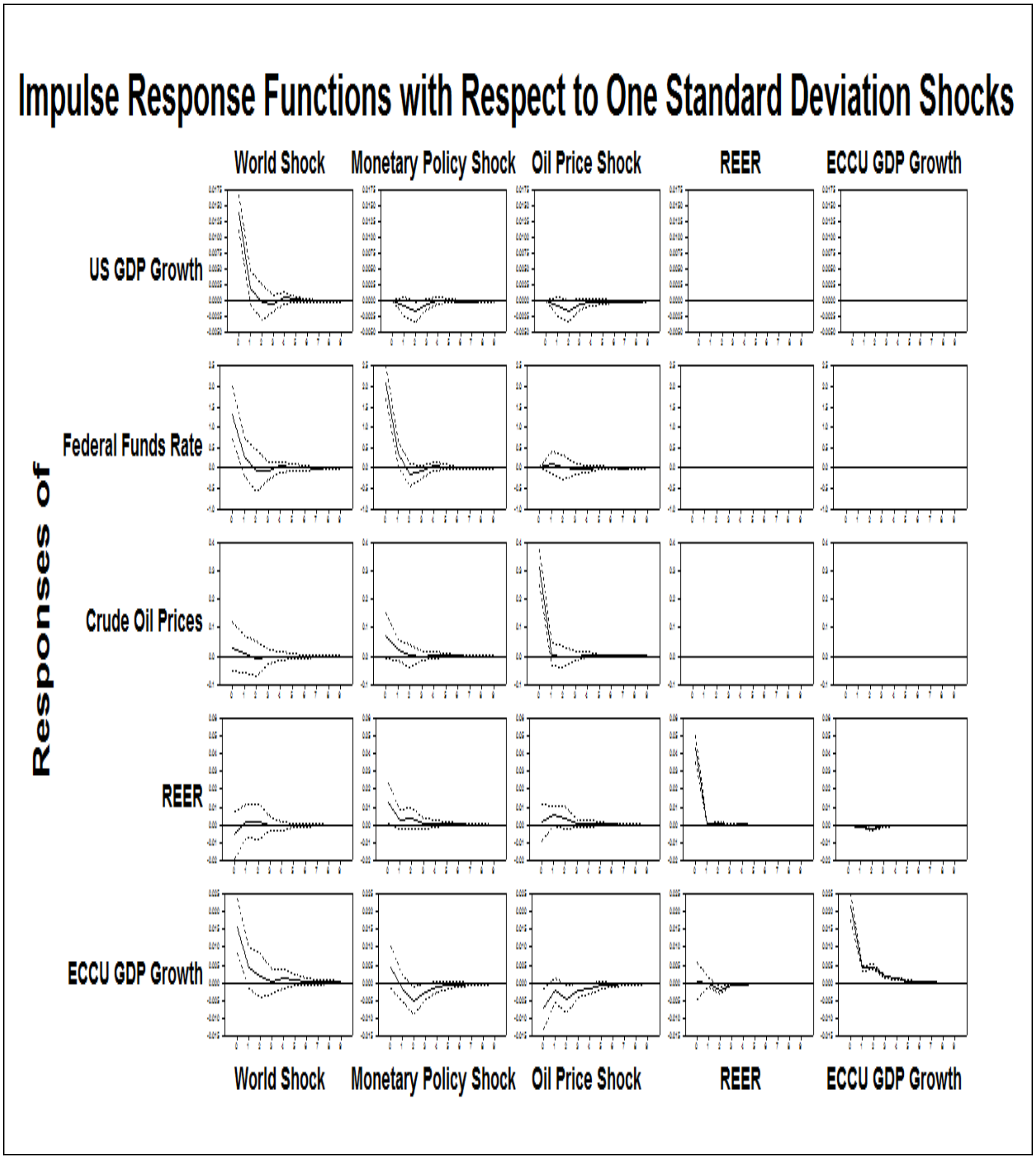
	Horizon	US Real GDP	Theil U	Federal Funds Rate	Theil U	Oil Prices	Theil U	REER	Theil U	ECCU Real GDP	Theil U
VAR	1	0.77	0.80	120.40	0.67	16.59	1.19	3.86	1.81	1.68	0.98
	2	0.77	0.60	133.10	0.45	25.80	1.48	2.70	0.99	2.13	0.79
	3	0.90	0.54	181.20	0.57	22.68	2.24	1.87	0.61	2.65	0.92
	4	1.84	0.82	168.40	0.71	24.52	5.60	1.50	0.44	2.10	0.96
BVAR	1	1.05	1.10	170.00	0.95	23.16	1.66	2.23	1.05	1.66	0.88
	2	1.27	0.98	210.40	0.71	23.72	1.36	1.36	0.50	1.93	0.72
	3	1.54	0.92	207.37	0.67	19.77	1.96	1.32	0.43	2.00	0.69
	4	1.90	0.97	199.36	0.83	21.38	4.88	1.63	0.48	1.90	0.87

Figure A1: Impulse Response Functions with Respect to One Standard Deviation Shocks



Note: Solid lines are the point estimates of the Impulse-Response mean. Dotted lines are the 16th and 84th percentiles from Monte Carlo simulations based on 1000 replications.

Figure A2: Impulse Response Functions with Respect to One Standard Deviation Shocks



Note: Solid lines are the point estimates of the Impulse-Response mean. Dotted lines are the 16th and 84th percentiles from Monte Carlo simulations based on 1000 replications.

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