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Growth Volatility in Belize

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Abstract

An open economy structural vector autoregressive (SVAR) model is developed for Belize with the objective of identifying the main factors behind the volatility in output growth. A Markov-Switching VAR (MS-VAR) model is also employed to explore whether the response to shocks is the similar across different economic states. The paper finds that Belize is one of the most volatile economies in Latin America and the Caribbean. Most this is volatility is driven by fluctuations in the economic growth of its main trading partners – United States and Mexico - and domestic price movements. The impact of these variables differs significantly depending on the prevailing economic conditions in Belize. Notably, the influence of trading partner's GDP on growth weakens during periods of intense volatility suggesting that the authorities may need to invest more in developing countercyclical measures to minimize the duration of instability. The paper also confirms that higher output volatility undermines the pace of economic expansion in the country and has kept growth in Belize lower than otherwise possible.

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1. Introduction

The growth experience of Belize has been very erratic over the past three decades. The country is reliant on its natural resource base, which supports the tourism and agriculture sectors. It is also relatively close to major markets such as Mexico and the United States (US). While the country enjoyed periods of high growth compared to its peers, such episodes were often followed by sharp declines, ranging in magnitude from 5 to 14 percentage points, followed by similar upturns a few years later. The first of two very distinct periods of sharp swings in growth in Belize coincided with a boom in the tourism sector financed by foreign direct investments (FDI) in the early 1990s and later by a significant increase in government expenditure. The expansion in government expenditure was unsustainable and quickly shifted the public sector from overall balance in the 1980s to a deficit of 8 percent of Gross Domestic Product (GDP) by 1993. This was mirrored by an even larger current account deficit. An adjustment program ensued, resulting in a notable falloff in economic activities. The second, which occurred in the latter half of the 1990s, saw growth being financed by external government borrowings. This too was unsustainable with the burst in growth giving way to another period of decline.[1]

Standard measures of volatility rank Belize as one of the most volatile in the world.[2] Output volatility, as measured by the standard deviation of real GDP growth, has been high and persistent in Belize. With an average of 4.3 percent per decade, the standard deviation of growth in Belize has been among the highest in the region since the 1970s. Although some peer countries in the Latin America and the Caribbean (LAC) region experienced similar average standard deviations in the last four decades, most resulted from a rapidly declining trend in volatility of growth from high values in the 1970s (e.g. the Bahamas, Chile, Dominica, Jamaica and Nicaragua). Conversely, for Belize, the standard deviation of growth has remained high, illustrating the persistent nature of volatility of growth in the country (Figure 1). The standard deviation of Belize's annual growth has been more than double the average of other middle-income countries.

Much of the volatility in GDP growth in Belize has been attributed to poor fiscal discipline, natural disasters, terms of trade shocks[3] and relatively weak institutions. Frankel, Vegh and Vuletin (2014) concluded that fiscal and budgetary policies in Belize have followed a strong pro-cyclical stance during most of the 1990s. This has only recently been converted into a mild counter-cyclical stance

[1] For a detailed account of the stop-go pattern of growth in Belize see Martin and Manzano (2010).

[2] Available evidence suggests that the impact of high volatility has adverse economic and social implications. Ramey and Ramey (1995), Hnatkovska and Loayza (2005) and Breen and Garcia-Penalosa (2005), among others, show that the link between volatility and growth is largely tied to the level of economic development with the negative effects of volatility being more pronounced in low-income countries. LAC economies are both much more volatile and much more unequal than industrial economies.

[3] Easterly and Kraay (2000) showed that small states do have greater volatility of annual growth rates, which is in part due to their greater volatility of terms of trade shocks.

after 2005. As a result, it has only been in recent years that the Government has been able to support economic activity during a downturn.

This paper investigates possible determinants of output volatility in Belize to help inform policy. The classical SVAR approach proposed by Blanchard and Quah (1989) is used to evaluate the impact of external and domestic shocks on output. In addition, the Markov switching vector autoregressions (MS-VAR) approach popularized by Hamilton (1989) is used to explore how the determinants of output volatility behave during different business cycles. The analysis is closed with a simple exercise to determine whether growth would be higher or lower had the economy been less volatile.

Figure 1: Standard Deviation of Output Growth: Belize vs. LAC, Caribbean, Small States 1970-2009

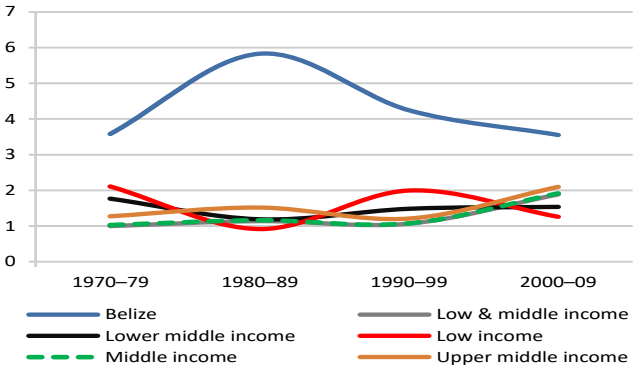
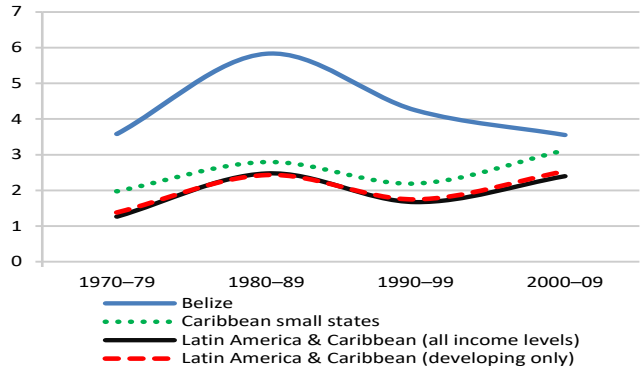


Figure 2: Standard Deviation of Output Growth: Belize vs. Low- and Middle-Income Countries 1970-2009



Source: World Bank staff estimates and World Bank

The paper finds that output volatility in Belize is largely explained by its trading partners GDP and domestic CPI. Fiscal and monetary policies are largely ineffective in assuaging the amplitude in output volatility in Belize. As such, actions aimed at addressing business cycle fluctuations in Belize require policy interventions that accurately account for the numerous channels through which developments in the country's main trading partners are transmitted to the economy.

The remainder of the paper is organized as follows. Section 2 summarizes the relevant literature which explores the relationship between output volatility and growth. Key features of the economy, along with the relevant drivers of business cycles in Belize, are discussed in section 3. In section 4, the methodology is discussed, focusing on the theoretical construct of the SVAR and the MS-VAR which allows us to gain insight into the dynamic relationships among variables and to quantify the effects of various shocks on growth in Belize. The results are presented in section 5. In section 6, the paper presents a simplified framework to illustrate the counterfactual of whether growth would be higher had the economy been less volatile. Section 7 concludes.

2. Literature Survey

There has been much debate on the link between output volatility and long-run growth. While some authors support the theory that volatility and growth share a positive relationship, others claim that the opposite is true, and evidence has risen to support both sides. There are two main approaches supporting a positive relationship between volatility and growth. First, to the extent that macroeconomic volatility measures the overall level of risk associated with investing in a country, long-run growth can be interpreted as the mean return expected on investment projects within that economy. Countries with low-variance technologies (i.e. low risk) would only benefit from low expected returns (i.e. low growth) while those with access to high-variance technologies would benefit from high expected returns (Black, 1987). Second, the relationship between volatility and growth may follow the creative destruction theory, where high volatility may lead to recessions, which in turn trigger the bankruptcy of less productive firms and higher overall research and development efforts, eventually resulting in higher long-run growth (Caballero and Hammour, 1994; Aghion and Saint-Paul 1998).[4] Other studies have shown that higher standard deviations of output growth are associated with higher mean growth rates (Kormendi and Meguire, 1985; Grier and Tullock, 1989; and Koteski et al., 2013). However, there is also evidence which suggest that when other volatility measures are included, the positive impact of volatility on output becomes insignificant (Gavin and Hausmann, 1995).

There is also evidence which suggest that economies that have frequent bouts of volatility tend to grow at a relatively slower pace compared to other economies.[5] Ramey and Ramey (1995) confirmed evidence of a negative relationship when controlling for income, population growth, human and physical capital. The paper also produces a panel analysis controlling for both time and country fixed effects, and the negative relationship between volatility and growth is shown to be robust to a large set of controls that vary with time period or country. Hnatkovska and Loayza (2003) find not only empirical support for a negative causal effect of volatility on growth, but also that the link is exacerbated in developing countries. The authors also suggested that a positive relationship between volatility and growth is highly dependent on well-developed financial markets and government institutions, attributes usually found only in developed economies. Finally, work from Imbs (2006) points to evidence of growth and volatility correlating negatively across countries, but positively across economic sectors. However, the author claims that whether sectoral growth and volatility are correlated positively has little impact at the aggregate level, which depends on the covariance between growth and the country specific components of aggregate volatility, reflecting fiscal or monetary policy shocks.

The sources of GDP volatility have also been studied in significant detail. Chauvet and Guillaumont (2008) argue that the international aid flows lead to higher economic growth mainly through a stabilizing effect, and that volatility of such aid flows reduces the overall beneficial effect. Judson and Orphanides (1999) not only used cross-country panel data to show that inflation and income growth have a strong negative correlation, but also constructed a measure of inflation

[4] Skidmore and Toya (2002) support the creative destruction theory through high risk of suffering from natural disasters, claiming that it serves to increase the return on human capital.

[5] See for example van der Ploeg and Poelhekke (2008) for more. Additionally, see Blattman, Hwang, and Williamson (2007), who show that countries that specialize in commodities with substantial price volatility experience lower growth rates.

volatility using intra-year data to show that inflation volatility and growth are robustly negatively correlated. After showing empirical evidence of the negative correlation between business-cycle volatility and long-run growth, using measures of volatility based on both period averages and lagged annual aggregates, Kneller and Young (2001) investigated the potential sources of volatility and arrived at the conclusion that both inflation uncertainty and oil price volatility presents robust negative correlations with long-run growth. Furceri (2007) found evidence that countries with higher government expenditure volatility have lower growth, even after controlling for investment, human capital, population growth and output volatility, although this relationship holds more significantly for non-OECD countries. Finally, Turnovsky and Chattopadhyay (2003) developed a model analyzing the effect of volatility on growth in a developing economy that faced an imperfect world capital market. The authors concluded that for high volatility economies, terms of trade volatility, government expenditure volatility, and monetary volatility, all have strong negative impacts on the equilibrium growth rate.

Output volatility has also been attributed to debt build-up and debt overhang. Pescatori et al. (2014) contribute to the literature on volatility by investigating whether there is a particular threshold in the level of government debt above which the medium-term growth prospects are compromised.[6] Despite applying a methodology based on the analysis of the relationship between debt and growth over longer periods of time, and thus reducing potential for reverse causality from growth to debt, the authors' failed to identify a clear threshold, concluding that the association between debt and medium-term growth becomes weaker at high levels of debt. Nonetheless, the authors showed that there is some relationship between high levels of debt and higher output volatility. They theorized that high levels of debt may induce output volatility through front-loaded fiscal consolidation or temporary bursts of inflation (hence, controlling for fiscal and monetary policy should implicitly control for the effect of debt on growth volatility). Samuel (2014), in looking at cyclicality of fiscal expenditure in 10 Caribbean countries, highlighted Belize as having the most dramatic pro-cyclical performance among its peers, where deficits appear to be higher during periods of positive output gaps (actual output higher than trend) and smaller deficits when the output gap is negative.

3. Stylized Facts About Growth Volatility in Belize

Overview of the Economy of Belize

Although the economy of Belize has been traditionally oriented towards agriculture it has undergone significant transformation over the last fifteen years. The country had its first commercial oil discovery in 2005 and its tourism product has since emerged as the country's main export. The service sector has become the largest contributor to GDP, accounting for 54 percent, while the agricultural sector contributes 13 percent. The country's natural beauty is the main

[6] The link between public debt and economic growth has been extensively covered in the growth literature. There is the view that whenever outstanding debt exceeds a threshold, public investments will be constrained by the debt overhang which raises the possibility of default. The possibility of default increases investor uncertainty and as such will induce rational investors to postpone longer-term investments in favor of short-run projects even if they are less profitable. High levels of debt may affect the allocation of resources and ultimately growth through other channels. There is the crowding out effect, as well as possibility of a fall in the amount and productivity of private investment arising from the loss of externalities associated with state investment in public goods. The crowding out effect is a result of the higher financing cost necessary to attract investors in government debt instruments. This is of concern to Belize given its relatively high debt burden.

attraction, making eco-tourism a specialty in Belize, which has the world's most important live coral reef. Small enterprises play a large role in Belize's tourism sector, compared with more traditional destinations such as the Bahamas and Barbados. The oil sector is an option in terms of diversifying sources of growth and fiscal revenues, but it attracts a great deal of challenges and risks. Oil production at Spanish Lookout near the inland border with Guatemala started in late 2005 and now contributes roughly 7 percent of GDP, although reserves are dwindling rapidly. Government oil revenue has been an important compliment to tax income, although it has been declining rapidly in recent years and has also been impacted by the recent plunge in oil prices. Food processing and other services comprise the remainder of private sector manufacturing activities. On the demand side, growth has been heavily dominated by the trade balance. Between 2001 and 2013, exports and imports have jointly contributed an average of 47.2 percent to GDP growth, constituting the largest portion of GDP growth from the demand side of the economy.

The growth decomposition shed some light on the possible sources that generate volatility. In order to further deepen the understanding of these drivers, a variance decomposition analysis is undertaken. The decomposition uses historical data from 2000 to 2014. We exploit the national income accounting GDP definition of expenditure using the following variance equation:

$$GDP = \sum_i x_i$$

$$Var\left(\sum_{i=1} x_i\right) = \sum_i Var(x_i) + 2\sum_{i \neq j} Cov(x_i, x_j) \quad (1)$$

$$Thus, \quad 1 = \left(\sum_i Var(x_i)\right) Var\left(\sum_{i=1} x_i\right)^{-1} + \left(2\sum_{i \neq j} Cov(x_i, x_j)\right) Var\left(\sum_{i=1} x_i\right)^{-1} \quad (2)$$

Equation (1)[7], which is derived from the properties of the variance operator, describes the variance decomposition of an additive variable, such as the national income accounts definition of GDP. The resulting equation (2) identifies the contribution of each variable to total GDP volatility. The two caveats to this methodology are: (i) it is only defined to linear functions; and, (ii) they are "dirty" correlations since there may be other underlying variables, which if not controlled for, may over/understate the overall explanatory power of a variable.

Table 1: Variance Decomposition of GDP at Factor Cost

Sectors of the economy	
Tertiary	29.9
Services-Taxes covariance	21.0
Services-Industry covariance	14.5
Services-Agriculture covariance	13.8
Agriculture-Taxes covariance	5.1
Taxes	4.1
Industry -Taxes covariance	3.7
Secondary	3.3
Primary	2.4
Agriculture-Industry covariance	2.1

Source: World Bank staff calculations

About 30 percent of Belize's volatility of growth stems directly from the service sector. This result is derived from a variance decomposition exercise aimed at identifying which sector of the economy contributes the most to the country's growth volatility. Another 50 percent can be

[7] If the relationship is subtraction, the covariances (not the variances) will enter with a minus sign in this identity.

attributed to covariate terms between the tertiary sector and agriculture, industry, and taxes (Table 2). In fact, the primary and secondary sectors of the economy account for only 2.4 and 3.3 percent of the variance in GDP growth, respectively. Although the difference between each sector's contributions to GDP variance is large, it comes as little surprise given that Belize's service sector has become the largest contributor to GDP. Within the tertiary sector of the economy, financial services emerged as one of the main drivers, accounting for nearly 10 percent of volatility. The second and third highest contributions come from transportation/communications and wholesale services at a level of 4.7 and 4.3 percent, respectively.

On the expenditure side, volatility of growth in Belize is mostly attributed to exports, which account for 43.8 percent. The second largest contributor is private consumption, accounting for 37.3 percent, followed by imports at 17.6 percent, investment at 2.6 percent, and public consumption at 2.3 percent. Covariance terms between the major factors account for a significant portion of variance but are counterbalanced by other covariance terms representing negative percentages. These results suggest that although the government of Belize has a large presence in the economy, its expenditure fluctuates little compared to other factors, resulting in only small contributions to the variance of output growth.

Data

The paper draws from the work of Araujo et al (2014) and Loayza, Fajnzylber and Calderón (2005) of the determinants of growth in LAC to guide the choice of indicators behind output volatility in Belize. Variables are grouped as either domestic or foreign.[8] On the domestic side, GDP (*rgdp*), interest rates differential (*b_tbill*), inflation (*cpi*), real effective exchange rate (*reer*) and government expenditure (*gvt_exp*, as a proxy for fiscal policy) are included. On the external side, world demand is measured as the trade-weighted GDP (*wrgdp*) of Belize's main trading-partners over the last two decades (i.e. United Sates, United Kingdom, Mexico, and Guatemala). Other external variables include world interest rate proxied by the US 3-month Treasury bill rate (*us_tbill*) and international oil prices (*oil*) as measured by the WTI crude oil spot price.[9]

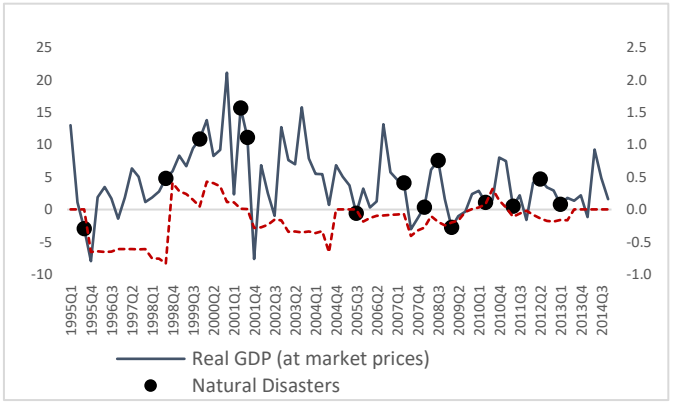
Table 2: Variable Names

Variable	Name
g_rgdp	Real Gross Domestic Product
g_oil	WTI Crude Oil Spot Price
g_cpi	Inflation
g_gvt_exp_~r	Government Expenditure (Recurrent)
g_gvt_exp_~p	Government Expenditure (Including Capital Project)
g_reer	Real Effective Exchange Rate
us_tbill	US 3-Month Treasury Bill Rate
b_tbill	Interest Rate Differential
g_wrgdp	Trade Weighted Gross Domestic Product

[8] See also the work of Kneller and Young (2001), Judson and Orphanides (1999), Turnovsky and Chattopadhyay (2003) and Furceri (2007) for more on macroeconomic indicators of volatility.
[9] See Hamilton (2008) for the role of oil prices in business cycles.

One of the explanations that has been forwarded in the literature for growth volatility in Belize is the impact of natural disasters. The view is that a large portion of total investments each year is dedicated to the replacement of lost or damaged capital as a result of natural disasters. Between 1995 and 2014, Belize was impacted by 14 natural disasters, most of which were tropical storms/cyclones, with the occasional flood, drought, or earthquake. Although the country is known for its high frequency of natural disasters, their magnitude can differ considerably, with estimated damage per occurrence varying from US$0.05 to US$277 million (EM-DAT, The International Disaster Database). There are instances where natural disaster events are followed by sharp declines in real GDP growth. However, there are also cases where these events appear to spur quick positive changes to growth rate, presumably from relief related construction recovery efforts (see Figure 3). A correlation analysis over a period of 12 consecutive rolling quarters show that real output growth is, at times, negatively correlated with natural disaster events, but positively correlated during other periods.

Figure 3: Belize is Regularly Impacted by Natural Disasters



Several important observations are apparent from further analysis of the data (see Tables 3 and 4). First, GDP has become less volatile over the past 10 years. In fact, except for capital expenditure, the volatility of all variables declined over the last five years of the review period. Second, government expenditure, both current and capital, are the most volatile of all indicators. Third, the volatility of real effective exchange rate almost doubled over the past 10 years relative to the previous decade due to relative price movements. A similar pattern is evident for the trade weighted GDP of Belize's main trading partners. Apart from the correlations between growth and foreign interest rates, there is nothing unusual about the signs of the correlations.

Table 3: Standard Deviations of Growth Rates

	1995 - 2014	1995 - 2004	2005 - 2014	1995 – 1999	2000 – 2004	2005 – 2009	2010 – 2014
g_rgdp	5.0	5.9	3.4	4.7	6.4	3.8	2.8
g_gvt_exp_~r	10.6	9.2	11.8	5.3	10.6	14.7	7.4
g_gvt_exp_~p	45.2	39.7	50.0	37.2	42.0	44.8	50.7
g_cpi	2.3	2.3	2.3	3.0	1.1	2.9	0.8
g_oil	35.2	36.3	34.1	37.5	34.3	42.7	38.9
g_wrgdp	1.8	1.3	2.0	1.1	1.3	2.6	0.4
us_tbill	2.1	1.8	1.8	0.3	1.8	1.7	0.2
b_tbill (BLZ-USD; ppt)	1.6	1.6	1.5	1.1	0.9	1.8	0.8
g_reer	4.3	2.6	5.5	3.1	1.7	5.8	5.1

Table 4: Variance-Covariance

	g_rgdp	g_oil	g_cpi	g_gvt_~r	g_gvt_~p	g_reer	us_tbill	b_tbill	g_wrgdp
g_rgdp	1.000								
g_oil	0.223	1.000							
g_cpi	-0.095	0.281	1.000						
g_gvt_exp_~r	0.149	0.083	-0.054	1.000					
g_gvt_exp_~p	0.337	0.046	-0.308	0.058	1.000				
g_reer	-0.143	-0.504	0.092	-0.144	-0.103	1.000			
us_tbill	0.179	0.095	0.106	-0.034	0.054	0.090	1.000		
b_tbill	0.355	0.100	-0.145	0.042	0.103	0.040	0.676	1.000	
g_wrgdp	0.286	0.434	0.065	0.044	0.211	-0.265	0.483	0.163	1.000

Source: WB staff calculations

4. Methodology

Structural Vector Auto Regression (SVAR)

The paper adopts the traditional SVAR framework to capture the dynamic relationship among the variables. This framework is superior to simple correlations as it allows us to delineate the impact of various shocks, both internal and external, on GDP. The SVAR is guided by economic theory. That is, if the dynamic relationship between/among a set of variables can be represented by a VAR framework, it is expected that the structural form is a delineation of the underlying structural economic relationships. The features of the SVAR which validate the choice of framework for explaining output volatility in Belize derive from the fact that: i) the error terms are not correlated, which implies that the underlined shocks which are responsible for the dynamics of the economic growth volatility are assumed to be independent.[10] This is particularly useful for distilling the effects of economically unrelated influences in the system; and ii) variables can have a

[10] All the variables in the system have a structural equation and an associated error term. These error terms are interpreted as shocks or innovations of that variable on the system. This allows for interpretation of the dynamic response of different shocks using impulse response functions.

contemporaneous impact on other variables – a feature which is desirable when data frequency is low[11].

An SVAR is specified with p lags as represented in the following equation:

$$A\,\Delta Y_t = B\,\Delta Y_{t-1} + \bar{\gamma}'\bar{c} + \bar{\varepsilon_t} \qquad (3)$$

Where, ΔY_t is the vector with the variables of interest, A is the structural matrix, B_i is a $k \times k$ matrix (for every $i = 0, ..., p$), $\bar{\gamma}$ is the vector with the coefficients of controls $\bar{c}$, and ε_t is a $k \times 1$ vector of error terms (structural shocks). The main diagonal terms of the B_0 matrix (the coefficients on the i^{th} variable in the i^{th} equation) are scaled to 1 with the particularity that all the elements off the main diagonal of the covariance matrix are zero. That is, the structural shocks are uncorrelated.

To identify the coefficients, it is necessary to specify appropriate exogeneity restrictions which are consistent with underlined theoretical assumptions of the contemporaneous interactions of the variables. In this case, we exploit the small open economy assumption. That is, a shock to domestic GDP will not affect the external variables contemporaneously. Additionally, the matrices below show that the restrictions are adequate to identify the structural innovations.[12] Each row in matrix A represents the dependent variables and each column, the explanatory variables for the system of differenced equation.

The SVAR uses quarterly data from 1994Q1 to 2014Q4. All variables, except *us_tbill*, are in log changes as to ensure stationarity. Where necessary, variables are seasonally adjusted. The vector Y_t is composed of: real trade weighted GDP growth and interest rate as the external variables, domestic inflation, real GDP, and government capital expenditure as the domestic drivers. The vector $\bar{c}$ contains a control for natural disasters dummy. The coefficients will therefore identify the magnitude of each variable's effect on real GDP growth. For reasons of parsimony, the Schwartz Information Criterion (SIC) was chosen as the system contains a large number of parameters to be estimated from a relatively small data set.[13] The SIC suggested that one lag was appropriate for estimating the system (see Table 5). The SVAR is over identified and converged after 14 iterations (81 observations).

$$A = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & a_{44} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & 1 \end{bmatrix};\ B = \begin{bmatrix} b_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & b_6 \end{bmatrix};\ \Delta Y_t = \begin{bmatrix} wrgdp \\ oil \\ us\_tbill \\ rgdp \\ cpi \\ gvt\ exp \end{bmatrix}$$

[11] The impact of this is expected to be muted given the open economy assumption adopted.
[12] The real effective exchange rate was eventually dropped as it did not add much to the various models contemplated.
[13] The Akaike Criterion is disregarded since it overestimates the order with some probability as shown by Luetkepohl (2005).

Table 5: Lag Selection Criteria

Lag	LogL	SC
0	924.145	-25.314
1	1062.824	-27.028*
2	1104.699	-26.053
3	1152.896	-25.253
4	1180.917	-23.894
5	1209.224	-22.542
6	1256.471	-21.716
7	1310.823	-21.087
8	1365.772	-20.475
9	1452.875	-20.756
10	1543.887	-21.146

Notes: LogL refers to the log likelihood value. SC refers to the Schwarz Information Criterion.

Markov Switching VAR (MS-VAR)

To ensure the accuracy of the investigative approach, it may be necessary to account for the possibility of an unstable data generating process. In other words, to incorporate probable structural breaks or changes, it may be useful to estimate a VAR model where discrete regimes are governed by a hidden Markov chain. It is useful to understand how the different variables or impulses impact real GDP growth in a calm state or in a state of high output volatility. This will help to explain whether high output volatility impairs growth by reducing the impact of the variables on real GDP growth. Regime switching models produce the required non-linear dynamics that can replicate the more realistic notion of exogenous events acting as intermittent disturbances on an economy.[14] Indeed, it is in the similar context of business cycle estimation that such models were firstly widely used, following the seminal work of Hamilton (1989).

In this context, consider that the Belizean economy is characterized by two states of volatility; one which has low output volatility and is characterized by a relatively calm macroeconomic environment (state 1) and the other being significantly more volatile with macroeconomic instability or turmoil (state 2). Let there be a vector of dependent variables, so that $Y_t = [g\_rgdp_t, g\_wrgdp_t, g-cpi_t, \Delta us\_tbill_t]$. Note that we have dropped oil prices and government expenditure from the model, due to their statistical insignificance and low impact coefficients when included. Further, let Y_t follow an autoregressive system with the vector, β_{S_t} as the matrix of parameters as follows;

$$Y_t = \beta_S \, Y_{t-1} + \varepsilon_t \qquad (4)$$

and where, ε_t is the error term with mean zero and a state dependent effect given by a 4 by 4 covariance matrix, Σ_{S_t} so that $\varepsilon_t \sim N(0, \Sigma_{S_t})$.

[14] Markov switching models are particularly useful when examining whether the effects of shocks (domestic or foreign) on the real economy have been subject to a structural break without making prior assumptions about its timing.

To complete the description of the data generating process, the paper describes the regime/state generating process and shows how this evolves from the data. In Markov switching models, the evolution of the switching process is governed by a hidden latent variable s_t, which is a discrete state Markov stochastic process. This gives transitional probabilities, defined as;

$$\Pr\{s_t = j \,|\, s_{t-1} = i\} = p_{ij} \text{ for all i and j } \in (1,2) \qquad (5).$$

These Markov state transition probabilities satisfy $\sum_{i=1}^{2} p_{ij} = 1$ for *j = 1, 2*. Note, p_{ij}, represents the probability of switching to state j from state i. That is, period t-1 is represented by i. The probabilities are collected in the following 2 by 2 transition matrix, *P*, for a row i, column j framework as follows;

$$P = \begin{bmatrix} p_{11} & 1-p_{11} \\ 1-p_{22} & p_{22} \end{bmatrix}.$$

Note that for i = 1, $p_{ii} = P$ and for i = 2, $p_{ij} = Q$.

Applying the chain rule and the Markov property, we also calculated the expected duration of each state, denoted as D_i using the transition probabilities. The probability of staying in each regime (say regime i, where i=1, 2) for k periods can be expressed as $\Pr(D_i = k) = p_{ii}^{k-1}(1-p_{ii})$. Therefore, the expected value of the duration itself can be expressed as $E(D_i) = \sum_{k=0}^{\infty} k \Pr(D_i = k) = \frac{1}{1-p_{ii}}$, for i=1, 2.

For the purposes of the study, we report the results for the first equation of the VAR representation. Note that the first equation of the VAR model represents the equation which uses real GDP growth rate, g_rgdp_t, as the dependent variable. Hence, for s=1, 2 using 1 lag, this equation is therefore defined and estimated as follows:

$$g\_rgdp_t = \beta_{1,S}.g\_rgdp_{t-1} + \beta_{2,S}.g\_wrgdp_{t-1} + \beta_{3,S}.g-cpi_{t-1} + \beta_{4,S}.\Delta us\_tbill_{t-1} \qquad (6)$$

5. Results

SVAR

External factors have a statistically significant impact on output variability in Belize. The system indicates that a positive shock to trading partners' GDP results in higher growth and the accumulated impact is pronounced and permanent (see Figure 4). A positive 1 standard deviation shock to world GDP increases domestic GDP by 0.1 percentage point with the potential to increase by as much as 0.2 percentage point. Note that the confidence interval implies that most of the outcomes are above 0, implying a highly likely positive impact of improving external conditions. Given the structure of the economy, this effect could potentially take place through the external sector channel. Notably, through increased tourism demand as well as higher merchandise exports – both of which have the potential to raise the level of domestic demand. This impact could also enter through the remittance channel, given that most of the transfers to Belize originate from its

major trading partner countries. The impact of international oil prices is somewhat unexpectedly positive but is not very strong. The positive response to a shock from oil prices possibly reflects local attempts to maximize output from the oil sector to benefit from higher prices. It could also reflect increased investment in other forms of energy to counter the impact of higher oil prices. Monetary policy adjustments in the US have the expected inverse relationship with output in Belize and although the accumulated impact is relatively small it does have some amount of permanence. This development reflects changes in investment decisions, either a postponement of foreign direct investments and/or portfolio holders adjusting long portfolio positions to benefit from interest rate differentials.

The paper finds that a positive domestic price shock leads to a decline in output which is consistent with the work of Judson and Orphanides (1999). As the price of goods increase in the economy, consumers quickly switch to cheaper imports either from neighboring Mexico or the US. With a fixed exchange rate regime, shock to prices follows a long memory process which suggests that the falloff in output will have some amount of permanence as the economy loses external competitiveness. A 1 standard deviation increase in prices triggers a contraction of GDP growth of as much as 0.01 percentage point. There does appear to be some amount of procyclicality where a positive shock to government expenditure leads to short-lived spike in output. Notwithstanding, the overall impact of government expenditure, which includes post disaster expansion, is negligible over time. The dummy for natural disaster was not statistically significant and was eventually excluded from the analysis.

The variance decomposition suggests that the main drivers of output variability in Belize are CPI and trading partners' GDP (Table 6). CPI accounted for more than 4 percent of the variance at some point in the 10-quarter horizon, while WRGDP accounted for just above 2 percent. None of the variables had an immediate impact on output variability.

Figure 4: Impulse Response Functions

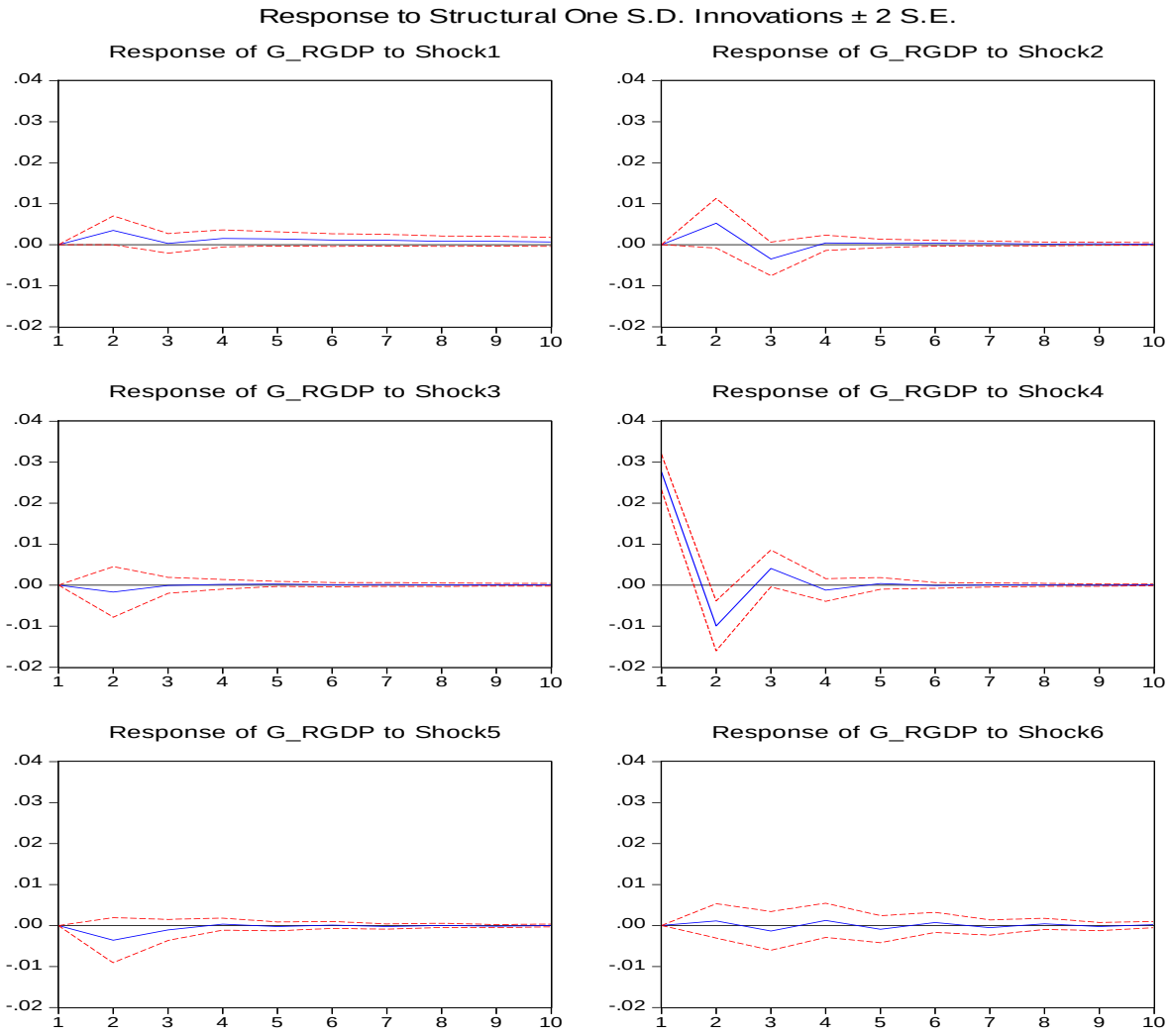


Figure 5: Impulse Response Functions

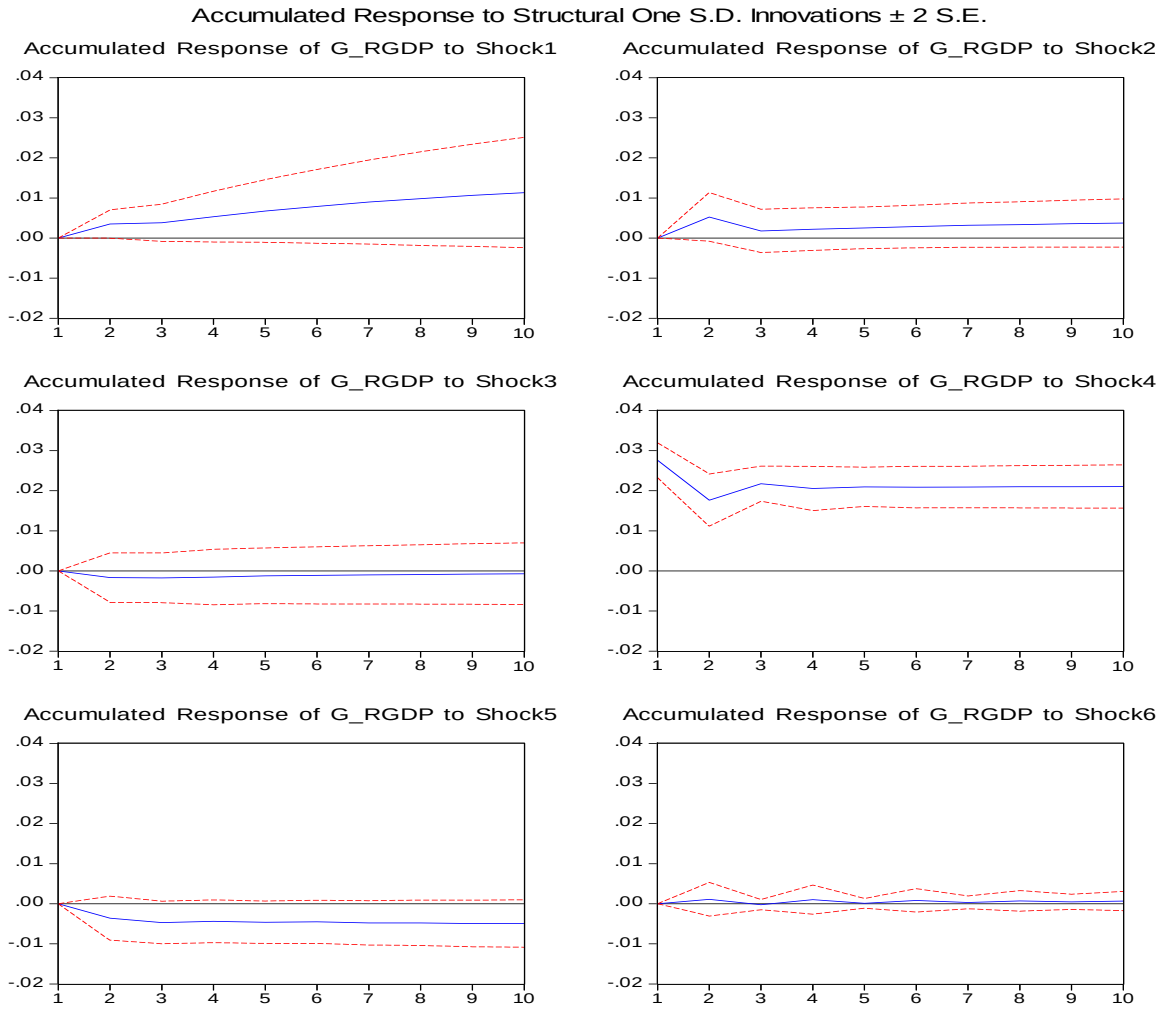


Table 6: Variance Decomposition of RGDP growth

Period	S.E.	*wrgdp*	*oil*	*us_tbill*	*rgdp*	*cpi*	*gvt_exp*
1	0.008	0.000	0.000	0.000	100.000	0.000	0.000
2	0.011	1.331	3.007	0.305	93.817	1.408	0.134
3	0.013	1.296	4.187	0.295	92.415	1.487	0.319
4	0.014	1.534	4.184	0.297	92.015	1.489	0.481
5	0.015	1.736	4.180	0.306	91.720	1.490	0.568
6	0.016	1.866	4.185	0.306	91.531	1.488	0.623
7	0.017	1.988	4.188	0.308	91.374	1.493	0.649
8	0.017	2.060	4.187	0.308	91.287	1.492	0.666
9	0.017	2.131	4.189	0.309	91.205	1.493	0.673
10	0.017	2.177	4.188	0.310	91.156	1.492	0.677

MS-VAR

The paper uses direct optimization of the log likelihood to derive the MLE estimates of the parameters in line with Hamilton (1994). The algorithm is used to deal with the dual uncertainty problem. That is, to overcome the uncertainty of parameter estimates and probability of regimes/states in each time period. After the first set of parameter values are derived, the process is repeated until the convergence criterion of parameter stabilization is satisfied. The results can be seen in Table 7. The final function value or log likelihood is 1087.191.

All impact coefficient signs are in line with expectations. All variables are found to be statistically significant except for US Treasury bill rate effects. The probability that a large and sharp movement will be followed by another (denoted as Q) is 0.598, while the probability that a calm state will be followed by another calm state (denoted as P) is 0.932. In terms of the expected duration in each regime, 14.9 quarters is derived for state 1 and 2.5 quarters for state 2. This suggest that the persistence of the regimes is asymmetric. As such, large output variations are characterized by sharp and short-lived episodes lasting roughly two quarters, while smaller output variations are characterized by much longer episodes lasting roughly 3.5 years. Figures 6 show the smoothed probabilities, generated from the model. These are simply the conditional probabilities of being in state 1 (low volatility state). Hence when the probability value goes below the 0.5 level, this represents a switch-point and implies that the economy is now in state 2 at that point in time. As can be seen in the plot, the switch from state 1 to state 2 coincides with the areas of excessive volatility during the sample period.

Trading partner's GDP has a strong, positive and statistically significant impact in both states $(\beta_{2,S})$. However, in state 2, the impact is significant at the 10 percent level only, which suggests that during periods of high volatility, the potency of the impact of world growth may be lower. Regarding the impact of CPI $(\beta_{3,S})$, as expected the impact is strong and negative reflecting the destabilising effects on GDP growth due to price elasticity and uncertainty. However, unlike state 2, the impact is not statistically significant for state 1 and the impact coefficient is much lower during the calm state. This implies that during periods of high output volatility (state 2), the negative impact of inflation on real GDP growth is significantly more pronounced. This points to the undesirability of high output volatility, considering that higher inflation during states of high output volatility may impede growth to a larger extent than during calm periods. With regards to the impact of US Treasury bill rate $(\beta_{4,S})$, as expected this impact is negative due to the adverse impact on GDP growth from capital flight and or delayed investment decisions. The impact was, however, statistically insignificant in both states, despite its economic significance.

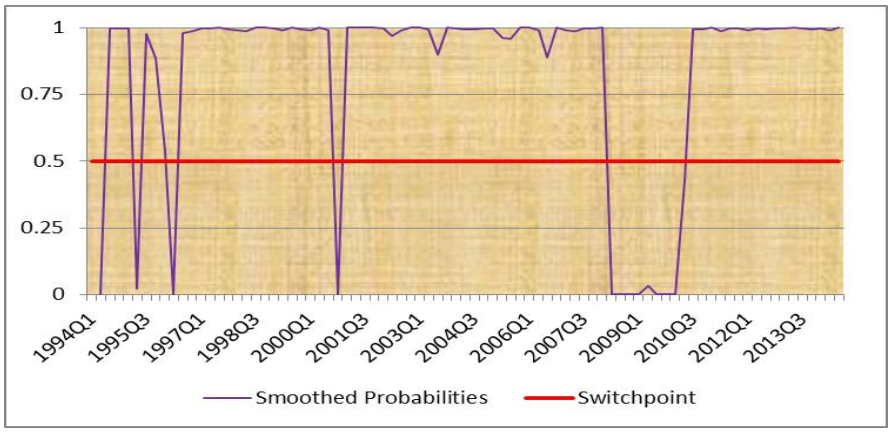
Overall, the results suggest that higher output volatility is less desirable than lower output volatility to maintain a high growth trajectory. When the economy is experiencing extreme bouts of volatility, trading partner's GDP lose some of its ability to influence domestic activities. This is further compounded by the negative effects of inflation, which tends to become more pronounced during these episodes.

Table 7: MS-VAR Estimates

Parameter	Value	Standard Error	P - Value
P	0.932	0.122	0.000
Q	0.598	0.231	0.010
β_{11}	-0.461	0.090	0.000
β_{12}	1.573	0.470	0.000
B_{21}	0.517	0.100	0.000
β_{22}	0.604	0.340	0.080
β_{31}	-0.198	0.330	0.550
β_{32}	-1.433	0.630	0.030
β_{41}	-0.368	0.680	0.590
β_{42}	-0.494	1.280	0.700
Log-Lik	1087.191		
AIC	2086.381		
BIC	1919.489		

Notes: Log-lik refers to the log likelihood function value at convergence.

Figure 6: Smoothed Probabilities



6. Counterfactual Exercise

A counterfactual exercise is undertaken to determine what would be the level of real GDP if the volatility of growth was historically lower**.** The paper tackles this by running a panel regression following the controls suggested in the simplified version of Ramey and Ramey (1995). The exercise uses GDP in 1995 - although the result does not change substantially when controlling for 1990 (i.e. beginning period of sample). A control to account for the skewedness of the distribution is also included.[15] To select the set of countries for the panel, a ratio of volatility to average growth calculated as:

$$\rho_i = \frac{75th\ percentile - 25th\ percentile}{Average\ Growth}.$$

This ratio captures those countries for which the pattern of volatility is similar when controlling for growth over the period. The countries which entered the panel are those that are ±0.1 away

[15] It should be noted that the result cannot be generalized since it only applies for the set of countries in the panel.

from the ratio of Belize (i.e. $\rho_i - \rho_{belize}$). The precise specification for the regression is the following:

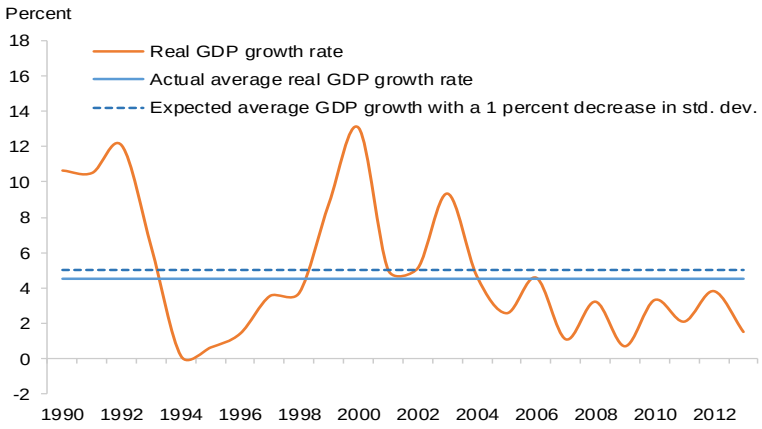
$$Avg\ Growth = \beta_0 + \beta_1(StDev) + \beta_2(Pop\ Growth) + \beta_3(GDP\ per\ cap\ 1995) + \beta_4(75th\ percentile - 25th\ percentile) + \varepsilon \quad (7)$$

This exercise suggests that if the standard deviation of GDP were to be reduced by 1 percent, average GDP growth for the period of 1990-2014 would increase by 0.06 percentage points. The standard deviation of GDP growth for Belize is estimated at 3.7. This implies that, given a period annual growth average of 4.5 percent, 95.4 percent of all growth rates lie between 12 percent and -2.9 percent. Therefore, reducing the standard deviation to that of Brazil or 1 percent - which produces an average growth rate of 4.7 percent close to Costa Rica's - would lead to a 9 percent higher GDP level than the actual outturn. This is due to the compounding effect of a higher growth rate, thus although 0.06 percentage points seem small, in the long-run it leads to substantially higher GDP levels.

Table 8: Regression Results

	Coefficient	P-value
St Dev	-0.06	0.09
Pop growth	-0.01	0.72
GDP per capita	0.00	0.29
Percentile difference	0.81	0.00
Constant	-0.03	0.85
R-square	0.99	
N	20	

Figure 7: Counterfactual



7. Conclusions and Recommendations

The paper explores the issue of output volatility in Belize using three approaches. First, the paper uses a standard SVAR. Second, the paper takes into consideration potential changes in the nature of the relationship between output volatility and its determinants during the period of analysis. For this, an MS-VAR model was employed to estimate the likely timing of the regime switch, as well as, the relevance of the respective dependent variables during periods of relative calm versus periods of intense volatility. Third, the paper considers what would happen to output growth if the level of volatility were significantly reduced.

Most of the volatility in output growth in Belize is tied to the evolution of its trading partners' GDP and domestic prices. Oil prices and interest rate adjustments in the US are also important determinants of the volatility observed in the country. Fiscal policy interventions, proxied by

government capital expenditure, was surprisingly not significant. Similarly, the impact of natural disaster shocks was not very pronounced and may be related to the offsetting impact of post disaster reconstruction spending on output.

There is a high degree of asymmetry with regard to the impact and duration of shocks. The probability that a large and sharp contraction in output is followed by another round of contraction is notably less than the probability that a period of relative calm will be followed by another. Periods of volatility are usually short lived with an average duration of eight months in comparison to over three years when there is no shock. The impact of a real sector shock in the US or Mexico is more pronounced in periods of relative calm compared to other times. The relationship, however, breaks down in periods of intense volatility. Regarding the impact of CPI, as expected, the impact is strong and negative reflecting the destabilising effects on GDP growth due to price elasticity and uncertainty. However, the impact is not statistically significant in the low volatility state and the impact coefficient are also much lower during this low volatility state. This implies that during periods of high output volatility, the negative impact of inflation on real GDP growth is significantly more pronounced.

Overall, the results confirm that lower output volatility is necessary to maintain a high growth trajectory in Belize. When the economy is experiencing extreme bouts of volatility, trading partner's GDP loses some of its ability to influence domestic activities. This is further compounded by the negative effects of inflation, which has a tendency of being more pronounced during these episodes. The results suggest that a strong track record of macroeconomic stability will be crucial for raising and sustaining the level of economic growth in Belize. With domestic stability assured, the country has a better chance of reaping the benefits of positive shocks originating from its major trading partners. Additionally, with the impact of trading partner's GDP weakening during periods of intense volatility, the authorities will have to invest in developing countercyclical measures to minimize the duration of bouts of volatility. Further, fiscal policy, has had limited impact on boosting output. Finally, the benefits to be derived from reducing the level of economic volatility in Belize is quite significant - potentially leading to a higher level of growth.

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