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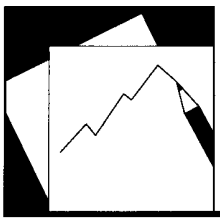

IMF Working Paper

Macroeconomic Fluctuations in the Caribbean: the Role of Climatic and External Shocks

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Macroeconomic Fluctuations in the Caribbean: the Role of Climatic and External Shocks

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Abstract

This paper develops country-specific VAR models with block exogeneity restrictions to analyze how exogenous factors affect business cycles in the Eastern Caribbean. It finds that external shocks play a key role, explaining more than half of macroeconomic fluctuations in the region. Domestic business cycles are especially vulnerable to changes in climatic conditions, with a natural disaster leading to an immediate and significant fall in output—but the effects do not appear to be persistent. Oil price and external demand shocks also contribute significantly to domestic macroeconomic fluctuations. An increase in oil prices (external demand) is contractionary (expansionary), and the effects dissipate up to three years after the shock.

JEL Classification Numbers: C32, E32, F41

Keywords: Business cycle; external shocks; VAR; block exogeneity; Eastern Caribbean

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Contents Page

I. INTRODUCTION

A small open economy is typically subject to a variety of exogenous, external shocks. These shocks are typically propagated through different channels, and the domestic economy responds by different adjustment mechanisms. As the Eastern Caribbean countries are very small open economies,[2] their business cycles are expected to be strongly influenced by changes in external conditions, especially given the dominant role played by the tourism sector in these countries.[3] Moreover, the small islands of this region are among the most natural disaster prone countries in the world. Hence, economic performance in the region is highly vulnerable to climatic conditions.

A correct identification and assessment of the sources of and adjustment mechanisms to external disturbances is important not only to better understand business cycles in the Eastern Caribbean, but also to inform the design and conduct of macroeconomic policy in the region. Appropriate policy responses to external shocks, and deciding whether or not it is a good idea to try to insulate the domestic economy from them, depend crucially on how these disturbances affect the domestic economy. The analysis of the sources of external shocks and their impact on the region's economies also brings additional perspective to the issue of coordination of macroeconomic policies, and to the discussion regarding the advantages and disadvantages of a currency union. Lastly, and also from the policy perspective, it is important to determine if actions can be taken to increase the resilience of these economies to external shocks.

Several interesting empirical questions arise here. First, are external, exogenous shocks in fact significant sources of domestic business cycle fluctuations in the Caribbean region? Second, which type of external shock—foreign or climatic—explains a larger fraction of real output fluctuations? Third, what is the dynamic response of domestic output to each of these shocks? This paper aims to address these questions, focusing on economic fluctuations in the Eastern Caribbean during the past three decades.

The empirical strategy of the paper is a country-specific VAR model with block exogeneity restrictions. The model contains two external blocks—one including climatic factors and the other including foreign economic variables—and a domestic economy block. The specification of the model incorporates the small open economy assumption in the sense that foreign variables are completely exogenous to the domestic economy. The model also assumes complete exogeneity of climatic conditions. Using variance decomposition analysis,

[2] The Eastern Caribbean countries analyzed in this paper are the six Fund members of the Eastern Caribbean Currency Union (ECCU): Antigua and Barbuda, Dominica, Grenada, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines.

[3] See Cashin (2004, 2006) for a characterization of business cycles in the Eastern Caribbean.

the relative contribution of each of the external factors to the variance of real GDP growth is quantified. Impulse responses, in turn, illustrate how domestic output growth has reacted to each of these external shocks, tracing out not only their direct effects but also the indirect impact through their feedback on other endogenous variables included in the model.

The block exogeneity approach in VAR models has been previously used in the literature on external shocks and macroeconomic fluctuations in both developed and developing countries. For instance, Cushman and Zha (1997), Dungey and Pagan (2000), Hoffmaister and Roldos (2001), Buckle et al. (2002), Franken, Le Fort and Parrado (2005), and Sosa (2008) applied this approach to Canada, Australia, Brazil and Korea, New Zealand, Chile, and Mexico, respectively. Raddatz (2006) quantified the impact of different external shocks and determined their contributions to output volatility in low-income countries. Finally, Osterholm and Zettelmeyer (2007) developed a Bayesian VAR with block exogeneity to investigate the sensitivity of GDP growth—for an aggregated group of the largest Latin American economies—to external developments.

The main results of the paper are:

- Altogether, external shocks—climatic, oil price, external demand, and world real interest rate shocks—constitute a key source of macroeconomic fluctuations in the Eastern Caribbean, accounting for more than half of real output fluctuations at standard medium-term horizons.

- Of these exogenous shocks, climatic shocks represent a dominant factor driving output fluctuations, especially at shorter-term horizons. Oil price and external demand shocks also play a significant role.
- In general, external shocks lead to similar patterns of output response across the ECCU countries. A natural disaster leads to an immediate and significant decline in output, but the effects do not appear to be persistent, typically vanishing one or two years after the shock. A positive innovation to oil prices is contractionary, and the adverse effect persists for up to three years. Output expands on impact with lasting effects of about two additional years, following a positive external demand shock.

The paper proceeds as follows. Section II describes the econometric approach—in particular the specification issues of the model and the estimation procedures. Section III contains the empirical results, mainly based on innovation accounting tools—impulse response functions and forecast error variance decompositions. Finally, Section IV presents some concluding remarks and policy implications.

II. ECONOMETRIC APPROACH

The empirical approach used to examine the role played by external factors as sources of business cycle fluctuations in the Eastern Caribbean, and to identify the dynamic responses of domestic output to external shocks, is a standard vector autoregressive (VAR) model with block exogeneity restrictions. A key feature of the model is that both climatic and foreign economic conditions are assumed to be completely exogenous to the economies of the ECCU region.

A. Specification and Identification Strategy

The structural model can be expressed—omitting the constant terms for simplicity—as:

$$A(L)y_t = \gamma_t$$

where y_t is an n vector of variables, $A(L)$ denotes a lag polynomial matrix, and γ_t is an n vector of structural shocks. A_0, a non-singular matrix normalized to have ones on the diagonal, contains the contemporaneous relationships between the variables of the model.

The reduced form corresponding to this structural model can be written as:

$$B(L)y_t = u_t$$

where $B(L)$ is a lag polynomial matrix such that $B(L) = (A_0)^{-1}A(L)$ and $B_0 = I$, and u_t is an n vector of mean zero reduced form disturbances with covariance matrix Γ, such that $u_t = (A_0)^{-1}\gamma_t$.

To identify the structural parameters, a set of restrictions must be specified. Following Sims (1980), the reduced form errors are orthogonalized by Choleski decomposition. The selected ordering is characterized by the idea that the external variables of the model precede the domestic ones. This implies that climatic factors and international economic variables do not respond instantly to changes in domestic economic variables, but domestic variables may be affected by contemporaneous changes in external conditions.

The selected Choleski ordering is consistent with the small open economy assumption for the countries of the Eastern Caribbean. It is worth noting, however, that restrictions implied by such ordering refer only to contemporaneous relationships between the variables of the model. To assume complete exogeneity of both climatic and foreign economic factors, lagged values of the domestic variables should not affect them either. This is achieved by imposing block exogeneity restrictions. Therefore, the model is separated in three blocks of equations: two external blocks—one including climatic factors and the other including international economic variables—and one domestic economy block. Domestic economic variables are completely absent from equations in the external blocks, meaning that shocks to domestic conditions cannot affect, neither contemporaneously nor with any lags, the external variables.

The block exogeneity approach implies that some of the VAR equations have regressors not included in others. This type of model is known as near-VAR in the literature. The block exogeneity procedure reduces the number of parameters to be estimated, limiting the erosion of degrees of freedom and improving the efficiency of the estimation.

B. Block Structure, Variables, and Data

The geographical location of the islands of the Eastern Caribbean provides a natural basis for tourism, but also creates a large exposure to hurricanes. In fact, natural catastrophes have continuously and regularly hit the countries of the region.[4] To reflect this vulnerability, the empirical model contains a block of climatic conditions.

Owing to the dominant role played by tourism, the economies in the region are also highly vulnerable to global economic shocks, such as sharp increase in oil prices or a slowdown in world economic growth that would adversely affect external demand. Moreover, changes in international real interest rates constitute an important factor driving portfolio capital inflows to emerging markets. Calvo, Leiderman, and Reinhart, (1993), and Calvo, Fernandez Arias, Reinhart, and Talvi (2001), for instance, argue that business cycles in Latin America have been strongly influenced by this external factor. The link between international interest rates and capital flows to emerging markets may be a consequence of a number of reasons. Low interest rates in mature markets may lead investors in those markets to seek higher returns in other markets, increasing the demand for emerging market assets. Not only does external financing become more abundant for emerging markets, but also the cost of borrowing declines as a consequence of the lower international interest rates. In fact, Fernandez Arias (1996) shows that country-risk premia in emerging markets is indeed affected by international interest rates, amplifying the interest rate cycles in mature markets. Against this background, the external block of the model includes oil prices, external demand, and international real interest rates.

Finally, the domestic economy block includes real output—the variable of main interest, as well as the real exchange rate—which plays a key role in macroeconomic adjustment to external shocks in open economies.

The block structure of the model follows naturally from the small open economy assumption for the countries of the ECCU, and from the fact that climate can be considered exogenous. The block exogeneity restrictions corresponding to this structure are summarized in Table 1. Each row indicates whether dependent variables of equations in a certain block are affected

[4] Rasmussen (2004, 2006) argues that small island states are especially prone to natural disasters, with the countries of the ECCU standing out owing to the large number of hurricanes that strike the region. He notes that a natural disaster typically occurred once every 4½ years in each of these countries.

by dependent variables of other blocks. Each column indicates whether dependent variables of equations of a particular block appear as regressors in any equation corresponding to another block. Hence, domestic economic variables do not appear in equations of either the climate block or the international economy block. Foreign economic conditions do not appear as regressors in the climate block, whereas climatic factors do not appear as regressors in the international block. Finally, both climatic and foreign economic factors enter the equations of the domestic economy block as explanatory variables.

Table 1. Block Exogeneity Restrictions of the VAR Model

		Independent Block		
		Climate	International Economy	Domestic Economy
Dependent Block	Climate	✓		
	International Economy		✓	
	Domestic Economy	✓	✓	✓

Two alternative measures are used to capture climatic conditions and natural disasters. First, country specific dummy variables are constructed, using the Emergency Disasters Database (EM-DAT) compiled by the Centre for Research on the Epidemiology of Disasters (CRED).[5] Second, a continuous measure is considered: the Atlantic Multidecadal Oscillation (AMO) index, which measures Atlantic sea-surface temperatures and wind conditions that are correlated with hurricane generation in the Caribbean (Zhang and Delworth, 2006).[6] The intensity and frequency of hurricanes increases as a consequence of an increase in sea-surface temperatures, which are driven by changes in ocean currents that cycle water and heat between the far northern Atlantic and the tropics. The source of the AMO index is the National Oceanic and Atmospheric Administration. Oil prices are measured as the average of three crude oil spot prices (Brent, West Texas Intermediate, and Dubai Fateh), in U.S. dollars per barrel. External demand is proxied by real GDP of industrial countries. The world real interest rate is computed using the 6-month LIBOR and the consumer price index inflation

[5] CRED is the most comprehensive database on natural disasters that is publicly available. See Rasmussen (2004, 2006) for additional details on how natural disasters are defined.

[6] The literature on external shocks in small open economies has used both dummies and continuous variables to measure the incidence of natural disasters and climatic factors. For instance, Raddatz (2006) uses dummy variables to capture the incidence of natural disasters, while Buckle et al. (2002) use a continuous measure of soil moisture conditions to capture the impact of changes in climatic conditions.

rate of industrial countries. Finally, the real exchange rate and real output of each of the ECCU countries are measured using the corresponding real effective exchange rate index and real GDP. The economic data sources are the IMF's International Financial Statistics (IFS) and World Economic Outlook (WEO).

The model is estimated using annual data from 1975 through 2008. All the variables—except the world real interest rate—are expressed in log levels and the model is estimated in first differences. The model was estimated in first differences because standard unit root tests (augmented Dickey-Fuller) show that all the variables are stationary in first differences.

C. Estimation

Standard VAR models may be estimated by ordinary least squares (OLS). However, as noted above, the model developed in this paper is a near-VAR (given the block exogeneity restrictions, not all the equations include the same regressors). When some of the equations in a VAR contain regressors not included in others, Seemingly Unrelated Regressions (SUR) can provide more efficient estimates of the coefficients than OLS, and the efficiency gains are larger the higher the correlation of the residuals across equations. Therefore, in this paper the system is estimated using SUR rather than OLS.[7]

III. Business Cycle Responses to External Shocks: Empirical Results

The main objectives of the paper are achieved through two useful tools that are standard practice in VAR analysis: forecast error variance decompositions and impulse response functions. Using variance decomposition analysis, the percentage of the variance of the error made in forecasting a variable due to each specific shock at different horizons can be determined. Hence, this tool is used to quantify the relative importance of each of the shocks as sources of output fluctuations in the ECCU region. Impulse responses constitute a practical way to identify the dynamic responses of the domestic economy to external shocks.[8] They can illustrate how growth in the Eastern Caribbean has tended to react to climatic and foreign economic shocks, taking into account not only the direct effects of disturbances, but also the indirect effect through reactions of other endogenous variables.

[7] The specification of the estimated equations follows from the block exogeneity restrictions discussed earlier. The model is estimated with two lags—the lag length being selected according to the Akaike Information Criterion (AIC).

[8] Impulse response functions trace out the response of current and future values of each of the variables to an increase in the current value of one of the VAR errors, assuming that this error returns to zero in the following periods and that all other errors are equal to zero.

Our results indicate that external shocks play a dominant role as a source of business cycle fluctuations in the Eastern Caribbean, accounting (on average) for 58 percent of output fluctuations at standard medium-term horizons (Table 2).[9] The fraction explained by external factors ranges from 74 percent in Grenada to 38 percent in St. Vincent and the Grenadines.[10] The overall influence of external shocks in the region appears to be similar to that in Latin America. According to two recent studies conducted at the International Monetary Fund—Osterholm and Zettelmeyer (2007), and IMF (2007)—external factors are responsible for about 50 to 60 percent of the variance of Latin American GDP growth. Other studies have quantified the contribution of external factors to output fluctuations in different countries and regions. External shocks explain 11 percent of real output fluctuations in low-income countries, 27 percent in Brazil and 29 percent in Korea, 36 percent in the CAFTA-DR region, 43 percent in Chile, 60 percent in Mexico, and 72 percent in Canada, according to Raddatz (2006), Hoffmaister and Roldos (2001), Kose, Rebucci, and Schipke (2005), Franken, Le Fort and Parrado (2005), Sosa (2008), and Cushman and Zha (1997), respectively. This comparison should be considered only as suggestive or illustrative, since the econometric strategies and identification procedures used, the variables included, and time periods analyzed differ across studies.

Table 2. Sources of Business Cycle Fluctuations in the Eastern Caribbean
(Variance decomposition of real GDP at a horizon of three years, in percent)

	External shocks	Domestic shocks
Antigua and Barbuda	62.1	37.9
Dominica	52.8	47.2
Grenada	74.1	25.9
St. Kitts and Nevis	54.1	45.9
St. Lucia	64.0	36.0
St. Vincent and the Grenadines	38.1	61.9
Average	57.5	42.5

Source: Authors' calculations.

[9] Throughout this paper, variance decomposition analyses focus on a horizon of three years, unless otherwise indicated.

[10] The complete variance decomposition of GDP growth in each of the countries of the ECCU is shown in Tables A1 to A6 of the Appendix. This broad characterization of the importance of external shocks is consistent with the openness of these tourism-dependent economies (see IMF 2008, 2009).

Climatic Shocks

The Eastern Caribbean is highly vulnerable to climatic conditions. In fact, the ECCU countries are among the most natural disaster prone countries in the world. Figure 1 illustrates the devastating effects that natural catastrophes can have on these islands' economies. Variance decomposition analysis shows that climatic factors—measured by country specific dummies capturing natural disasters—are a dominant exogenous source of output fluctuations in the region, accounting (on average) for almost 20 percent of the variance of real GDP growth (Table 3). The contribution of climatic conditions ranges from 36 percent in Antigua and Barbuda to 7 percent in St. Vincent and the Grenadines. The average influence of natural disasters is also significant at short-term horizons, with climatic shocks representing the biggest exogenous influence—in fact, explaining almost half of the overall contribution of external shocks at a one-year horizon (see Appendix tables).

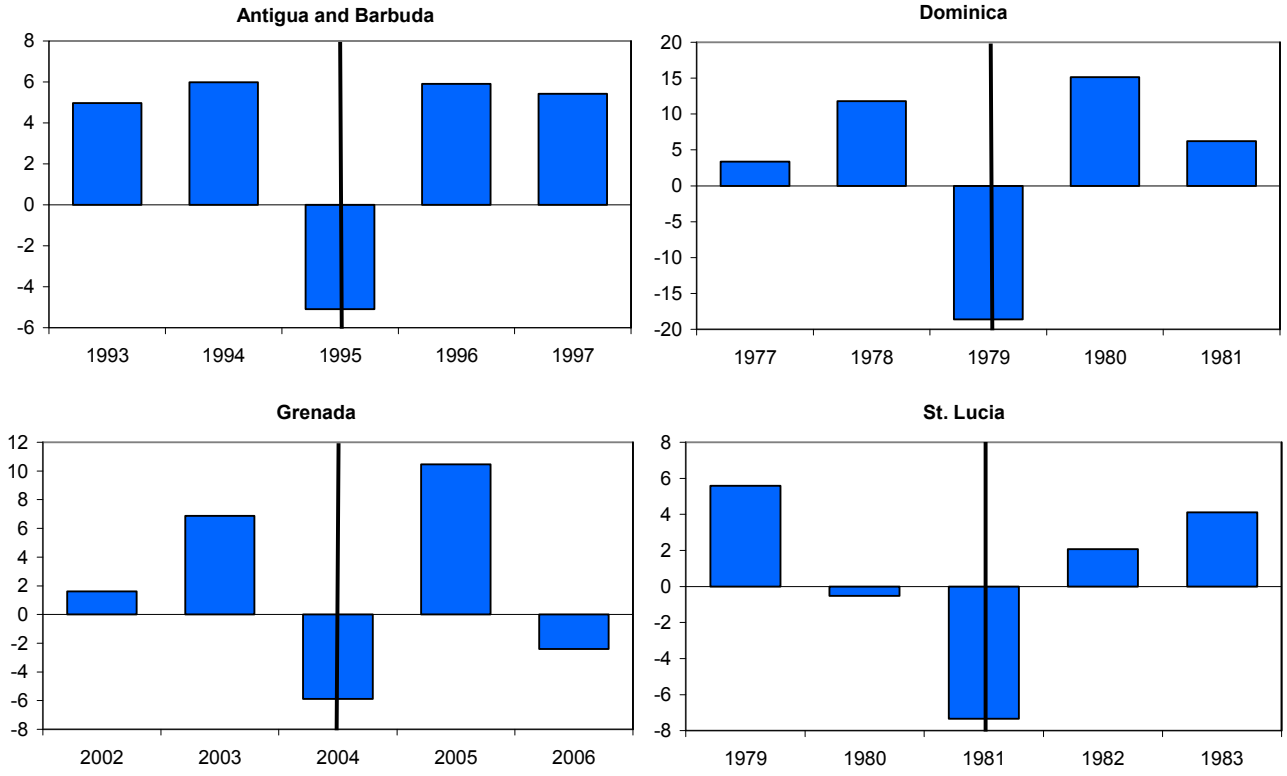
Table 3. Climatic Shocks and Output Fluctuations in the ECCU
(Contribution of climatic shocks to the variance of real GDP growth, in percent)

Horizon	Antigua & Barbuda	Dominica	Grenada	St. Kitts & Nevis	St Lucia	St. Vincent & the Grenadines	Average
1	28.2	31.2	8.6	14.6	5.2	1.9	14.9
2	30.9	28.7	16.4	10.8	5.9	6.9	16.6
3	35.6	26.7	18.3	10.7	10.8	6.7	18.1
4	34.2	26.4	18.0	9.4	11.8	6.7	17.7
5	34.6	26.3	17.8	9.4	12.1	6.8	17.8

Source: Authors' calculations. .

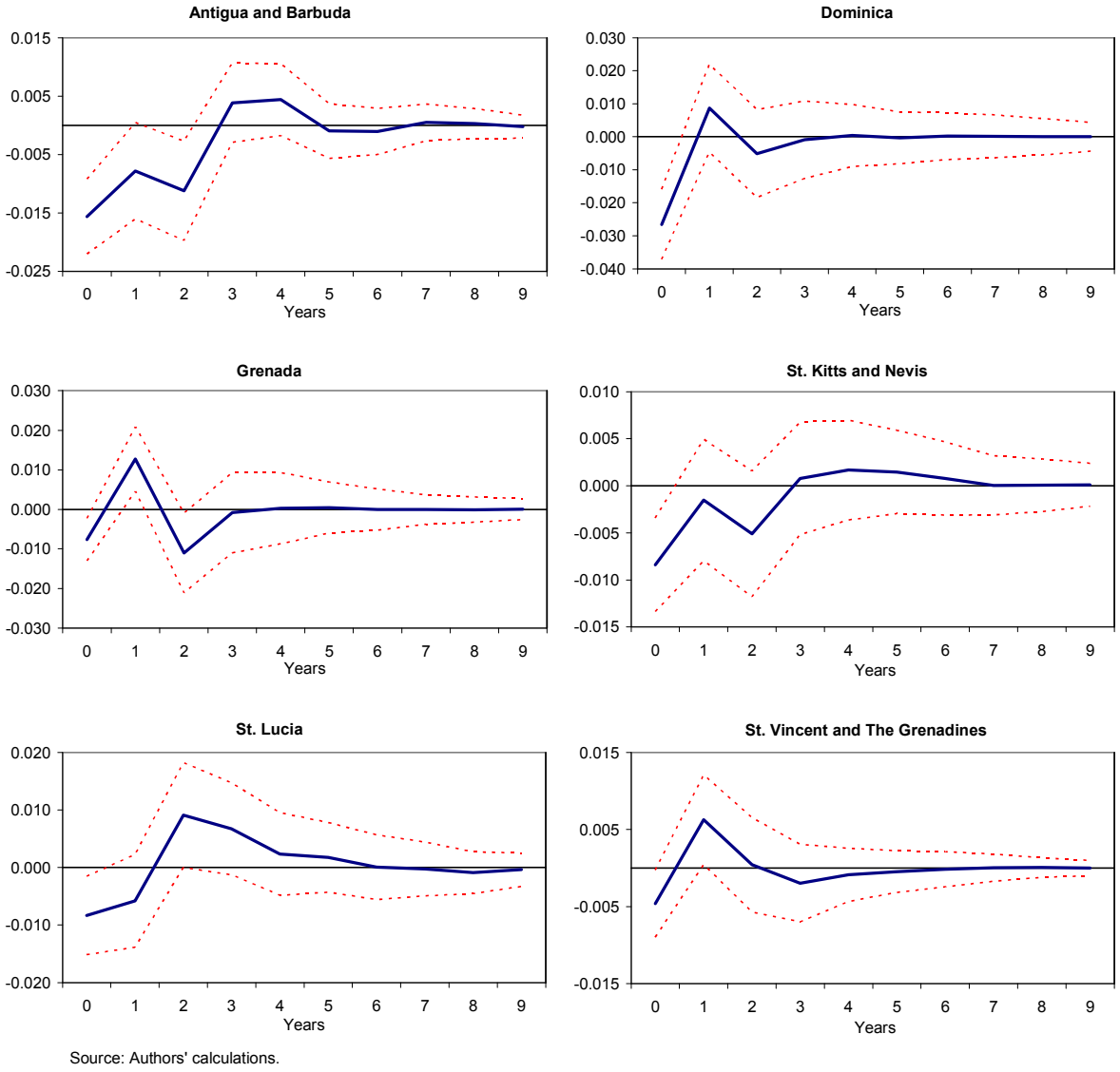
Natural disasters are followed by rapid and large contractions in output in the region, and the negative effects on domestic activity do not appear to be persistent (Figure 2). These results are consistent with the literature on macroeconomic effects of natural disasters. A number of studies reveal that natural disasters are associated with an immediate contraction in economic output, but the evidence of their long-term economic effects is inconclusive. For instance, Benson and Clay (2003) suggest that proneness to natural disasters has a negative impact on long-term economic growth, while the World Bank (2003) finds no significant impact.

Figure 1. Natural Disasters and GDP Growth in the Eastern Caribbean
(Real GDP, annual percentage change)



Sources: IMF, World Economic Outlook; and CRED, EM-DAT
Note: Solid line denotes year of the natural disaster.

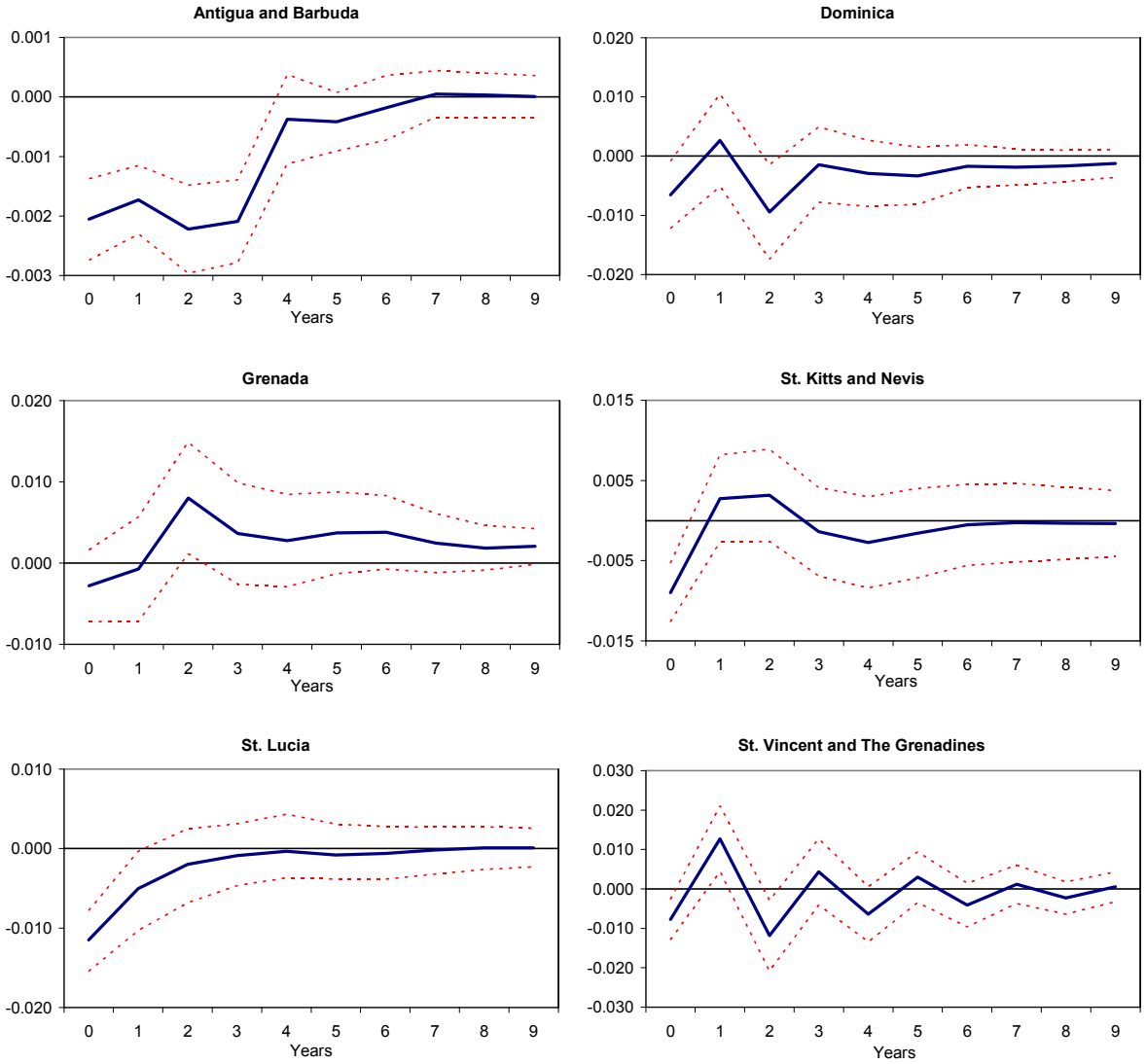
Figure 2. Response of Real Output to Climatic Shocks
(Using country specific dummy variables to capture natural disasters)



Source: Authors' calculations.

The analysis is also conducted using a continuous variable—the AMO index—rather than dummy variables to capture climatic conditions. It is worth noting that, in contrast to the dummy variables, the AMO index—which measures Atlantic sea-surface temperatures and wind conditions that are correlated with hurricane generation in the Caribbean—constitutes a regional rather than a country-specific variable. Impulse response functions show—in general—similar results, with a large and rapid negative impact of climatic shocks on real GDP growth (Figure 3). St. Vincent and the Grenadines seems to be an exception to this response pattern, potentially due to the relatively high variability of output in that country (see Cashin 2004, 2006).

Figure 3. Response of Real Output to Climatic Shocks
(Using the AMO index as a proxy for climatic conditions)



Source: Authors' calculations.

Oil Price Shock

The region's small economies are completely dependent on imports for their supply of petroleum products, and oil price hikes are likely to represent a major exogenous shock that can slow economic growth. In fact, oil price shocks play an important role in explaining domestic output fluctuations, accounting (on average) for almost 20 percent of the variance of real GDP growth (Table 4). The regional average figure masks differences in the contribution of oil price shocks across individual countries in the region: while this factor explains more than 30 percent of output fluctuations in Grenada and St. Lucia, it accounts for only 10 percent or less in Dominica, St. Vincent and The Grenadines, and Antigua and Barbuda.

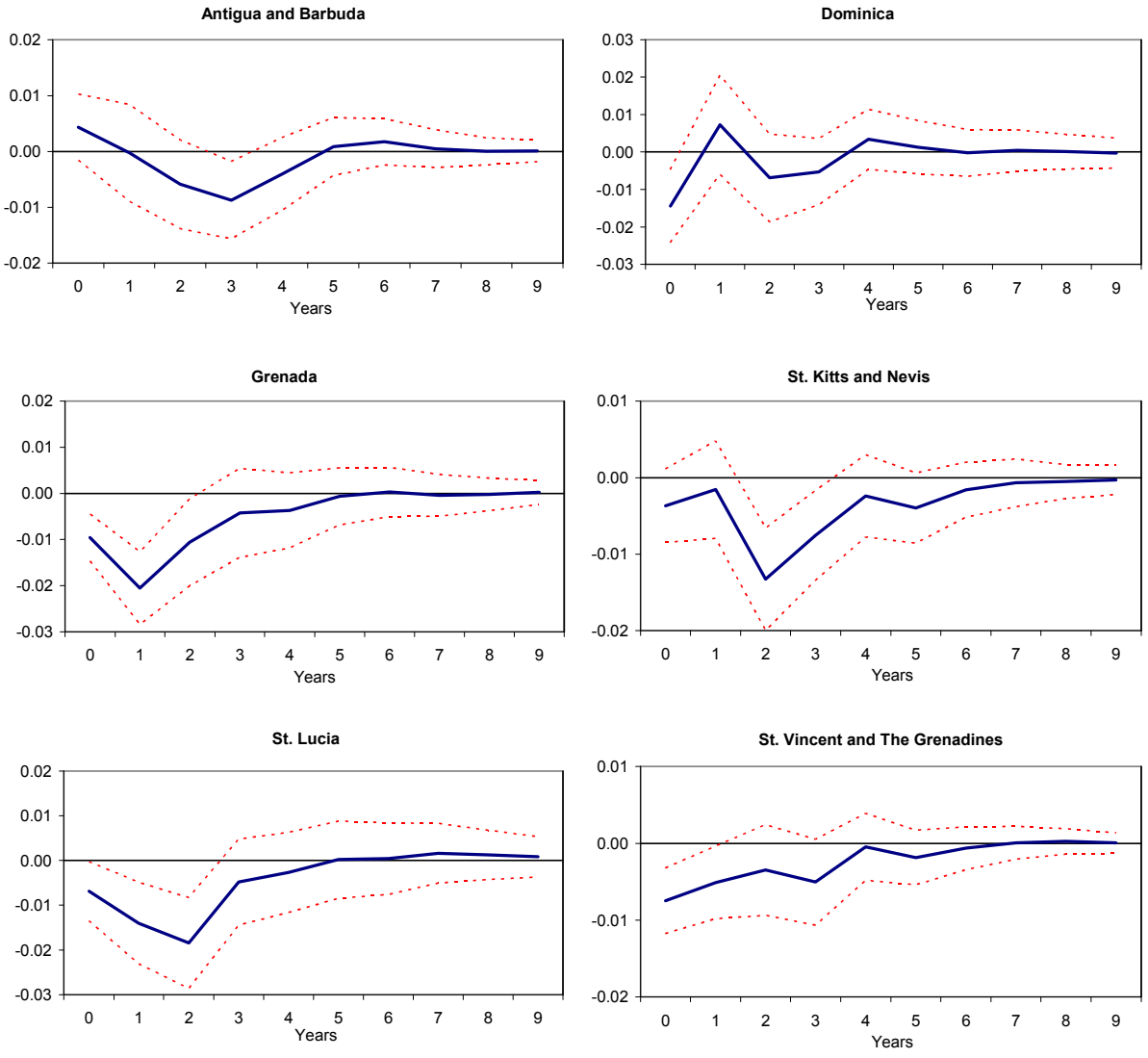
Table 4. Oil Price Shocks and Output Fluctuations in the ECCU
(Contribution of oil price shocks to the variance of real GDP growth, in percent)

Horizon	Antigua & Barbuda	Dominica	Grenada	St. Kitts & Nevis	St Lucia	St. Vincent & the Grenadines	Average
1	2.2	9.3	16.2	2.8	5.6	8.8	7.5
2	1.9	9.6	33.8	2.3	20.1	9.1	12.8
3	4.4	10.3	35.1	20.8	33.3	9.8	19.0
4	9.9	11.0	35.5	23.5	31.4	11.5	20.5
5	10.8	11.4	36.0	23.4	31.2	11.5	20.7

Source: Authors' calculations.

Oil price increases have a negative and significant impact on GDP growth in all ECCU countries. Figure 4 shows the dynamic responses of domestic output to a one standard deviation positive shock to oil prices: GDP growth falls on impact (except in Antigua and Barbuda, where the decline begins one year after the shock) and the negative effects last for two to three years.

Figure 4. Response of Real Output to Oil Price Shocks



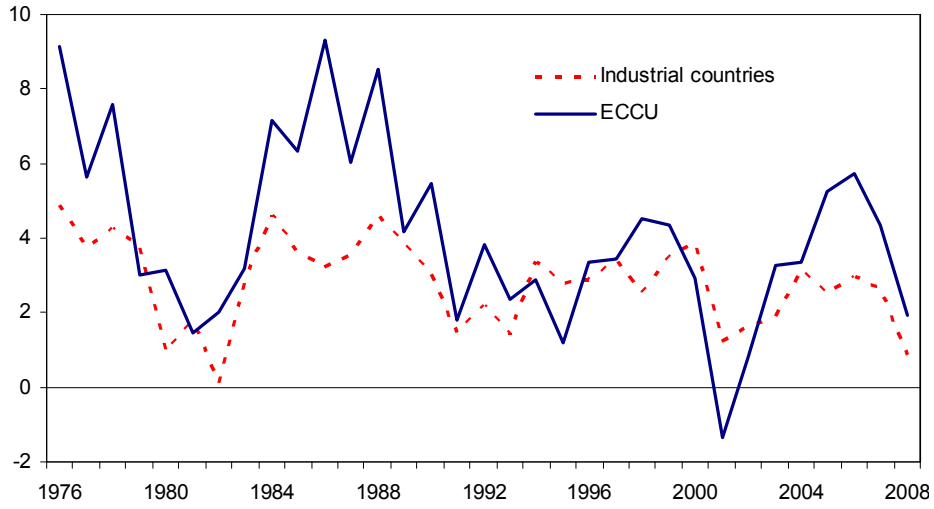
Source: Authors' calculations.

External Demand Shock

Owing to the importance of the tourism sector in the small economies of the Eastern Caribbean, external demand is expected to have a strong influence on business cycles in the region. Hence, changes in industrial countries' economic growth can affect output growth in

these islands' economies (Cashin 2004, 2006).[11] In fact, the comovement between industrial countries' GDP growth rates and those of the ECCU countries is striking (Figure 5).[12]

Figure 5. Real GDP Growth in the Eastern Caribbean and Industrial Countries
(Annual percentage change)



Source: IMF, World Economic Outlook.

Variance decomposition analysis indicates that shocks to external demand—proxied by GDP growth in industrial countries—explain almost 15 percent of output fluctuations in the region (Table 5). The relative contribution of external demand influences is especially large in St. Kitts and Nevis and small in Dominica, potentially due to the relatively greater dependence of St. Kitts and Nevis on tourism than the more agricultural-dependent economy of Dominica (see IMF 2008, 2009).

[11] Shocks to GDP growth in industrial countries can be transmitted to the ECCU countries through other channels, such as the substantial inflows of remittances resulting from the large-scale migration of skilled workers to industrial countries.

[12] The correlation coefficient between GDP growth in industrial countries and that of the ECCU is 0.71.

Table 5. External Demand Shocks and Output Fluctuations in the ECCU
(Contribution of external demand shocks to the variance of real GDP growth, in percent)

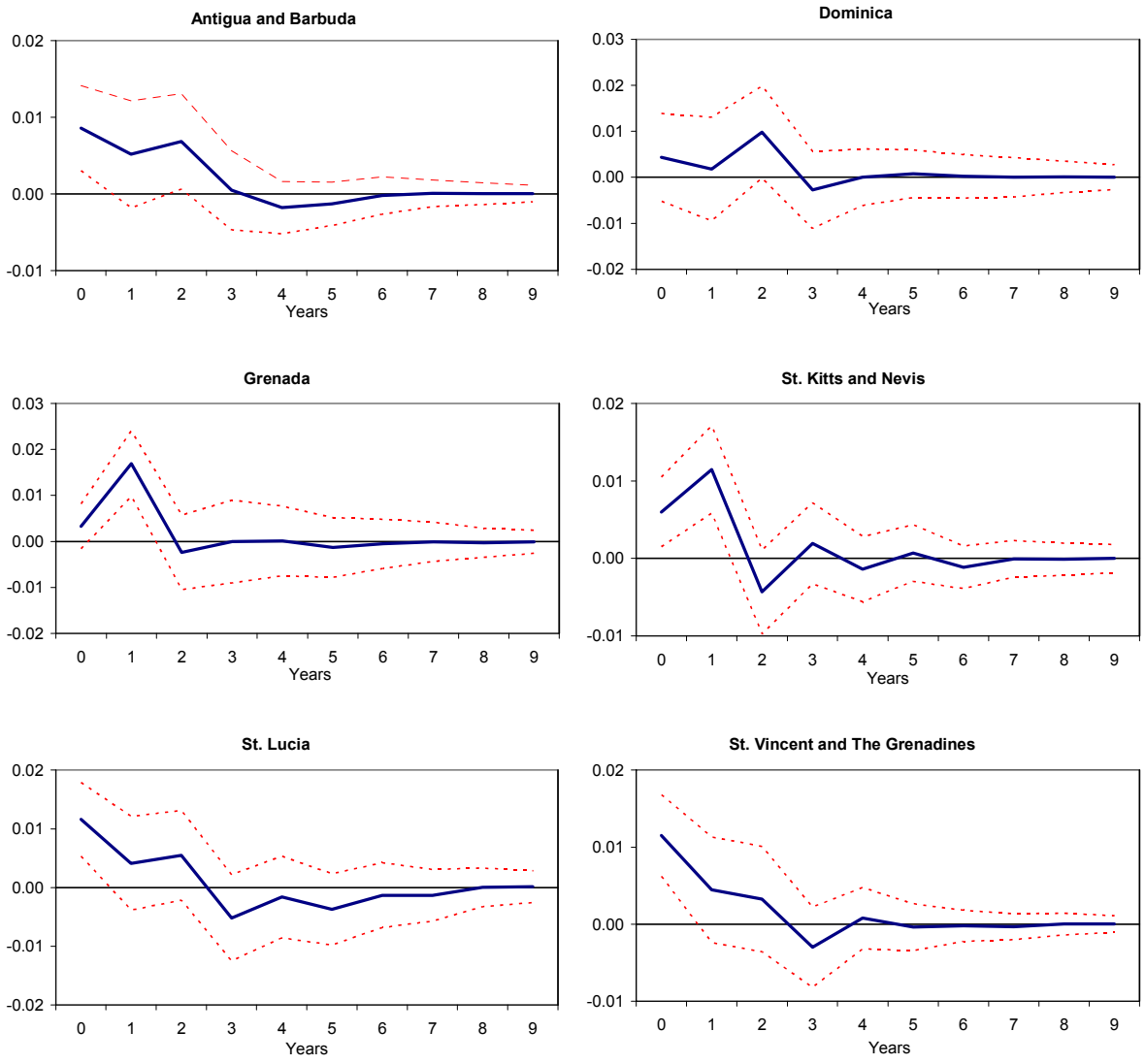
Horizon	Antigua & Barbuda	Dominica	Grenada	St. Kitts & Nevis	St Lucia	St. Vincent & the Grenadines	Average
1	8.6	0.8	1.9	7.4	15.9	20.8	9.2
2	10.2	0.8	19.6	24.9	12.6	17.0	14.2
3	12.2	3.9	17.1	20.2	10.4	17.0	13.5
4	11.3	4.1	16.8	18.0	10.8	16.5	12.9
5	11.3	4.1	16.6	17.7	10.8	16.6	12.8

Source: Authors' calculations.

A positive shock to external demand is expansionary in all ECCU countries, and the impact is rapid and large. Figure 6 shows the dynamic response of GDP growth in each of the countries of the region to this type of shock: output growth increases on impact, with effects lasting one to two years, and the largest response typically occurs either in the contemporaneous year or one year after the shock. A "rule of thumb" elasticity can be derived from the impulse response functions, indicating that a one percentage point increase in industrial countries' growth leads—on average—to an increase in ECCU growth of 1½ percentage points. This estimated elasticity is relatively high compared to those of other developing countries. Osterholm and Zettelmeyer (2007), for instance, find that increases in world growth are passed on to Latin America about one-to-one.[13]

[13] Sosa (2008) finds that shocks to U.S. growth are passed on to Mexico almost one-to-one as well. The fact that estimated elasticities for the ECCU are higher is notable, given the large trade linkages between Mexico and the U.S.

Figure 6. Response of Real Output to External Demand Shocks



Source: Authors' calculations.

World Real Interest Rate Shocks

Global financial conditions are also likely to influence macroeconomic fluctuations in the Eastern Caribbean. As discussed in Section II, changes in international real interest rates constitute an important factor driving portfolio capital inflows to emerging markets, thus affecting business cycles in these economies. Table 6 shows the relative contribution of world real interest rates shocks to the variance of domestic GDP growth. Global financial shocks do not appear to be a significant driver of output fluctuations in the region, potentially due to the limited links between international and ECCU banking and financial sectors (see Chai, 2006; IMF 2008, 2009). In each of the ECCU countries—except Dominica—shocks to world real interest rates explain less than 10 percent of the variance of GDP growth.

Table 6. World Real Interest Rate Shocks and Output Fluctuations in the ECCU
(Contribution of world real interest rate shocks to the variance of real GDP growth, in percent)

Horizon	Antigua & Barbuda	Dominica	Grenada	St. Kitts & Nevis	St Lucia	St. Vincent & the Grenadines	Average
1	11.5	4.2	0.5	0.4	5.0	0.7	3.7
2	12.1	8.6	0.2	0.3	11.3	3.7	6.0
3	9.9	11.9	3.6	2.4	9.4	4.6	6.9
4	9.2	11.8	3.7	8.7	13.1	8.0	9.1
5	9.0	11.7	3.7	10.3	13.5	8.0	9.4

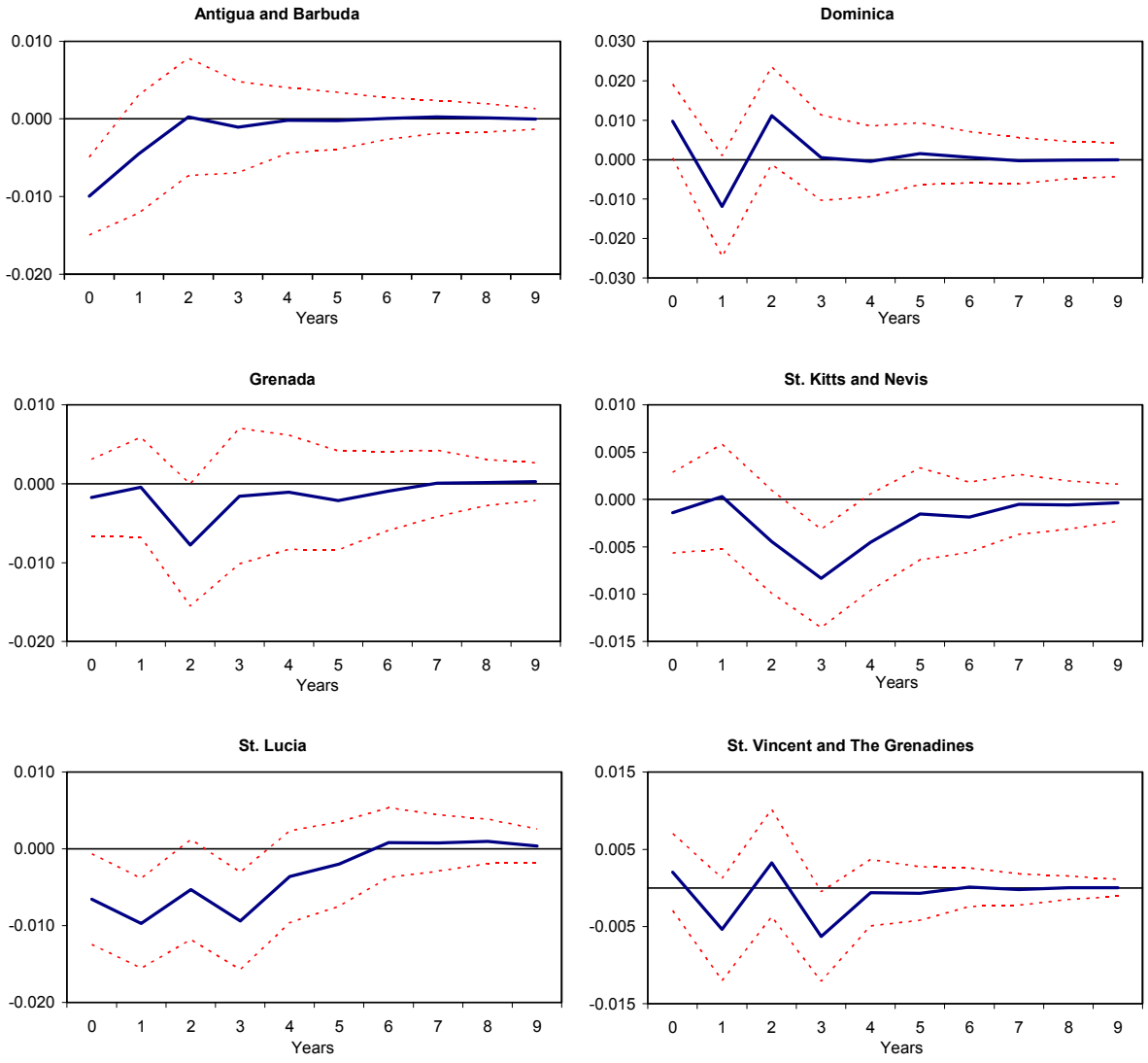
Source: Authors' calculations.

The dynamic response of domestic output in the ECCU countries to a rise in international real interest rates is shown in Figure 7. In some countries this type of shock leads, as expected, to a decline in output either on impact or with a lag. However, this does not seem to be a generalized pattern across the region; in fact the response of output growth in agricultural-dependent Dominica and St. Vincent and the Grenadines is not statistically significant.

Finally, it may be argued that other external factors—such as foreign aid flows—might also play a role in driving output fluctuations in the region. In particular, ECCU countries have traditionally received significant aid from members of the Organization for Economic Cooperation and Development (OECD), largely to support the transition away from traditional agriculture (bananas and sugar) and in response to natural disasters. Against this background, the VAR was estimated using an alternative specification that adds foreign aid flows in the external block of the model.[14] The main results do not change substantially. Moreover, the relative importance of changes in aid flows in explaining output fluctuations in the region appears to be very small, and the dynamic response of domestic output to a shock in foreign assistance is not statistically significant. This may partly reflect that, with independence and the rise in per capita income has also come a large reduction in external aid flows to the region (IMF 2008, 2009). In fact, while aid flows from OECD members have remained roughly constant in U.S. dollar terms since the mid-1970s, they have decline significantly both in real terms and relative to GDP.

[14] The time series used is the OECD's Official Development Assistance (ODA).

Figure 7. Response of Real Output to World Real Interest Rate Shocks



Source: Authors' calculations.

IV. Concluding Remarks

This paper develops country-specific VAR models with block exogeneity restrictions for the Eastern Caribbean countries. A key characteristic of the models is that both climatic and foreign economic conditions are assumed to be completely exogenous to these economies, capturing the small open economy assumption and the high exposure of these economies to climatic shocks. The attempt to capture the effect of changes in domestic climatic conditions represents an interesting feature of these VAR models. Using innovation accounting techniques—impulse response functions and forecast error variance decompositions—they help to assess the relative contribution of external factors in explaining output fluctuations in

the ECCU countries, and to analyze the dynamic responses of domestic business cycles to external shocks.

The main results of the paper confirm the commonly-held view about the high vulnerability of the Eastern Caribbean economies to external shocks. These shocks represent a major source of business cycle fluctuations in the region, explaining more than half of the variance of real output growth at standard medium-term horizons. These results also raise the question of how policymakers in these small and vulnerable economies should prepare and respond to large and sometimes unanticipated shocks. In principle, stronger domestic fundamentals and policy frameworks would make these economies more resilient, though the region is likely to remain sensitive to external shocks. Reducing the vulnerability of the Eastern Caribbean to such shocks would require strong efforts to achieve fiscal consolidation and lower public debt, make budgets more flexible, strengthen domestic financial systems, and diversify the export structure (see IMF 2008, 2009).

Among external disturbances, climatic shocks represent a dominant factor driving output fluctuations in the region, especially at shorter-term horizons. In fact, natural disasters account (on average) for almost 20 percent of the variance of real GDP growth. In general, a natural catastrophe leads to a rapid and large decline in output, and the effects are not persistent—vanishing one or two years after the shock. The exposure of these small islands to climatic conditions is likely to remain high or even increase in the years to come, because the rise in global warming augurs natural disasters with even greater frequency and severity. These results highlight the importance of developing policy frameworks to mitigate the risks of natural disasters in the region. A key policy question in this regard is how the small island economies should respond to the vulnerability induced by natural catastrophes.[15] In general, insurance and capital markets can provide compensation for capital and income losses, alleviating the damage to households, firms, and the government, and smoothing the immediate impact on consumption. Good construction practices and other precautionary arrangements can mitigate the impact of natural hazards before they happen. Improving how these mechanisms function represents a pivotal challenge for the ECCU countries.

Oil price shocks and shocks to external demand also contribute significantly to output fluctuations in the region, typically accounting for slightly less than 20 percent and 15 percent of the variance of domestic GDP growth, respectively. A positive shock to oil prices is contractionary, with negative effects persisting for up to three years. A positive shock to external demand is expansionary in all ECCU countries, and the impact is rapid and large: output expands on impact with lasting effects of about two additional years, and the

[15] Cashin and Dyczewski (2006) provide a discussion of the major channels through which small, disaster-prone economies can respond to the challenge posed by natural disasters, focusing on the options for mitigating disaster risk in the Caribbean.

largest response typically occurs either in the contemporaneous year or one year after the shock. As a "rule of thumb", a one percentage point increase in industrial countries' growth leads (on average) to an increase in ECCU growth of 1½ percentage points. The large sensitivity to changes in industrial countries' growth is particularly relevant in light of the current recession in the global economy, which has adversely affected not only external demand but also remittances to the Eastern Caribbean region.

APPENDIX

Table A1. Antigua and Barbuda: Variance Decomposition of Real Output
(In percent)

Horizon	Std Error	Climate	Oil Price	World Demand	World Real Int. Rate	Real Eff. Exch. Rate	Real Output
1	0.029	28.2	2.2	8.6	11.5	0.1	49.5
2	0.031	30.9	1.9	10.2	12.1	1.4	43.5
3	0.035	35.6	4.4	12.2	9.9	1.2	36.7
4	0.036	34.2	9.9	11.3	9.2	1.2	34.1
5	0.037	34.6	10.8	11.3	9.0	1.2	33.1

Source: Authors' calculations.

Table A2. Dominica: Variance Decomposition of Real Output
(In percent)

Horizon	Std Error	Climate	Oil Price	World Demand	World Real Int. Rate	Real Eff. Exch. Rate	Real Output
1	0.047	31.2	9.3	0.8	4.2	0.1	54.4
2	0.052	28.7	9.6	0.8	8.6	2.2	50.1
3	0.055	26.7	10.3	3.9	11.9	2.0	45.2
4	0.055	26.4	11.0	4.1	11.8	1.9	44.8
5	0.055	26.3	11.4	4.1	11.7	1.9	44.6

Source: Authors' calculations.

Table A3. Grenada: Variance Decomposition of Real Output
(In percent)

Horizon	Std Error	Climate	Oil Price	World Demand	World Real Int. Rate	Real Eff. Exch. Rate	Real Output
1	0.024	8.6	16.2	1.9	0.5	17.4	55.3
2	0.039	16.4	33.8	19.6	0.2	8.7	21.4
3	0.042	18.3	35.1	17.1	3.6	7.6	18.3
4	0.042	18.0	35.5	16.8	3.7	7.9	18.1
5	0.043	17.8	36.0	16.6	3.7	7.9	18.0

Source: Authors' calculations.

Table A4. St. Kitts and Nevis: Variance Decomposition of Real Output
(In percent)

Horizon	Std Error	Climate	Oil Price	World Demand	World Real Int. Rate	Real Eff. Exch. Rate	Real Output
1	0.022	14.6	2.8	7.4	0.4	24.3	50.5
2	0.026	10.8	2.3	24.9	0.3	24.9	36.8
3	0.030	10.7	20.8	20.2	2.4	18.4	27.5
4	0.032	9.4	23.5	18.0	8.7	16.1	24.2
5	0.033	9.4	23.4	17.7	10.3	15.8	23.5

Source: Authors' calculations.

Table A5. St. Lucia: Variance Decomposition of Real Output
(In percent)

Horizon	Std Error	Climate	Oil Price	World Demand	World Real Int. Rate	Real Eff. Exch. Rate	Real Output
1	0.029	5.2	5.6	15.9	5.0	19.1	49.1
2	0.035	5.9	20.1	12.6	11.3	14.8	35.4
3	0.042	10.8	33.3	10.4	9.4	11.1	24.9
4	0.044	11.8	31.4	10.8	13.1	10.1	22.8
5	0.044	12.1	31.2	10.8	13.5	9.9	22.4

Source: Authors' calculations.

Table A6. St. Vincent and the Grenadines: Variance Decomposition of Real Output
(In percent)

Horizon	Std Error	Climate	Oil Price	World Demand	World Real Int. Rate	Real Eff. Exch. Rate	Real Output
1	0.025	1.9	8.8	20.8	0.7	0.0	67.9
2	0.030	6.9	9.1	17.0	3.7	12.5	50.8
3	0.031	6.7	9.8	17.0	4.6	13.6	48.2
4	0.032	6.7	11.5	16.5	8.0	12.8	44.5
5	0.032	6.8	11.5	16.6	8.0	12.8	44.4

Source: Authors' calculations.

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