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Abstract

This paper estimates a 3-country DSGE model to identify the drivers of exchange rate volatility in small open economies (SOE). In addition to the usual cross-country linkages through trade and asset holdings, the model features common shocks that affect economies symmetrically. Using data from Jamaica, the US and the G-7 region (excluding the US), the paper finds that external financial shocks are the primary drivers of exchange rate fluctuations in the SOE. While domestic financial shocks are bigger contributors than US and G-7 specific shocks, shocks that are common across the US and the G-7 generally play the main role. Nonfinancial shocks, domestic and external, are inconsequential for exchange rate volatility. Inferences from a vector autoregressive model with exogenous variables are consistent with these results.

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1 Introduction

There has been a resurgence of capital controls following the 2008 global financial crisis not only in the developing world but also in some advanced economies. While these controls aim to protect economies from large exchange rate fluctuations, they are also known to impose long-run structural costs that could more than offset any potential short-run benefits. It is, therefore, critical to determine whether capital controls are fully justified. From a policy perspective, if the main source of exchange rate volatility is external to a country, capital controls could be the only comprehensive tool available to mitigate the damaging effects of this volatility. If, by contrast, domestic shocks are the main drivers of exchange rates, prudent policies could ensure stability while avoiding the costs of blunt tools such as capital controls. These issues are especially important for small open economies (SOE) with relatively low levels of domestic absorbtion and high degrees of financial integration as exchange rates fluctuations are crucial for local business cycles.

In this paper, I identify and compare the internal and external drivers of exchange rate volatility in a SOE and determine if the country has the potential to control her own destiny without taking the pill with substantial long-run side effects. I do so by constructing and estimating a three region dynamic stochastic general equilibrium (DSGE) model that follows a New Keynesian framework with nominal and real rigidities. The three regions in the model are represented by a SOE and two large open economies one of which is also the main trading partner of the SOE. Including these three regions instead of following a more common two-country approach is a key distinguishing feature of my analysis. Specifically, the three country setup allows me to differentiate between two types of shocks that are external to the SOE, shocks that originate in one of the two large open economies and shocks that are common to both. Designating the latter as a global shock, I am therefore able to measure the effects of common global and external country-specific shocks on the SOE exchange rate and compare these effects with those generated by domestic shocks.

The closed economy features are identical across the three regions and they closely follow the structure in Christiano et al. (2005) and Smets and Wouters (2007). The three regions are linked through trade of goods and services and risk-free bonds as described by Justiniano and Preston

(2010). In modelling these linkages, I reasonably assume that while the SOE trades, goods and assets, with both large economies, changes in the quantity of its exports and imports, and its interest rates are negligible for the two large economies. SOE shocks, therefore, have no effect on the two large economies.

In addition to the linkages mentioned above, I assume that the two large economies can face common financial shocks. There are three financial shocks in the model, a monetary policy shock, a credit spread shock and a bond holding risk shock. The latter shock is introduced through the interest rate parity conditions and it generates an exogenous increase in exchange rates. I designate this shock as a common shock if the currency risk associated with holding the bonds of a given country, say the major trading partner of the SOE, increases symmetrically with respect to the risk of holding the other economies' bonds. Conversely, I assume that the shock is country-specific if the risk of holding bonds increases only relative to one of the economies. The model also includes country-specific demand and price shocks in each region. The main reason that I allow for the common shock specification only on the financial side of the economies is that the results, without the common shock specification, indicate that fluctuations in exchange rates are primarily determined by financial shocks. It is also a common finding that most global and common drivers of business cycles are financial in nature (c.f., Miranda-Agrippino and Rey, 2020) as the degree of global financial integration is higher than general economic integration.

Combining the closed economy components with inter-regional linkages, I obtain a large scale model with 123 variables and 20 shocks. To estimate this model, I first log-linearize its equations so that the variables represent deviations from steady state values. I then obtain 20 quarterly data series, matching the number of shocks in the model and spanning the 1997Q1- 2021Q1 period, from three economies: Jamaica, U.S. and the G-7 economies (excluding the U.S.).[1] Hereafter, I refer to the latter economic bloc as G-6. While I focus on Jamaica as the SOE and US as her major trading partner in this paper, the framework that I develop is sufficiently versatile so that it can be easily applied to other groups of countries. Adopting common prior mean values and distributions of model parameters, I use a Bayesian methodology to estimate the posterior

[1] Using quarterly data to estimate the model is a common practice since some observable variables are only available at he quarterly frequency. The model, therefore, is not designed to capture the effects of exchange rate volatility measured at high frequencies.

distributions of both the structural parameters and those governing the shock processes. This estimation ensures that the parameter values used in model simulations are strongly pinned down by data and that the results are not loosely derived from a particular set of parameter values (especially those governing shock processes) under a more traditional calibration exercise.

There are several inferences from the post-estimation statistics. First, financial shocks are the primary drivers of exchange rate volatility in all three economies as their contributions to this volatility are much larger than the contribution of the other types of shocks in the model (price and demand shocks in particular). Second, external financial shocks are just as important as domestic financial shocks for exchange rate volatility in the SOE only if they are common across the two large economies (U.S. and G-6). By contrast, if the financial shocks originate in either the U.S. or G-6 and they are idiosyncratic to one of these economies then they are weaker contributors to SOE's exchange rate fluctuations relative to domestic and common financial shocks. Nevertheless, the results demonstrate that the total contributions of external shocks, common plus idiosyncratic, are considerably larger than those of domestic shocks. Third, out of the three financial shocks, monetary policy shocks and bond holding risk shocks are the main determinants of exchange rate volatility in the SOE, and the effects of risk spread shocks are relatively small. Finally, common shocks are also important drivers of the US dollar volatility and that their effects are even more pronounced compared to their effects on the Jamaican dollar. These inferences are uniformly drawn from different statistics for exchange rates such as, impulse responses, historical decompositions and forecast error variance decompositions. They are also similar when different sample periods, forecast horizons and definitions of exchange rates are used.

The DSGE methodology allows me to impose structure on the data and identify the independent effects of different types of shocks on exchange rate volatility. To check the empirical relevance of the results, I use a simpler approach that imposes minimal restrictions on the data in the final part of the paper. I do so by constructing a simple 3 variable vector autoregressive model with exogenous variables (VARX) for Jamaica. The model includes quarterly data for Jamaican exchange rates and interest rates and a U.S. or global data series as the exogenous variable. The results show that the Jamaican dollar (and the trade weighted Jamaican currency) is more responsive to domestic shocks compared to the changes in U.S. variables (U.S. policy rates or the \$/Euro exchange rate). However, when I use two variables that are more closely associated with global financial conditions (i.e., global push factors), the Chicago Board Options Exchange's Volatility Index (VIX) and Gold ETF Volatility Index, I find that the magnitudes of the Jamaican currency responses (depreciation in response to an increase in global financial volatility) to these externally determined variables is comparable to those generated by domestic shocks.

Overall, the results suggest that currency fluctuations in small open economies such as Jamaica, an economy with a substantial amount of trade and relatively free capital markets, are more strongly related to external factors. While prudent domestic policies carry stabilization capacity, the effectiveness of these policies are limited by the potential destabilizaing effects of global push factors.

The more traditional approach to the identification and the quantification of the drivers of business cycles has been empirical. Studies such as Clark and Shin (2000), Kose et al. (2003), Mumtaz et al. (2011), Kose et al. (2012), Fernandez et al. (2017), Kamber and Wong (2020), use Vector Autoregression (VAR) and Principal Component Analyses (PCA) to determine the common and idiosyncratic drivers of business cycles. The main focus in this literature is on advanced economies. My approach and the scope of the paper are fundamentally different in several ways. First, I use a structural analysis to identify the impact of different shocks. The restrictions coming out of the general equilibrium model allow me to distinguish shocks not only by type but also by where they originate. An empirical identification strategy by contrast requires restrictions that can be unreasonable. Any Cholesky ordering, and the associated contemporaneous correlation matrix, with G-6 and US variables for example can be subject to scepticism. Nevertheless, the VAR evidence that I find is consistent with those drawn from the structural analysis. Second, instead of identifying the common components of business cycles across a wide group of countries, I take the perspective of a small open economy and investigate how this economy responds to domestic and external factors. Third, I hone in on the exchange rate variable as it is highly responsive to external shocks, and it plays an important role for Jamaica as she is more open to trade and capital flows relative to an average developing country. More generally and to the best of my knowledge, this paper is the first to use an estimated DSGE model to compare the external and internal drivers of exchange rates.

My paper is also related to the long standing literature that incorporates financial and real frictions to strengthen the link between economies in a DSGE setting. Without these frictions, it is widely known that DSGE models fail to replicate the high degree of comovement between economies, especially amongst advanced economies (see, Christiano et al., 2018 and Linde, 2018). While studies such as Elliott and Fatás (1996), Stockman and Tesar (1995), Kose and Yi (2001), and Keller (2004) focus on real sector frictions, particularly those related to technology adoption, as the source of comovement, others such as Zimmermann (1997), Obstfeld and Rogoff (2001), Kollmann et al. (2011), Kollmann (1996), Kehoe and Perri (2002), Heathcote and Perri (2002) introduce trade and asset market frictions to explain the high degree of macroeconomic correlation across countries. A relatively more recent approach has been to incorporate frictions in global banking to generate the cross-country symmetry (e.g., Devereux and Yetman, 2010; Kollmann et al., 2011; Alpanda and Aysun, 2014). The relative effectiveness of these frictions are still debated as they can all achieve the same purpose. In this paper, I am silent on the topic of international frictions. I instead allow the data to determine where and how much the commonality is. I do so by configuring the shock process so that some shocks in the model have both common and country-specific components. This is one unique feature of my analysis that can be used for any country to determine its responsiveness to external economic developments. It is important to point out here that this approach also allows me to distinguish between two types of external shocks, those that are country-specific and those that are common across foreign countries. I find that this nuance is important as it is the latter shock that is the main driver of exchange rates in the small open economy.

Turning to the studies of exchange rates in developing countries, the majority of the work has been on either the effects of exchange rates on economic performance (growth in particular) or on the effects of institutional factors such as trade and financial openness and exchange rate regimes on exchange rate fluctuations. This literature uniformly documents the negative effects of exchange rate volatility on long-run economic performance (e.g., Servén, 1998; Aghion et al., 2009). In this paper, I take the opposite direction and investigate the effects of economic factors on exchange rate volatility. I find that it is mainly financial shocks that determine exchange rates. This finding is different from earlier empirical evidence that documents a positive link between real economic performance and the strength of currencies (Balassa, 1964; Bleaney, 2001) yet it is consistent with more recent evidence showing either that there is no such link or that financial factors play the major role (Ghosh et al. 2003; Verdelhan, 2018). Verdelhan (2018), also consistent with my results, finds that common global risk factors hold a substantial explanatory power over exchange rates. In this paper, I take an agnostic approach to institutional factors and their potential effects on exchange rate volatility in Jamaica. The reason I follow this strategy is that institutional factors are relatively sluggish over time, especially with respect to the dynamic financial variables that I consider in my model. The policy implications of my findings are more relevant for short-run monetary policies that are more dynamic and can exert an immediate impact on exchange rates. I should point out, however, that there is a vast literature on how institutional factors can affect exchange rate volatility in developing countries. These institutional factors are not only trade and financial openness but they also include the composition of trade and assets (Calderon and Kubota, 2018; Coeurdacier and Gourinchas, 2016).

2 Model

The model follows a DSGE framework that consists of three regions. Two of these are large open economies that are bilaterally linked through goods and financial markets. As I discuss below in the data section, I use data from the U.S. to represent one of these economies and data from G-7 countries (excluding the U.S.) to represent the other. The third economy in my model is a small open economy that is affected by but does not affect the two large economies. One objective in this paper is to measure the contribution of external financial shocks on the exchange rate volatility in the small open economy. Following a medium scale DSGE model here allows me to identify financial shocks that are independent of shocks originating from other sides of the economy (demand, price, productivity). In this identification, I distinguish between two types of external financial shocks, those that are country specific and those that are common to the two large open economies. The three country setup, unlike its more standard two country version, provides a more precise way to gauge how shocks that are global in nature are transmitted to the foreign exchange market of small open economies.

The DSGE model includes the nominal and real rigidities in Smets and Wouters (2007) that allows for a closer representation of responses to shocks in standard vector autoregressive (VAR) models. The economies in the model are linked through the open economy mechanisms in Justiniano and Preston (2010). In addition to these endogenous channels, I enhance the specification of financial shocks in the two large open economies so that they have both a country specific component and a common component. Most parts of the framework are modelled symmetrically across the three economies and they closely follow the studies mentioned above. Their complete description is thus deferred to Appendix A. Below I summarize these standard parts, display the key equations that link the three economies and describe the common shock specification.

Each economy is populated by households that maximize their life-time utility by choosing how much to consume and work. The labor services of the households are sold to the intermediate goods producers after they are aggregated by perfectly competitive labor intermediaries. The households also save by holding 1-period government bonds issued by the three economies and they are the owners of capital. They purchase capital from perfectly competitive capital producers and rent them out to monopolistically competitive intermediate goods producers. These firms combine labor with capital goods to produce intermediate goods. The intermediate goods are then purchased by perfectly competitive final goods producers who combine them to produce a final good. The model also features monopolistically competitive import intermediaries that buy foreign currency denominated import goods and sell them to an import aggregator that combines these into a uniform import good. Central banks in each region conduct monetary policy according to a Taylor rule and governments spend by using their tax revenues and bond funding. The government spending is introduced as a shock in model.

I proceed by listing the equations that link the economies endogenously and that are thus central to the cross-country transmission of shocks. On the demand side, I assume that consumption and investment are constant elasticity of substitution (CES) aggregates of the goods produced in the three regions. The two equations below display these aggregates for Jamaica only. The aggregates for the other two regions are of similar form except Jamaican variables have a much smaller share in the consumption aggregates for the US and G-6 households.

$$C_t^J = \left[\left(\gamma_c^{J,J}\right)^{\frac{1}{\lambda_c^J}} \left(C_{h,t}^J\right)^{\frac{\left(\lambda_c^J - 1\right)}{\lambda_c^J}} + \left(\gamma_c^{J,US}\right)^{\frac{1}{\lambda_c^J}} \left(C_{f,t}^{J,US}\right)^{\frac{\left(\lambda_c^J - 1\right)}{\lambda_c^J}} + \left(\gamma_c^{J,G6}\right)^{\frac{1}{\lambda_c^J}} \left(C_{f,t}^{J,G6}\right)^{\frac{\left(\lambda_c^J - 1\right)}{\lambda_c^J}} \right]^{\frac{\lambda_c^J}{\left(\lambda_c^J - 1\right)}} \tag{1}$$

$$I_t^J = \left[\left(\gamma_i^{J,J}\right)^{\frac{1}{\lambda_i^J}} \left(I_{h,t}^J\right)^{\frac{\left(\lambda_i^J - 1\right)}{\lambda_i^J}} + \left(\gamma_i^{J,US}\right)^{\frac{1}{\lambda_i^J}} \left(I_{f,t}^{J,US}\right)^{\frac{\left(\lambda_i^J - 1\right)}{\lambda_i^J}} + \left(\gamma_i^{J,G6}\right)^{\frac{1}{\lambda_i^J}} \left(I_{f,t}^{J,G6}\right)^{\frac{\left(\lambda_i^J - 1\right)}{\lambda_i^J}} \right]^{\frac{\lambda_i^J}{\left(\lambda_i^J - 1\right)}}. \tag{2}$$

Here consumption and investment goods in Jamaica, C_t^J and I_t^J, are aggregates of home goods, $C_{h,t}^J$ and $I_{h,t}^J$, those imported from the US, $C_{f,t}^{J,US}$ and $I_{f,t}^{J,US}$, and those imported from the G-6 countries, $C_{f,t}^{J,G6}$ and $I_{f,t}^{J,G6}$. The parameters $\gamma_c^{J,J}$, $\gamma_c^{J,US}$, $\gamma_c^{J,G6}$ represent the share of of these goods in the consumption aggregate, respectively. The corresponding parameters with the i subscript do the same for investment. The elasticity of substitution between the two imports and the domestic good is regulated by λ_c^J and λ_i^J for consumption and investment, respectively. I assume that the elasticity of substitution is the same for each pair of goods in the aggregate.

These demand functions also determine how prices in Jamaica are linked to the price of imports. Specifically, the aggregate price indices that correspond to equations (1) and (2) are given by,

$$P_t^J = \left[\gamma_c^{J,J} \left(P_{h,t}^J\right)^{\left(1-\lambda_c^J\right)} + \gamma_c^{J,US} \left(P_{f,t}^{J,US}\right)^{\left(1-\lambda_c^J\right)} + \gamma_c^{J,G6} \left(P_{f,t}^{J,G6}\right)^{\left(1-\lambda_c^J\right)} \right]^{\frac{1}{\left(1-\lambda_c^J\right)}} \tag{3}$$

$$P_{i,t}^J = \left[\gamma_i^{J,J} \left(P_{h,t}^J\right)^{\left(1-\lambda_i^J\right)} + \gamma_i^{J,US} \left(P_{f,t}^{J,US}\right)^{\left(1-\lambda_i^J\right)} + \gamma_i^{J,G6} \left(P_{f,t}^{J,G6}\right)^{\left(1-\lambda_i^J\right)} \right]^{\frac{1}{\left(\lambda_i^J - 1\right)}} \tag{4}$$

On the financial side, the three economies are linked through two mechanisms. First of these is described by an uncovered interest parity (UIP) condition that is derived from the arbitrage between domestic and foreign bonds. There are two UIP conditions in the model and they are given by,

$$E_t \left[\beta^J \frac{\Lambda_{t+1}^J}{\Lambda_t^J \pi_{t+1}^J} \left(R_t^J - \frac{\varepsilon_{d,t}^{J,US}}{\varepsilon_{d,t}^{US}} \frac{E_{t+1}^{J,US}}{E_t^{J,US}} R_t^{US} \right) \right] = 0 \tag{5}$$

$$E_t \left[\beta^{US} \frac{\Lambda_{t+1}^{US}}{\Lambda_t^{US} \pi_{t+1}^{US}} \left(R_t^{US} - \varepsilon_{d,t}^{US,G6} \varepsilon_{d,t}^{US} \frac{E_{t+1}^{US,G6}}{E_t^{US,G6}} R_t^{G6} \right) \right] = 0 \tag{6}$$

These two conditions describe the arbitrage between the returns to US and Jamaican assets and the arbitrage between US and G-6 assets, respectively. Here, I reasonably assume that there is no triangular arbitrage and thus the two conditions above can be combined to obtain a UIP condition for US and G-6 assets. In the formulation above, R_t^J, R_t^{US} and R_t^{G6} are the risk-free bond interest rates in Jamaica, US and the G-6 countries, and $E_t^{J,US}$ and $E_t^{US,G6}$ are the Jamaican dollar/US dollar (JMD) and US dollar/G-6 exchange rates (expressed as local currency per foreign currency). The latter can be interpreted as an asset holdings weighted average of exchange rates between the USD and the G-6 currencies (the Euro, Pound, Canadian dollar and the Yen).

In the two equations above, there are three depreciation shocks, $\varepsilon_{d,t}^{J,US}$, $\varepsilon_{d,t}^{US,G6}$ and $\varepsilon_{d,t}^{US}$ that play an important role. The next section describes the nature of these shocks but I should point out here that I classify the first shock $\varepsilon_{d,t}^{J,US}$ as an internal shock, with positive values indicating an exogenous depreciation of the Jamaican dollar against the US dollar. The second shock, $\varepsilon_{d,t}^{US,G6}$, is an external shock that takes positive values when there is an exogenous depreciation of the USD against G-6 currencies. The final depreciation shock, $\varepsilon_{d,t}^{US}$, enters both equations and it is thus interpreted as a common shock in my analysis. To visualize the difference between the two shocks that originate outside of Jamaica, $\varepsilon_{d,t}^{US,G6}$ and $\varepsilon_{d,t}^{US}$, imagine that there are two scenarios. First, the USD depreciates (exogenously) against both the Jamaican dollar and the G-6 currencies. Second, USD only depreciates against only the G-6 currencies. Then according to the specification above, while the exchange rate shock in the first scenario, i.e., the common shock, would be captured by $\varepsilon_{d,t}^{US}$, $\varepsilon_{d,t}^{US,G6}$ would capture the exchange rate shock in the second scenario. It is this unique specification of shocks that allows me to distinguish between internal, external and common financial shocks and assess their significance for the Jamaican foreign exchange market. The remaining variables in the two equations above, β, Λ_t and π_{t+1} denote the time discount factor, consumers' Lagrange multiplier and the inflation rate. I defer the discussion of these parameters and variables to Appendix A as they drop out when I linearize the model and they thus do not play a critical role in this part of the model.

Finally, I allow for a potential exogenous link between the financial sides of the US and G-6 economies by reconfiguring the shock processes governing monetary policy and those affecting the cost of capital. By doing so, I am able to introduce any global push effects such as coordinated monetary policies and risk aversion in global bond markets.

The shocks mentioned above appear in the following Taylor rule and cost of capital conditions for the two large economies, indexed by j:

$$R_t^j = \left(R_{t-1}^j\right)^{\rho^j} \left[R^j \left(\pi_t^j/\pi^j\right)^{r_\pi^j} \left(Y_t^j/A_t^j y^j\right)^{r_y^j} \left(Y_t^j/\gamma^j Y_{t-1}^j\right)^{r_{\Delta y}^j}\right]^{1-\rho^j} \varepsilon_{r,t}^j \tag{7}$$

$$E_t\left[\left(\beta^j \frac{\Lambda_{t+1}^j}{\Lambda_t^j}\right)\left(R_{t+1}^{k,j} - \frac{\varepsilon_{k,t}^j \varphi^j R_t^j}{\pi_{t+1}^j}\right)\right] = 0 \tag{8}$$

where the Taylor rule takes the common form (see Appendix A for a full description) and the shock $\varepsilon_{r,t}^j$ captures monetary policy shocks. In the second equation, φ^j and $\varepsilon_{k,t}^j$ represent the steady state level of risk premium and a risk premium shock, respectively.

The two shocks are configured as follows:

$$\varepsilon_{r,t}^j = \varepsilon_{r,t}^{j,h} * \varepsilon_{r,t}^c \tag{9}$$

$$\varepsilon_{k,t}^j = \varepsilon_{k,t}^{j,h} * \varepsilon_{k,t}^c \tag{10}$$

The implicit assumption is that the monetary policy shock of a country, say the US, has a component that is idiosyncractic $\varepsilon_{r,t}^{j,h}$, and a component that is common across the US and the G-6 countries, $\varepsilon_{r,t}^c$. Same assumption applies to the cost of capital shock with $\varepsilon_{k,t}^{j,h}$ and $\varepsilon_{k,t}^c$ representing the idiosyncratic and common components of the shock, respectively. These two components, as well as all other shocks in the model, are orthogonal to each other by construction and they follow an AR(1) process.

In the analysis below, an important part of the focus will be on the three shocks, $\varepsilon_{d,t}^{US}$, $\varepsilon_{r,t}^c$ and $\varepsilon_{k,t}^c$, that are common to the U.S. and the G-6 countries and how they contribute to exchange rate volatility in the small open economy.

3 Data and estimation methodology

To estimate the structural parameters and those governing the shock processes in the model, I obtain 6 quarterly data series for the U.S., Jamaica and G-6 countries, and the two exchange rates,

$E_t^{J,US}$ and $E_t^{US,G6}$ (the third exchange rate is implied by the first two in the absence of triangular arbitrage). The data are quarterly and they are obtained for the 1996Q1-2021Q1 period. These data describe how various sides of the economies evolve over time. Real government expenditures, for example, capture demand side dynamics. GDP deflator and import price index data describe prices in the three regions. The overnight interbank interest rates, medium-term lending rates, and the two exchange rates (Jamaican dollars per US dollar and US dollar per G-6 currencies) represent the financial side, and finally real gross domestic product describes the supply side of the economy. The definitions of the variables are provided in Table B.1 of Appendix B. It is important here to note that the choice of these observable variables was dictated by the availability of quarterly data in Jamaica.

Before I estimate the model, all data series are seasonally adjusted and demeaned. I also measure growth rates by log-differencing all series except interest rates that are expressed as percent changes over the previous quarter. While applying this procedure to Jamaican and U.S. data is straightforward, G-6 data have to be combined across countries to form region-wide data series. To this end, I collect the 6 data series mentioned above, and the US dollar exchange rates for Canada, France, Germany, Italy, Japan and the United Kingdom. For GDP and government spending, I convert the series into real US dollars (using the same base year) and compute the G-6 series as the sum of country-specific values. For the remaining series, including the exchange rate $E_t^{US,G6}$, I use countries' US dollar GDP values as weights to obtain G-6 variables as weighted averages. Import price index is not available for each country. I, therefore, approximate this index as the ratio of nominal imports to real imports.

The model includes 5 shocks for each region, the 3 depreciation shocks, and the 2 common shocks (monetary policy and cost of capital shocks) so that the number of shocks in the model match the number of observable variables that I use. The 5 country-specific shocks are government spending, domestic price, import price, monetary policy and cost of capital shocks.

Appendix A describes the shock processes and how they are introduced into the model. It is useful, however, to describe the shocks at this point, as I will analyze how they are transmitted to the SOE in the next section. The central shock in the model is a depreciation shock that, for positive values, represents an increase in the risk of holding domestic bonds over foreign bonds. Hereafter, these shocks will be referred to as bond risk shocks. The first of these shocks, $\varepsilon_{d,t}^{J,US}$, represents an increase (decrease) in the risk of holding Jamaican risk free assets relative to US assets (also relative to G-6 assets through the implied no-arbitrage condition) for positive (negative) values. Similarly, positive (negative) values of $\varepsilon_{d,t}^{US,G6}$ suggest an increase in the risk of holding US assets relative to G-6 assets. The final shock, $\varepsilon_{d,t}^{US}$ is a common shock and it represents the change in the risk of holding US bonds relative all other assets in the world.

The only demand shock in the model is an exogenous change in government spending that captures discretionary fiscal policy. The 2 shocks that originate in the supply side of the economy, the domestic and import price shocks, reflect the exogenous change in the mark-up rate of intermediate good producers and importers, respectively. On the financial side, the monetary policy shock, as displayed above, is introduced via a Taylor rule and its positive values indicate a monetary tightening. Finally, the model features a cost of capital shock that captures exogenous changes in credit spreads. A common interpretation of this shock is as follows: Capital owners in the model face idiosyncratic returns to capital shock and that there is a systematic change in the volatility of this idiosyncratic shock which affects credit spreads.[2] It should be noted that there are alternative mechanisms in the literature that generate credit spreads (e.g. Anzoategui et al., 2019).

To estimate the model, I use a Bayesian methodology. The methodology first derives the reduced form of the model from its state space representation as described by Blanchard and Khan (1980). Measurement equations are then used to match data with the predetermined variables in the model. Incorporation of these data, also referred to as observable variables, provides a distinct advantage of the Bayesian estimation over a more traditional calibration exercise. Most importantly, the data allow me to estimate shock process parameters and use these estimated values when assessing the contributions of shocks to exchange rate volatility. Using the estimated values for the persistence and standard deviation of the shocks then provides a more accurate way of gauging their importance over a calibration exercise that uses arbitrary values. Estimation also allows for a better way of pinning down the values for some of the nonstandard parameters

[2] A more common approach is to introduce the returns to capital shock through the financial accelerator mechanism of Bernanke et al. (1999). I did not do so since this would require including equity returns as an additional observable to identify credit spread shocks. Jamaican equity returns data are only available for the latter half of the sample period and they are reported at the annual frequency.

of the model. This is especially important for my model that includes a small open economy as the greater majority of the consensus for common parameter values describe advanced economies rather than emerging market economies.

After linking model variables to the observable variables, a likelihood function is constructed via a Kalman filter. This function incorporates the observable variables and the parameters' prior distributions and it is maximized to obtain posterior density functions. To solve the maximization problem, I use a Markov Chain Monte Carlo simulation.[3] Before estimating the model, all variables log-linearized and transformed so that they reflect deviations from steady state values.

The prior distributions that were used and the posterior distributions that were obtained are displayed in Appendix B, Tables B.2 and B.3. The tables report the distributions for the structural and the shocks process parameters in the model, respectively. The prior distributions displayed in the table are commonly used in the literature (e.g. Smets and Wouters, 2007 and Gilchrist et al., 2009). I also follow the common practice when fixing the level parameters in the model as they are derived from the mean values of the observable variables prior to estimation. These level parameters and their corresponding values are included and discussed in Appendix B. I find in general that the posterior mean values are considerably different from their prior mean values and they are also different across the three economies thus indicating that the dataset is informative.

4 Results

In this section, I report the impulse responses, historical decompositions (HD), and forecast error variance decompositions (FEVD) obtained from postestimation analysis. I also provide some evidence from a vector autoregressive model with exogenous variables (VARX). In this section, I refer to the deviations of exchange rates from their steady state values as exchange rate volatility.

4.1 Impulse responses

The central focus of my analysis is on the financial drivers of exchange rate volatility in the SOE. To identify these drivers and quantify their effects, I begin by reporting the response of the SOE's

[3] I use the mode_compute=6 estimation routine in Dynare to estimate the model.

exchange rate (hereafter, the Jamaican dollar per US dollar, JMD) to a one standard deviation positive innovation in the monetary policy rate of the SOE (Jamaica), SOE's main trading partner (the US), and the other large economic bloc (G-6 economies). These three responses, along with the corresponding 95% confidence intervals, are displayed in the first three panels of Figure 1. The results in the top figure demonstrate a 17 basis points JMD appreciation (on a quarterly basis) in response to a one standard deviation positive monetary policy shock. The response exhibits low persistence as it becomes insignificant after the first forecast horizon. The same can be said about the responses to US and G-6 monetary policy shocks displayed in the next two panels. The responses reveal a JMD depreciation of roughly 6 and 12 basis points, respectively, in response to these two shocks. If I express monetary policy shocks as a 1% increase in the policy rate, these numbers correspond to a 15 basis points appreciation in response to a SOE monetary policy shock, and a 2.2 and 4.2 basis points depreciation of the JMD in response to US and G-6 monetary policy shocks, respectively. The bottom panel in the figure shows the SOE exchange rate response to a monetary policy shock that is common for both the US and the G-6 economies. The JMD appreciation in response to this shock is not only stronger compared to the responses to US specific and G-6 specific shocks, its magnitude is also larger relative to the amount of appreciation generated by a Jamaican monetary policy shock. I should also note here that the low persistence in the responses is due to the strong exchange rate pass-through into domestic prices and the ensuing monetary policy response via the Taylor rule.[4]

The main inference from these results is that while Jamaica's monetary policy is a more important determinant of its exchange rate fluctuations compared to those of the US and G-6 countries, monetary policy shocks that are global in nature generate the largest response in JMD. I observe a similar ranking in Figure 2 that displays the effects of shocks originating in credit markets. Specifically, the impact of common credit shocks is the largest, followed by domestic shocks, with US and G-6 specific shocks ranking last. Notice also that the disparity between the responses to common credit spread shock and the other shocks is now more evident. The signs of the responses imply that while an increase in domestic credit spreads causes a depreciation of the JMD, JMD appreciates if credit spreads increase abroad. The reason is that an increase in

[4] According to my results, the degree of pass-through ranges between 0.44 and 0.62 percentage points throughout the forecast horizon.

domestic credit spreads suppresses economic activity and inflation, prompting a decline in policy rates which in turn depreciates the local currency. Conversely, higher credit spreads in foreign countries prompt a decline in their policy rates and a JMD appreciation.

As a final financial shock, I consider an exogenous increase in JMD and the $/Euro exchange rate. I refer to this as a bond risk shock since the exogenous change in exchange rates is usually due to a change in the risk of holding bonds denominated in a specific currency. In the first two panels of Figure 3, I observe that a one standard deviation Jamaican bond risk shock has a much bigger impact on JMD than a one standard deviation US-specific bond risk shock. The bottom panel displays the responses to a US bond risk shock that, for positive values, increases the risk of holding U.S. bonds relative to G-6 and Jamaican bonds symmetrically. This common shock, while reasonably appreciating the JMD, generates a quantitatively similar response in JMD compared to a Jamaican bond risk shock.

From these results I infer that developments in external financial markets can have a bigger impact on the SOE's currency market if this shock is more global in nature. Otherwise, currency market fluctuations in the SOE are more responsive to domestic financial shocks.

A natural question to ask at this point is whether the relative importance of internal and external shocks for the SOE currency also applies to major currencies. In other words, are internal and external global shocks also the main determinants of the major currency fluctuations? The responses displayed in Figure 4 offer mixed evidence. The figure shows the USD responses to U.S., G-6 and common financial shocks. The magnitude of the responses also imply that common financial shocks appear to be the most important driver of a major currency such as the USD. Domestic shocks, however, exert a relatively smaller effect on the USD. Also the magnitudes of the responses are generally smaller compared to the magnitude of the JMD responses to financial shocks.

In Figure 5, I report the JMD responses to the three nonfinancial shocks in the model. These responses are reported separately for each region where the shock originates. The main inference that I draw from the figure is that nonfinancial shocks are much less important for JMD fluctuations relative to financial shocks as the magnitudes of the responses are much smaller. The appreciations of JMD in the first column are caused by the positive response of policy rates to the increase in government spending and output (the top figure) and to the rise in inflation (the next two subfigures). Conversely, if the shocks originate in the U.S. or in the G-6 bloc, higher U.S. and G-6 policy rates generally prompt a JMD depreciation. The reason JMD appreciates in response to a G-6 import price shock is that the currency of the SOE's main trade partner (US) depreciates to offset higher import good mark-ups in the G-6 bloc.

4.2 Historical decompositions and forecast error variance decompositions

I proceed by computing two additional sets of statistics that allow me to draw more general inferences about the relative importance of shocks for SOE exchange rate volatility. The first of these statistics indicate the contribution of shocks to the historical decomposition of exchange rates. The contributions represent the fraction of the exchange rate deviations from its steady state value in a given period that are generated by the current level of the shock and its lagged values. Unlike impulse responses, historical decompositions are computed by using smoothed values of shocks (best estimates of shock values for each period) and they are period specific. This statistic, therefore, gives a more historical perspective when determining the main drivers of exchange rate volatility.

The decompositions of exchange rate volatility that correspond to each period in the sample are displayed in Figures 6 to 8 and they are summarized in Tables 1 and 2. The decompositions in Figure 6 demonstrate the importance of common monetary policy, credit spread and bond risk shocks for the volatility of JMD. The contribution of these shocks are higher during the periods leading up to and immediately following the 2008 global financial crisis. Domestic shocks, especially during the first few years of the sample period, also make an important contribution. For a majority of the periods in the sample, I observe that these two types of shocks, common and domestic, have symmetric effects on JMD. By contrast, domestic shocks' contributions are negatively correlated with those of G-6 and US shocks. As I describe below, monetary policy shocks are one of the principal drivers of JMD fluctuations. The observations I make above then would imply that Jamaican monetary policy features the leaning against the wind property in reaction to G-6 and US specific shocks. Same can be said about U.S. bond risk shocks.[5] Jamaican

[5]US bond risk shock is reported individually since it can neither be classified as a common shock, according to our definition nor is it specific only to US or G-6. This shock could also reflect changes in risk associated with

monetary policy, however, does not exhibit this behavior when the financial shocks are global in nature.

Table 1 summarizes and compares the relative importance of the different types of shocks in the model for JMD and USD ($/Euro exchange rate) volatility. The figures reported in the first and second columns of the table represent the contributions of the listed shocks to the variation in JMD and USD, respectively. I compute these summary statistics as follows: First, I measure the absolute values of shock contributions separately for each period and I add these values to compute the total contribution. I then find the share of a specific shock's contribution in a given period by dividing the absolute value of its contribution by the total contribution in that period. Finally, for each shock, I calculate the average value of its contribution share across the whole sample period. The statistics in Table 1 also indicate that domestic and common financial shocks are the main drivers of exchange rate volatility in Jamaica. Common shocks play an even bigger role for USD volatility. The results in column 2 reveal that G-6 shocks have a bigger impact for USD volatility compared to their impact on JMD volatility.

Turning to shocks by type, in Table 1 and in Figures 7 and 8, I observe that financial shocks are by far the most important domestic and global drivers of exchange rates (both JMD and USD). In particular, monetary policy shocks and bond risk shocks (domestic, common, US, and G-6) make the largest contributions to the variation in both the JMD and the USD. Credit spread shocks are ranked a distant third when compared with the other two in terms of their contribution share. As expected, Jamaican shocks do not appear to make a substantial contribution to USD volatility. From Figure 7, I also infer that Jamaican monetary policy has offset the depreciation in JMD caused by an increase in the risk of holding Jamaican bonds in the second half of the sample period. I should note here that this effect of monetary policy could also reflect the sizeable fiscal consolidation in the second half of the sample period given the linkages between the two policies.

In Table 2, I reproduce the HD statistics by using only the first half of the sample period. Comparing the relative shares of the different types of shocks, I do not detect a considerable difference as common shocks are still the main drivers of JMD and USD volatility, followed by domestic shocks. Common shocks, however, have slightly larger shares and common bond risk

holding G-6 bonds.

shock now appear to be more important for USD volatility.

The second set of statistics that I compute in this section are the forecast error variance decompositions (FEVD). These statistics measure the contribution of each shock to the variance of the forecast error at different horizons. Here the focus is similarly on the variance of exchange rates. Forecast errors are computed by feeding the smoothed values of each shock (using posterior moments for parameters governing shock processes) separately into the estimated model and then computing how much the shock contributes to the volatility of exchange rates (volatility of its deviations from its steady state value). This is a long-standing tool in macroeconomics that is used to determine the sources of business cycles (e.g., Gali, 1999; King et al., 1991) and it is measured for different horizons.

Table 3 displays the FEVD statistics for both a short (1 quarter ahead) and a long (10 quarter ahead) forecast horizon. These results, too, reveal the considerable importance of financial shocks for exchange rate volatility, with nonfinancial shocks playing a negligible role. This time, however, common shocks appear to be more important for exchange rate volatility, especially for the USD. Monetary policy and bond risk shocks are again the primary drivers of exchange rate fluctuations, with bond risk shocks playing a more prominent role for the USD. The results in the top panel reasonably show that Jamaican shocks do not make a significant contribution to USD volatility and that the impact of monetary policy shocks on JMD declines as the horizon gets longer. The latter observation also holds for the US, G-6 and common monetary shocks' effects on the two currencies. Overall, the results indicate that the two exchange rates are primarily driven by external shocks.

4.3 VARX evidence

So far, I have identified the drivers of exchange rate volatility by using a structural model. One of the main inferences was that domestic shocks are more important relative to external shocks if these external shocks are not global in nature. To test whether empirical evidence is consistent with this projection of the model, I use a vector autoregressive model with exogenous variables (VARX model) and compare the relative importance of domestic and external shocks for exchange rate volatility. The main goal of the analysis here is to avoid imposing any structure on the data and to let data determine the main drivers of exchange rates. It is for this reason that I do not attempt to incorporate common shocks into the analysis. Doing so would require imposing additional structural restrictions to identify common components of financial shocks.

The VARX model can be described as follows:

$$\Gamma_t = \lambda + \sum_{i=1}^{n} \vartheta_i \Gamma_{t-i} + \sum_{i=1}^{n} \psi_i X_{t-i} + \varepsilon_t \tag{11}$$

where ε_t represents the error term and the matrix Γ_t includes quarterly observations (1997Q1:2021Q1) for the Jamaican interbank interest rates and the JMD in my baseline estimations. This Cholesky ordering implies that while exchange rates are contemporaneously responsive to interest rates, interest rates respond only to the lagged values of exchange rate shocks. The reason I use this identification scheme is that it is more plausible for monetary policy formulation to factor in past values of exchange rate shocks than presuming that the exchange rate, the more dynamic variable, only responds to the past values of interest rates. X_t in the equation above represents the external variable that I assume is exogenously determined. In the analysis below I use three different variables that I assume are determined outside of Jamaica (and hence Jamaican economy does not affect it), the USD/Euro exchange rate, and the US and G-6 interbank interest rates.

The responses of JMD to the changes in these exogenous variables are displayed in Figure 9. The figure also displays the responses of a trade weighted measure of Jamaican exchange rate to the USD/Euro exchange rate. The responses, similar to the earlier results, indicate that domestic financial shocks are more important for exchange rate volatility relative to external shocks that are not global in nature. The responses indicate reasonably that the Jamaican exchange rates depreciate (appreciate) in response to external (domestic) interest rate shocks.

There are two noticeable differences between DSGE and VARX impulse responses. The exchange rate responses in the VARX model are both larger in magnitude and they are more persistent. Also while a positive USD/Euro shock in the VARX model appreciates the Jamaican exchange rates, a US bond risk shock (also resulting in a USD/Euro depreciation) prompts a depreciation of the JMD. The source of the discrepancy is that the shocks in the two models are not the same. While the DSGE shocks are structural, VARX shocks are not. The latter are only orthogonal to Jamaican exchange rates and interest rates. They, therefore, are not independent of all other shocks including common shocks, G-6 shocks and other domestic US shocks. I should also note that an important part of the variation in the U.S. monetary policy variable is explained by the changes in U.S. output and inflation rate via the Taylor rule. While it would be straightforward to incorporate the component of the interest rate that is orthogonal to these variables, I refrain from doing so given my agnostic view on structure in this section. Nevertheless, the general inference that domestic shocks are more important than external shocks (that are not global), is consistent with one of the main inferences that I draw from the estimated DSGE model.

The other important inference from the DSGE model was that common global shocks are just as important as domestic shocks for exchange rate volatility in a SOE. To test this prediction of the model, next I use two measures that reflect global financial conditions. Specifically, the Chicago Board Options Exchange's Volatility index (VIX) and Gold ETF volatility indices allow me to capture the degree of risk perception in global financial markets. These factors, also referred to as global push factors, are closely related to the ebbs and flows of global funding in small open economies and they are thus a good match for the common factor in the DSGE model (see Miranda-Agrippino and Rey, 2020). The impulse responses in the bottom two panels of Figure 9 are obtained by separately using the VIX and Gold ETF index as the exogenous variable in the VARX model. The responses indicate that the JMD depreciates when there is heightened risk perception in the world. More importantly, the responses demonstrate a much larger response to the global push factors relative to the responses to the external variables above. This is consistent with the second important prediction of the DSGE model. An alternative approach here would be to use a principal component analysis to find the common component of US and G-6 financial variables and then to incorporate this into the VARX model. This approach, too, goes against the spirit of this section as it would require the itroduction of generated variables into the analysis. Overall, while I cannot conclude from this evidence that the data fully support the predictions of the DSGE model, I can state that empirical evidence does not contradict these predictions.

5 Conclusion

In this paper, I built a unique 3-country framework to identify the determinants of exchange rate volatility in small open economies. Using data from Jamaica, US and the G-6 countries (G-7 excluding the US), I estimated an open economy New Keynesian DSGE model that linked the 3 three countries not only through trade and asset holdings but also through common shocks. The results demonstrated that financial shocks are the main drivers of Jamaica's exchange rate (JMD) fluctuations and that external financial shocks, if they are common across the US and G-6 countries, are more important than domestic shocks in terms of their contributions to JMD volatility.

The model serves as a blueprint to identify the determinants of exchange rate volatility in other small open economies. In this identification, the availability of quarterly data is the most important bottleneck. Quarterly consumption, investment, hours worked, and wage data are only available for recent time periods in Jamaica. I, therefore, could not include a broader set of shocks such as preference, total factor productivity, wage mark-up and investment technology shocks. The analysis revealed that exchange rates in Jamaica are mostly determined by financial shocks. It would be useful, nevertheless, to determine the significance of a broader set of nonfinancial shocks for not only exchange rate volatility but also general macroeconomic volatility in Jamaica as quarterly data becomes increasingly available.

One interesting application of the model could be to analyze the effects of exchange rate volatility on output and welfare in small open economies. In this analysis one could also quantify the volatility and welfare costs of external and domestic shocks that are transmitted through exchange rates. While this topic is outside the scope of my paper, researchers could conduct higher order estimations of the model to also allow for the effects of volatility shocks on the mean values of macroeconomic variables. This application, while rigorous, could allow for a more accurate comparison of external and internal shocks.

As mentioned above, I take a neutral stance on the institutional aspects of countries and financial frictions. The countries in my model, for example, do not follow fixed exchange rate regimes, they do not impose restrictions on the quantity and composition of capital flows and their monetary authority follows a Taylor rule. When applying my framework to other countries, it would be necessary to modify the model to incorporate some of these institutional idiosyncracies. Also, the calibration of the level parameters in the model should be modified to match long-run moments such as average interest rates, government spending and investment shares in GDP.

My model does not only provide policy implications for Jamaica but it can also inform portfolio managers about a country's level of integration and correlation with global markets. This in turn could be useful for determining optimal weights in international portfolios. While there are recent insightful empirical studies on this topic (e.g., Verdelhan, 2018), my framework presents a structural perspective.

6 Supplementary material

The links to Appendix A and Appendix B are given below

Appendix A, Appendix B.

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Table 1. Historical decompositions of exchange rates, summary

Shocks		JMD	USD
Jamaica	government spending	0.64	0.01
	price, domestic goods	0.69	0.01
	price, imports	1.88	0.03
	monetary policy	17.84	0.41
	credit spread	1.57	0.03
	bond risk	11.09	0.13
	financial	**30.49**	**0.57**
	nonfinancial	**3.21**	**0.05**
	total	**33.70**	**0.62**
US	government spending	0.26	0.15
	price, domestic goods	0.32	0.76
	price, imports	0.21	0.51
	monetary policy	5.60	6.52
	credit spread	0.81	1.70
	bond risk	10.42	19.81
	financial	**16.83**	**28.03**
	nonfinancial	**0.79**	**1.42**
	total	**17.62**	**29.45**
G6	government spending	0.01	0.04
	price, domestic goods	0.20	0.16
	price, imports	1.02	2.13
	monetary policy	12.46	22.30
	credit spread	0.45	0.36
	financial	12.91	22.66
	nonfinancial	1.23	2.34
	total	**14.15**	**25.00**
Common	monetary policy	20.16	20.39
	credit spread	3.55	3.09
	bond risk	10.83	21.44
	total	**34.53**	**44.93**

Note: The statistics represent the average contributions of Jamaican, US and G-6 shocks to the historical variance of the two exchange rates listed in columns 1 and 2. The averages are computed across time.

Table 2. Historical decompositions of exchange rates, 1997-2008

Shocks		JMD	USD
Jamaica	government spending	0.80	0.01
	price, domestic goods	0.47	0.01
	price, imports	1.70	0.02
	monetary policy	15.90	0.37
	credit spread	1.19	0.01
	bond risk	10.83	0.11
	financial	**27.93**	**0.49**
	nonfinancial	**2.97**	**0.04**
	total	**30.90**	**0.53**
US	government spending	0.18	0.09
	price, domestic goods	0.34	0.78
	price, imports	0.22	0.47
	monetary policy	5.61	6.59
	credit spread	1.00	1.51
	bond risk	11.26	19.36
	financial	**17.87**	**27.45**
	nonfinancial	**0.75**	**1.33**
	total	**18.62**	**28.79**
G6	government spending	0.01	0.04
	price, domestic goods	0.20	0.16
	price, imports	1.18	2.17
	monetary policy	11.60	19.48
	credit spread	0.54	0.19
	financial	12.14	19.67
	nonfinancial	1.39	2.37
	total	**13.53**	**22.04**
Common	monetary policy	18.91	18.32
	credit spread	4.19	3.19
	bond risk	13.85	27.13
	total	**36.95**	**48.64**

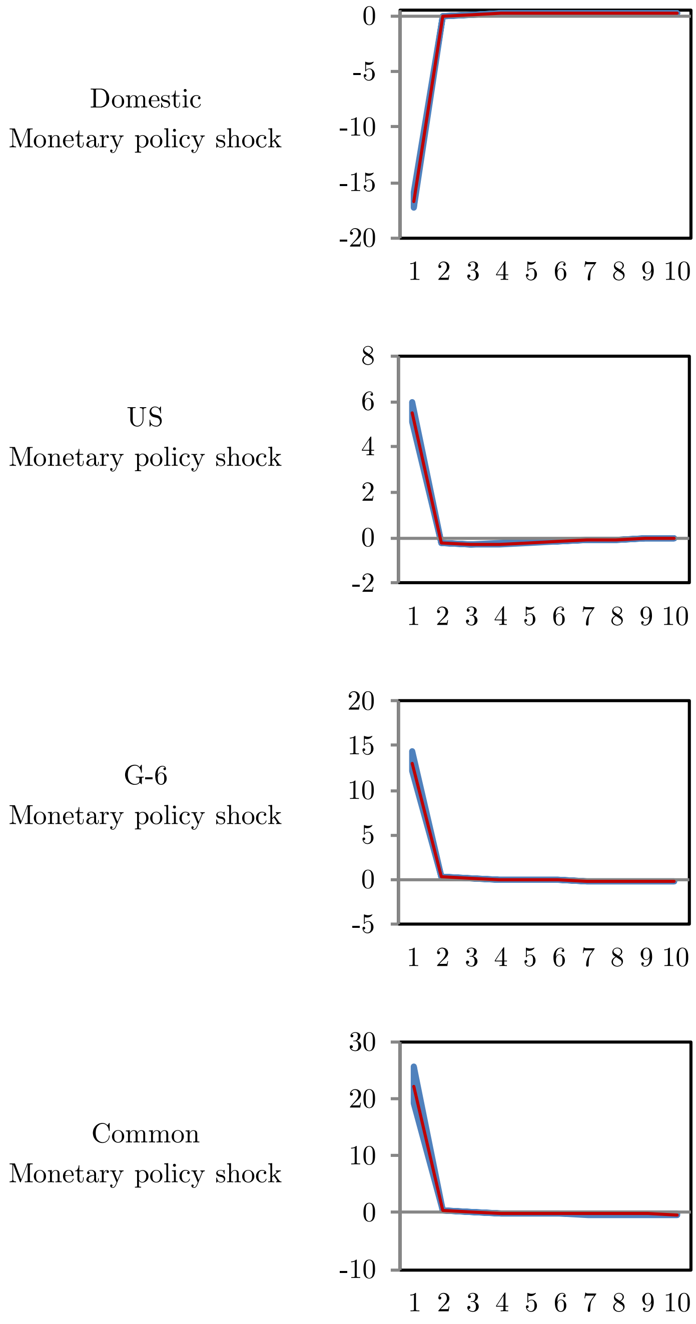
Note: The statistics represent the average contributions of Jamaican, US and G-6 shocks to the historical variance of the two exchange rates listed in columns 1 and 2. The averages are computed across the first half of the sample period.

Table 3. Forecast Error Variance Decompositions (FEVD)

		1 quarter horizon		10 quarter horizon	
		JMD	USD	JMD	USD
Shocks					
Jamaica	government spending	0.01	0.00	0.01	0.00
	price, domestic goods	0.02	0.00	0.02	0.00
	price, imports	0.15	0.00	0.14	0.00
	monetary policy	16.21	0.00	14.67	0.00
	credit spread	0.12	0.00	0.11	0.00
	bond risk	19.33	0.00	23.26	0.00
	financial	**35.66**	**0.00**	**38.04**	**0.00**
	nonfinancial	**0.18**	**0.00**	**0.17**	**0.00**
	total	**35.84**	**0.00**	**38.21**	**0.00**
US	government spending	0.00	0.00	0.00	0.00
	price, domestic goods	0.01	0.00	0.01	0.00
	price, imports	0.00	0.00	0.00	0.00
	monetary policy	1.76	1.73	1.60	1.51
	credit spread	0.04	0.06	0.04	0.06
	bond risk	4.85	10.61	4.39	8.58
	financial	**6.65**	**12.40**	**6.04**	**10.15**
	nonfinancial	**0.01**	**0.00**	**0.01**	**0.01**
	total	**6.66**	**12.40**	**6.05**	**10.15**
G6	government spending	0.00	0.00	0.00	0.00
	price, domestic goods	0.00	0.00	0.00	0.00
	price, imports	0.05	0.10	0.05	0.09
	monetary policy	9.68	22.40	8.75	18.09
	credit spread	0.01	0.00	0.01	0.00
	financial	**9.69**	**22.40**	**8.76**	**18.09**
	nonfinancial	**0.05**	**0.10**	**0.05**	**0.09**
	total	**9.74**	**22.50**	**8.81**	**18.18**
Common	monetary policy	28.61	18.76	25.87	15.18
	credit spread	0.65	0.20	0.61	0.18
	bond risk	18.48	46.14	20.46	56.30
	total	**47.75**	**65.09**	**46.93**	**71.66**

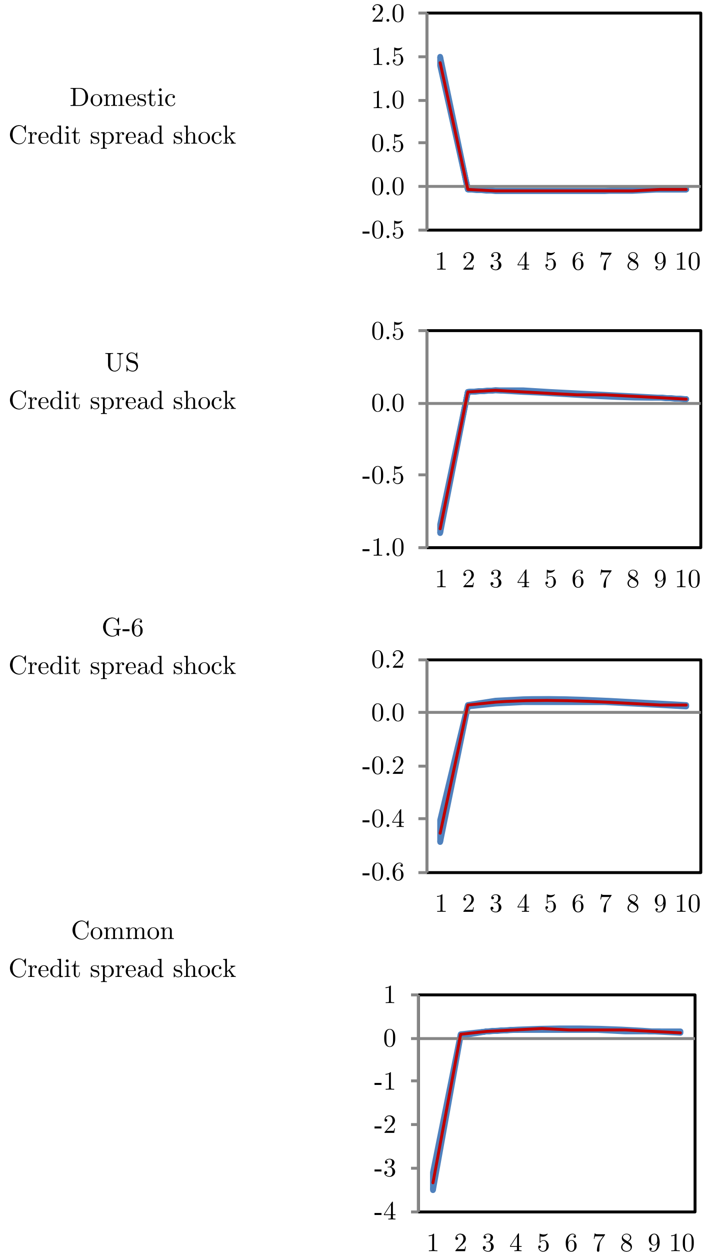
Note: The statistics represent the average contributions of Jamaican, US, and G-6 shocks to the forecast error variance of the exchange rates listed in the columns. The forecast horizons for the statistics in the first and last two columns are 1 quarter and 10 quarter ahead, respectively.

Figure 1. Jamaican Dollar response to monetary policy shocks



Note: The figure shows the Jamaican Dollar responses (in basis points) to a one standard deviation innovation to policy rates. The figure also displays the 95% confidence intervals for impulse responses. Common monetary policy shock refers to a simultaneous increase in the policy rates of U.S. and the remaining G-7 countries.

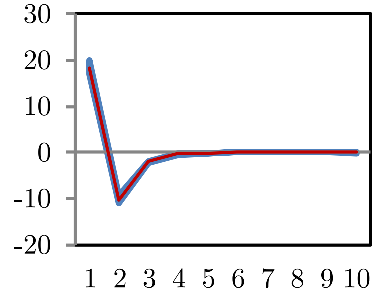
Figure 2. Jamaican Dollar response to credit spread shocks



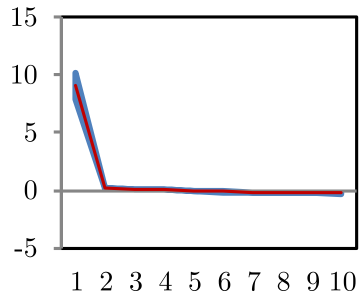
Note: The figure shows the Jamaican Dollar responses (in basis points) to a one standard deviation innovation to credit spreads. The figure also displays the 95% confidence intervals for impulse responses. Common credit spread shock refers to a simultaneous increase in the credit spreads in the U.S. and the remaining G-7 countries.

Figure 3. Responses to bond risk shocks

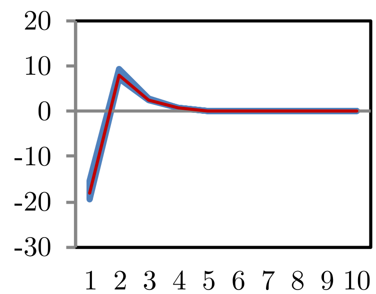
Jamaica, bond risk shock



US, bond risk shock

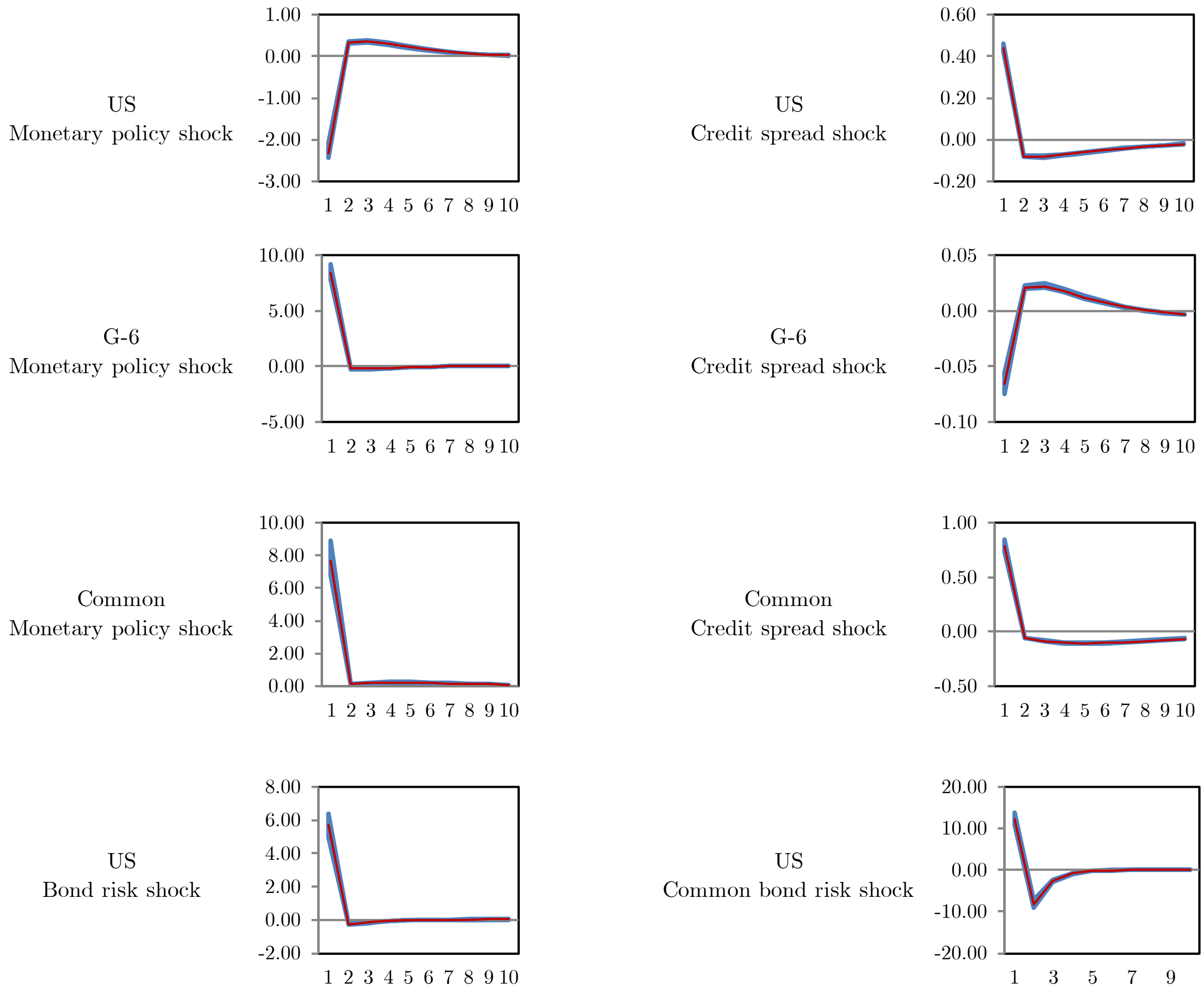


US, common bond risk shock



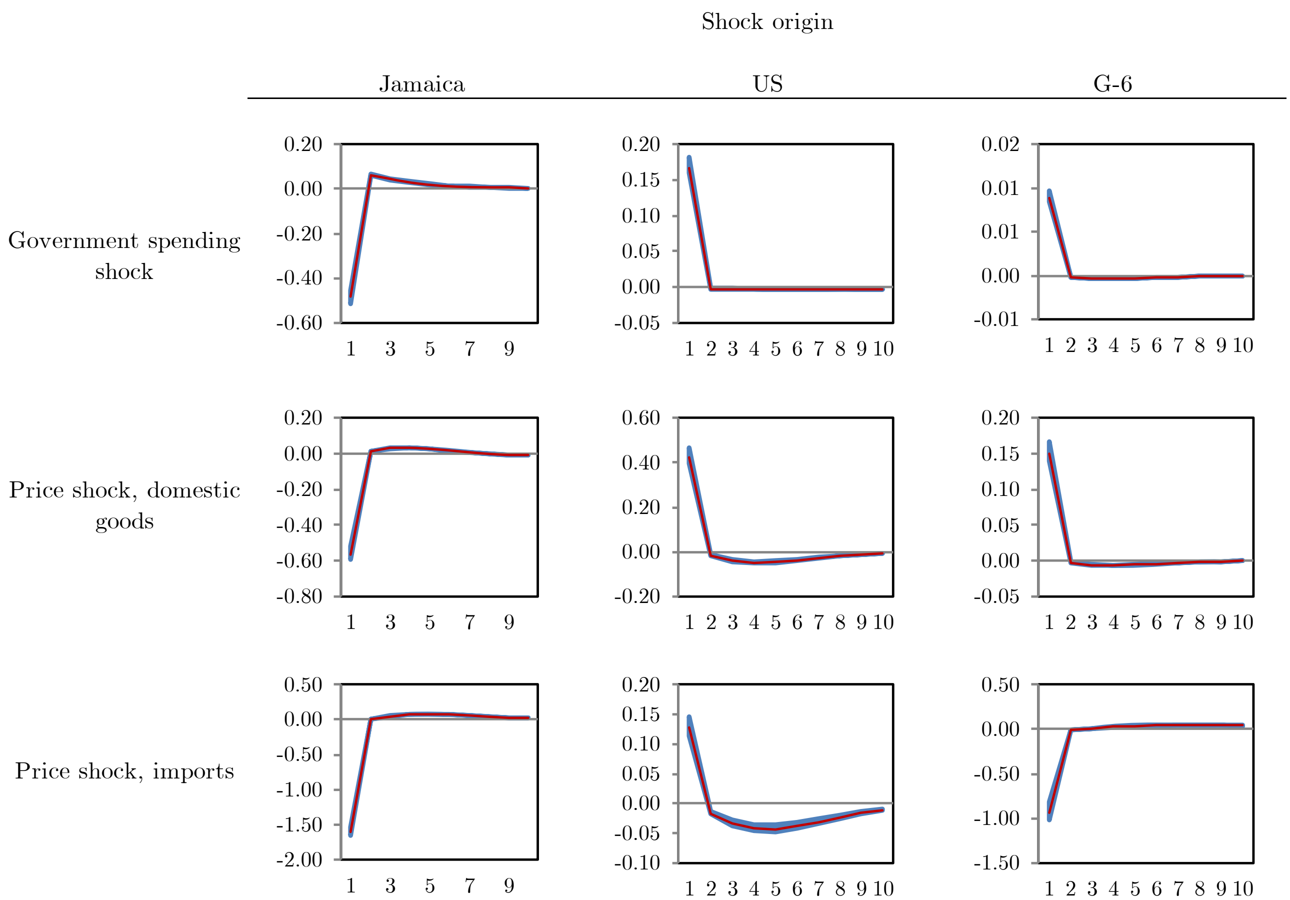
Note: The figure shows the depreciation responses (in basis points) to a one standard deviation innovation on the right hand side of the interest parity conditions. The figure also displays the 95% confidence intervals for impulse responses.

Figure 4. US Dollar responses to US&G-6 shocks



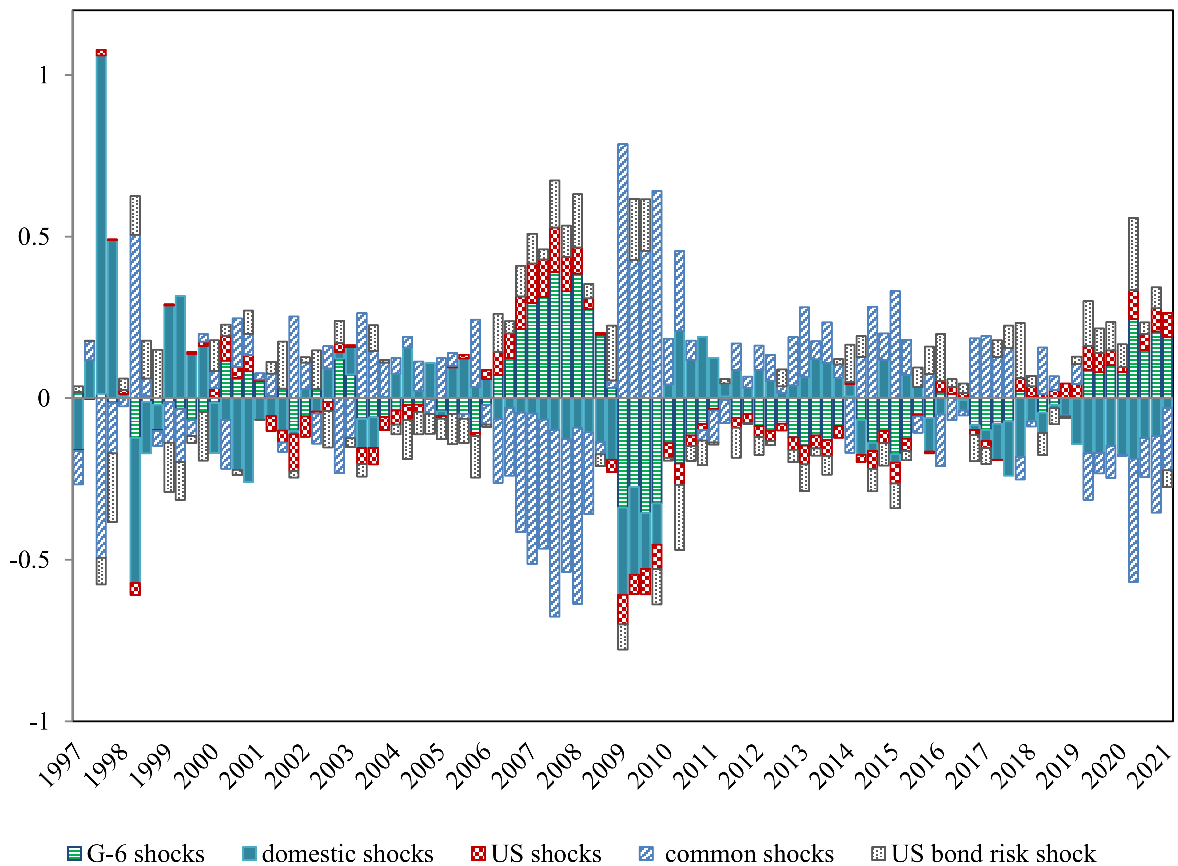
Note: The figure shows the US Dollar responses (in basis points) to a one standard deviation innovation to US and G-6 monetary policy and credit spread shocks. The figure also displays the 95% confidence intervals for impulse responses. Common credit shocks refer to a simultaneous increase in the policy rate and credit spreads in the U.S. and the remaining G-7 countries.

Figure 5. JMD responses to other shocks



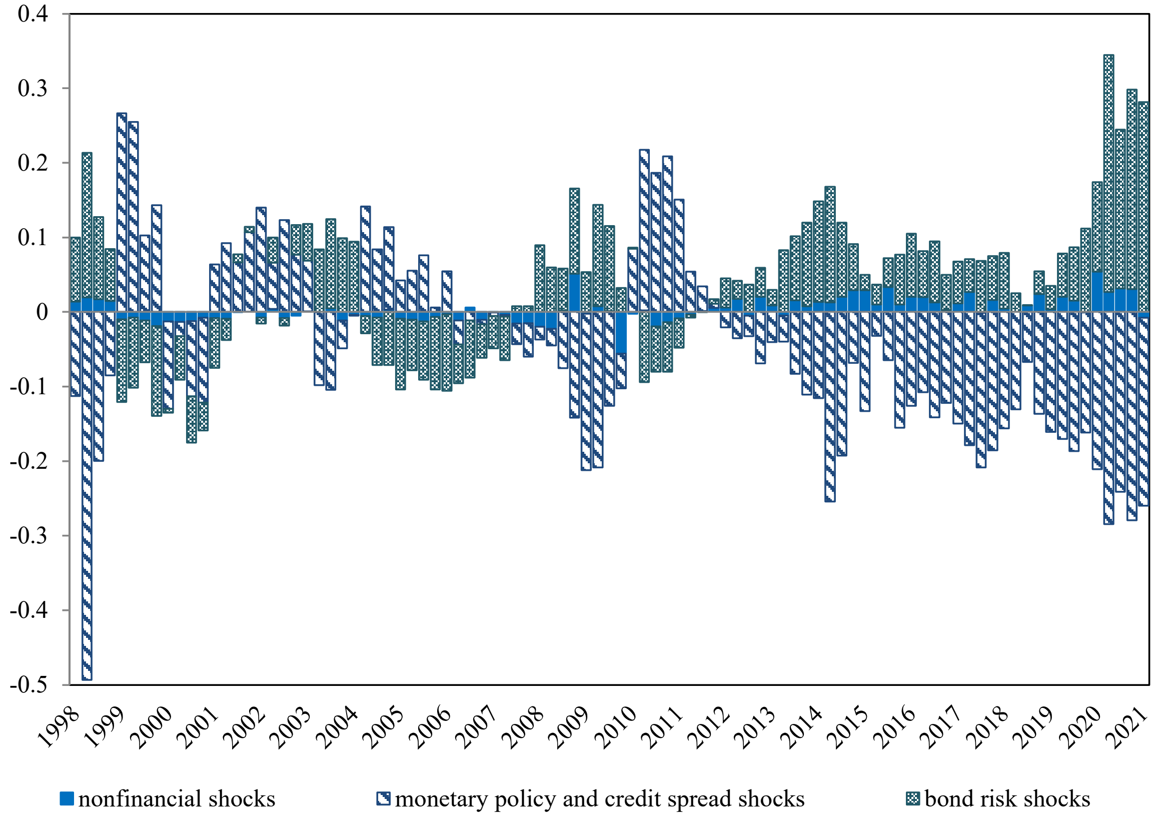
Note: The figure shows the Jamaican Dollar responses (in basis points) to one standard deviation innovations to Jamaican, US and G-6 government spending, domestic and import price shocks. The figure also displays the 95% confidence intervals for impulse responses.

Figure 6. Historical decomposition of JMD, external, internal and common shocks



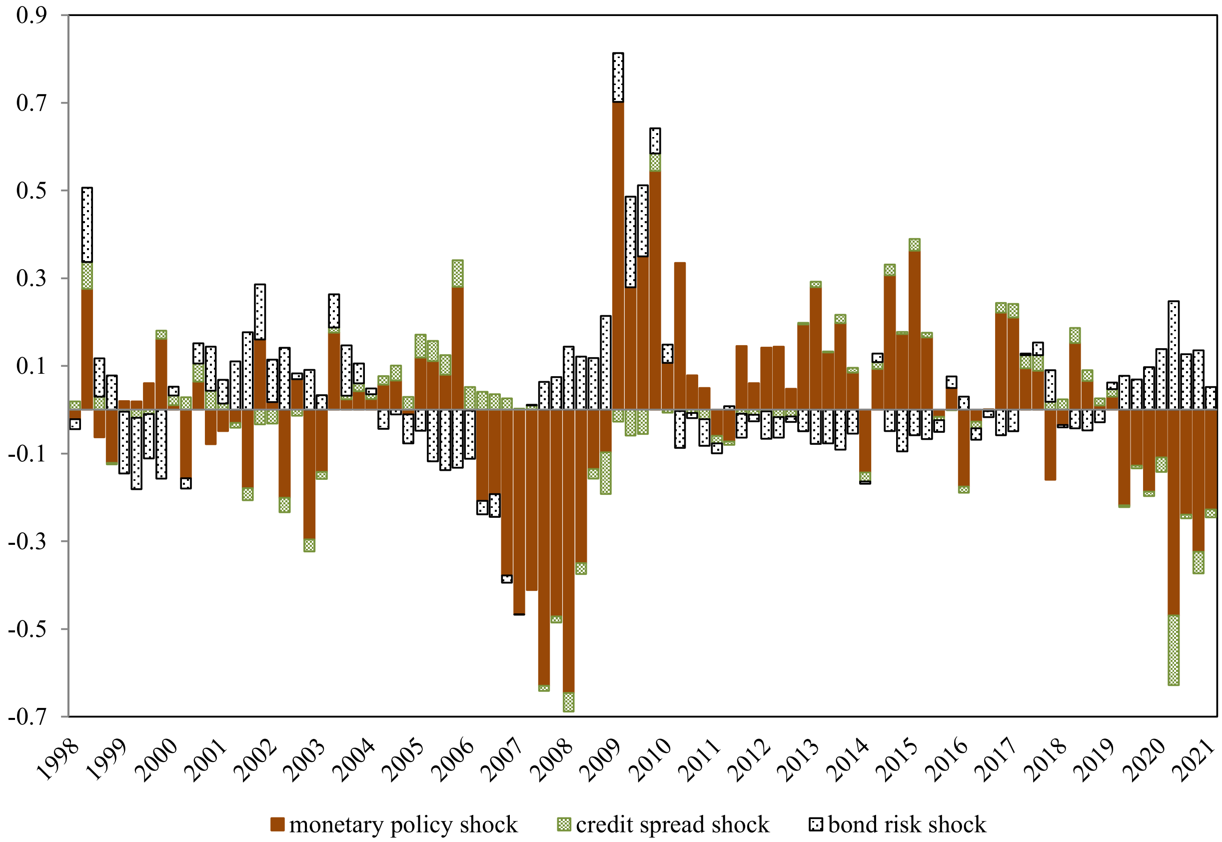
Note: The figures displays the contributions of domestic, US, G-6, US bond risk and common shocks to the historical variance of the Jamaican Dollar. The contributions are aggregated by type of shock in each quarter.

Figure 7. Historical decomposition of JMD, contributions of domestic shocks by type



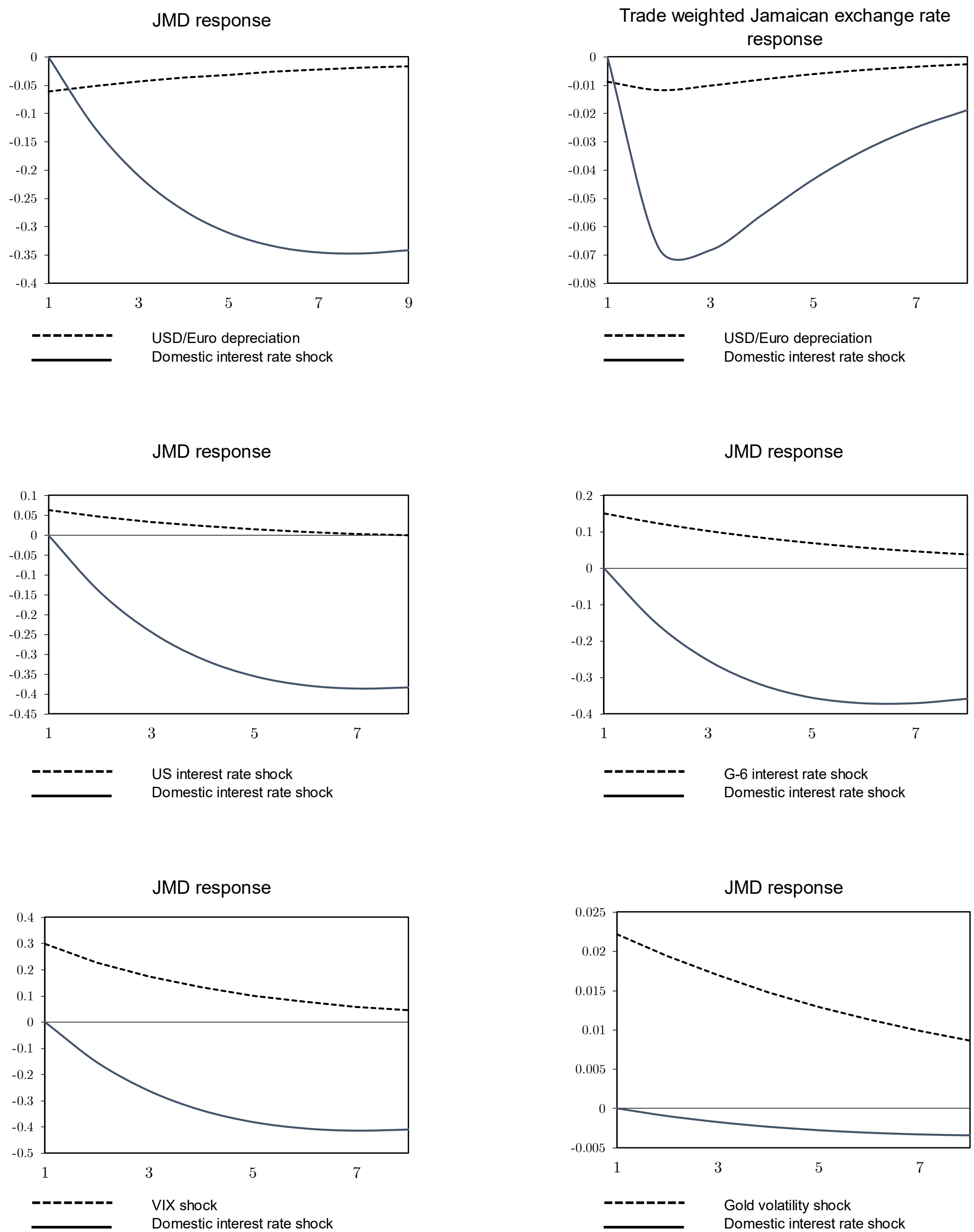
Note: The figures displays the contributions of nonfinancial, monetary policy and credit risk, and bond risk shocks to the historical variance of the Jamaican Dollar. The contributions are aggregated by country/region.

Figure 8. Historical decomposition of JMD, contributions of common shocks by type



Note: The figures displays the contributions of common monetary policy, common credit spread and common US bond risk shocks to the historical variance of the Jamaican Dollar.

Figure 9. Jamaican exchange rate responses, VARX model



Note: The figure displays the Jamaican Dollar and the trade weighted Jamaican exchange rate's responses to domestic and foreign interest rate, VIX and Gold ETF volatility, and USD/Euro exchange rate shocks. The impulse responses are obtained from a VAR model that includes foreign variables as exogenous variables.

Appendix A. Model Economies (for online publication)

The framework is a 3-economy DSGE model with two large and one small open economy. The three economic areas are linked through the trade of goods and bonds, and common shocks. The large economy blocs of the model do not include any small open economy variables. Below, I describe the model and the optimization problems of the agents. I then solve for the first order conditions for only the US. I do this for brevity since most of the other two economies are symmetrically modelled. I do, however, describe the differences for the other two economies when there is asymmetry.

A.1. Households

The economy features a continuum of households. These households, indexed by j, have infinite lives and they decide how much to save, work, $L_t(j)$ and consume, $C_t(j)$, in each period. In doing so, household j maximizes the following utility function:

$$U_t(j) = E_0 \sum_{t=0}^{\infty} \widetilde{\beta}^t \frac{1}{1-\sigma} \left[\left\{ C_t(j) - \lambda C_{t-1}(j) \right\} \exp\left(-\xi \frac{L_t(j)^{1+\sigma_l}}{1+\sigma_l} \right) \right]^{1-\sigma} N_t \tag{A.1}$$

where $\widetilde{\beta}$, σ_l and σ are the growth-adjusted discount factor, the inverse elasticity of labor supply, and the elasticity of intertemporal substitution, respectively. Consumers have external habit formation with the parameter λ, determines the intensity of habit persistence. The parameter ξ is included and calibrated so that labor supply is equal to one at steady state. N_t represents the population of households and it grows at the rate of η. Household j faces the following constraint when maximizing her utility function:

$$N_t C_t(j) + \frac{D_t(j)}{P_t} + \frac{B_{h,t}(j)}{R_t P_t} + \frac{E_t B_{f,t}(j)}{\varepsilon_{d,t}^c \varepsilon_{d,t} R_t^* P_t} + \varepsilon_{k,t} Q_t K_{j,t+1} + \frac{T_t}{P_t} \leq \frac{W_t(j)}{P_t} N_t L_t(j) + \frac{B_{h,t-1}(j)}{R_t}$$

$$+ \frac{E_t B_{f,t-1}(j)}{\varepsilon_{d,t}^c \varepsilon_{d,t} P_t} + R_t^d \frac{D_{t-1}(j)}{P_t} + \varepsilon_{k,t} R_t^k Q_{t-1} K_{j,t} + \Pi_{h,t} + \Pi_{f,t} + \frac{\kappa_w}{2} \left(\frac{W_t(j)/W_{t-1}(j)}{\gamma \pi_{t-1}^{\iota_w} \pi^{1-\iota_w}} \right) \frac{W_t}{P_t} N_t L_t \tag{A.2}$$

where $W_t(j)$ is household j's wages, W_t and P_t denote aggregate wages and prices in the economy, respectively. Household j saves by holding one-period nominal foreign and domestic bonds $B_{h,t}(j)$

and $B_{f,t}(j)$, and making bank deposits where E_t is the US Dollars per Euro exchange rate, R_t, R_t^*, and R_t^d are the interest rates on domestic and foreign bonds and the domestic bank deposits, respectively. The two bond rates also reflect the central bank rates. The households pay lump-sum taxes, T_t, to the government and they are the owners of capital, $K_{i,t}$. They buy capital from capital producers by paying Q_t per unit of capital and they earn the rate R_t^k after renting capital to the intermediate goods producers. Besides wages and capital income households also collect profits, $\Pi_{f,t}$ and $\Pi_{h,t}$ and from importers and intermediate goods producers.

Wage-stickiness is introduced via a Rotemberg (1982) formulation with quadratic wage adjustment costs (the last tern in the equation)..Here ξ_w represents the probability of keeping wages constant, ι_w governs the degree of indexation, $\kappa_w = (1-\xi_w)\left(1-\xi_w\widetilde{\beta}\right)/6\xi_w$, γ is the per-capita economic growth rate, and the inflation rate $\pi_t = P_t/P_{t-1}$.[1] The shock variable $\varepsilon_{d,t}$ represents an exogenous change in the risk of holding domestic bonds. The shock follows an AR(1) process given by $\varepsilon_{d,t} = \rho_d \varepsilon_{d,t-1} + \eta_{d,t}$ where ρ_d is the persistence parameter, and $\eta_{d,t}$ is the *i.i.d* distributed shock innovation (mean 0 and standard deviation σ_d, normally distributed). The other shocks in the model similarly follow an AR(1) process. While $\varepsilon_{d,t}$ measures the riskiness of holding US bonds relative to G-6 bonds, the shock $\varepsilon_{d,t}^c$ captures the riskiness of holding US bonds relative to all other bonds in the world. The shock $\varepsilon_{k,t}$ represents an exogenous change in credit spreads that is usually explained in the literature as a change in liquidity demand (e.g., Anzoategui et al., 2019) or a change in the volatility of an idiosyncratic capital return shocks that capital owners face (Bernanke et al. 1999).

In equation (A.2), the foreign bonds for the US households are those issued by G-6 countries. In the corresponding equation for the G-6 bloc, the foreign bonds are represented by US bonds. For the Jamaican households, there are two foreign bonds, US and G-6 bonds. The arbitrage between the three bonds produces the two uncovered interest parity conditions described by equations (5) and (6) in the text.

A perfectly competitive labor aggregators collect the households' labor services, $L_t(j)$, over

[1] The expression for κ_w is from Smets and Wouters (2007).

which they have a monopoly, transform these into an aggregate labor unit, L_t, as follows:

$$L_t = \left[\int_0^1 L_t(j)^{\frac{\Theta_{L,t}}{\Theta_{L,t}-1}} dj \right]^{\frac{\Theta_{L,t}-1}{\Theta_{L,t}}} \tag{A.3}$$

These aggregate labor services in turn are hired by intermediate good producers. The maximization problem of labor aggregators (maximizing $W_t L_t - \int_0^1 W_t L_t(j)\, dj$) produces the following labor demand condition:

$$L_t(j) = \left[\frac{W_t(j)}{W_t} \right]^{-\Theta_{L,t}} L_t \tag{A.4}$$

where $\Theta_{L,t}$ is the elasticity of substitution between the labor services that also determines wage mark-up $\varepsilon_{w,t} = \frac{\Theta_{L,t}}{\Theta_{L,t}-1}$. I assume that this time-varying wage mark-up follows an AR(1) process given by.

$$\log \varepsilon_{w,t} = (1-\rho_w) \log \phi_w + \rho_w \log \varepsilon_{w,t-1} + \eta_{w,t} \tag{A.5}$$

where the mark-up over the marginal rate of substitution between leisure and consumption is captured by the parameter ϕ_w.

A.2. Producers and importers

Intermediate goods producers are monopolistically competitive and they an intermediate good according to the following Cobb-Douglas function:

$$Y_t(i) = [Z_t(i) K_t(i)]^{\alpha} [A_t N_t L_t(i)]^{1-\alpha} - (\eta\gamma)^t f \tag{A.6}$$

where , $K_t(i)$, $L_t(i)$, $Y_t(i)$ and $Z_t(i)$ are the capital, labor, output and the capital utilization rate of firm i. A_t and f represent productivity and fixed costs of production respectively and these grow at the rate of γ and $\eta\gamma$, along the balanced growth path.[2]

The evolution of firm i's capital is given by,

$$K_t(i) = (1-\delta) K_{t-1}(i) + \left[1 - \frac{\varphi}{2} \left(\frac{I_t(i)}{\eta\gamma I_{t-1}(i)} - 1 \right)^2 \right] I_t(i) \tag{A.7}$$

[2]Setting the parameter f equal to $(\theta - 1) Y_t / (\eta\gamma)^t$ ensures that intermediate good producers don't make profits along the balanced growth path.

where φ regulates the level of investment adjustment costs and $I_t\,(i)$ represents firm i's investment.

Perfectly competitive capital producers convert final goods and capital that is undepreciated into new capital. To do so, they buy final investment goods from final goods producers and consumers' undepreciated capital by paying a price of P_t and Q_t, respectively. They then sell the newly produced capital to consumers at a price of Q_t. Capital producers' life-time profits are as follows:

$$E_t \sum_{t=0}^{\infty} \widetilde{\beta}^t \Lambda_t \left[Q_t K_t - Q_t \left(1-\delta\right) K_{t-1} - \frac{P_{i,t}}{P_t} I_t \right] \tag{A.8}$$

The stochastic discount factor of capital producers, Λ_t, is the same as the shadow value on the consumers' budget constraint. This factor is given by,

$$\Lambda_t = \frac{1}{N_t} \left(C_t - \lambda C_{t-1}\right)^{-\sigma} \exp\left(\frac{\sigma-1}{1+\sigma_l} \xi L_t^{1+\sigma_l}\right) \tag{A.9}$$

Perfectly competitive final goods producers purchase the intermediate goods and who combine them as follows:

$$Y_t = \left(\int_0^1 Y_t\left(i\right)^{\frac{\Theta_{h,t}-1}{\Theta_{h,t}}} di\right)^{\frac{\Theta_{h,t}}{\Theta_{h,t}-1}} \tag{A.10}$$

where Y_t is the final good. Final goods producers' cost minimization problem produces a firm specific demand condition given by,

$$Y_t\left(i\right) = \left(\frac{P_t\left(i\right)}{P_t}\right)^{-\Theta_{h,t}} Y_t \tag{A.11}$$

where $\Theta_{h,t}$ represents time varying mark-ups which are subject to a price shock that evolves as follows:

$$\log \varepsilon_{h,t} = \left(1-\rho_h\right) \log \phi_p + \rho_h \log \varepsilon_{h,t-1} + \eta_{h,t}. \tag{A.12}$$

Here ϕ_p represents the mark-up rate at steady state, $\eta_{h,t}$ follows an AR(1) process, and $\varepsilon_{h,t} = \Theta_{h,t}/\left(\Theta_{h,t}-1\right)$.

The intermediate good producers set the amount of production, inputs and their prices by taking the demand for their goods as given and maximize their profits given by,

$$\pi_t(i) = P_{h,t}(i) Y_t(i) - W_t N_t L_t(i) - \left[MPK_t - \frac{\kappa_z}{1+\varpi} \left(z_t(i)^{1+\varpi} - 1 \right) \right] K_t(i) \\ - \frac{\kappa_{ph}}{2} \left(\frac{P_{h,t}(i) / P_{h,t-1}(i)}{\pi_{h,t-1}^{\iota_h} \pi^{1-\iota_h}} - 1 \right)^2 \frac{P_{h,t}}{P_t} Y_t \tag{A.13}$$

where the marginal product of capital, MPK_t, is related to the cost of capital R_t^k as follows: $R_t^k = [MPK_t + (1-\delta) Q_t] / Q_{t-1}$. There are two frictions here that allow me to match the persistence in inflation that is observed in the data. These frictions operate through price stickiness and marginal costs. The first of these is a real friction that is prompted by the time varying capacity utilization variable, $z_t(i)$, and the costs to adjusting the level of utilization. Here, ϖ and κ_z regulate the elasticity of adjustment and fixed costs, respectively. The second friction is due to the quadratic costs faced by firms when their pricing deviates from past inflation, where, $\kappa_{ph} = (1-\xi_h)\left(1-\xi_h\widetilde{\beta}\right)/3.5\xi_h$ represents fixed costs, ξ_h is the probability of keeping prices constant and ι_h is the price indexation parameter.

The importers in the economy are also monopolistically competitive. Their production is purchased by perfectly competitive final goods aggregators to yield a final good. These firms, too, incur costs if their pricing deviates from past inflation. Their main task is to differentiate imported goods and sell these domestically at a mark-up. The demand for importer k's goods, $Y_{f,t}(k)$, is as follows:

$$Y_{f,t}(k) = \left(\frac{P_{f,t}(k)}{P_{f,t}} \right)^{\Theta_{f,t}} Y_{f,t} \tag{A.14}$$

where $P_{f,t}$ and $P_{f,t}(k)$ are the aggregate and firm specific import prices, $Y_{f,t}$ denotes aggregate imports, and the time-varying mark-up parameter, $\Theta_{f,t}$, is subject to a cost push shock given by,

$$\log \varepsilon_{f,t} = (1-\rho_f) \log \phi_f + \rho_f \log \varepsilon_{f,t-1} + \eta_{f,t}. \tag{A.15}$$

Here ϕ_f is the mark up rate at steady state, $\varepsilon_{f,t}$ is a cost-push shock, related to mark-ups as follows: $\varepsilon_{f,t} = \Theta_{f,t} / (\Theta_{f,t} - 1)$.

Importers set the amount of imports and their prices to maximize life-time profits:

$$E_t \sum_{t=0}^{\infty} \Lambda_t \left[\left(P_{f,t}(k) - E_t P^*_{h,t} \right) Y_{f,t}(k) - \frac{\kappa_{pf}}{2} \left(\frac{P_{f,t}(k) / P_{f,t-1}(k)}{\pi_{f,t-1}^{\iota_f} \pi_f^{1-\iota_f}} - 1 \right)^2 P_{f,t} Y_{f,t} \right] \tag{A.16}$$

where $\pi_{f,t}$ is the imports goods' inflation rate, ξ_f denotes the probability of keeping prices constant, ι_f captures the degree of indexation and $\kappa_{pf} = (1-\xi_f)\left(1-\xi_f\widetilde{\beta}\right)/6\xi_f$.

A.3. Monetary Policy and Fiscal Balance

The monetary policy is determined by the following Taylor-rule:

$$R_t = \rho R_{t-1} + (1-\rho)\left(\log R + \gamma_\pi \log \frac{\pi_t}{\pi} + \gamma_y \log \frac{Y_t}{(\gamma\eta)^t Y} + \gamma_{\Delta y} \log \frac{Y_t}{\gamma\eta Y_{t-1}} \right) + \varepsilon_{r,t} \tag{A.17}$$

where γ_y, γ_π, and $\gamma_{\Delta y}$ are the weights of output, inflation and output growth rate, ρ governs interest rate smoothing, R is the policy rate's steady state level, and $\varepsilon_{r,t}$ is the monetary policy shock that follows an AR(1) process.

The government collects lump-sum taxes and issues discount bonds to finance its real expenditures, G_t, and its debt payments so that,

$$P_t G_t + B_{h,t-1} + B^*_{f,t-1} = T_t + \frac{B_{h,t-1}}{R_t} + \frac{B^*_{f,t}}{R_t} \tag{A.18}$$

where $B^*_{f,t}$ is the domestic government bond holdings of foreign households. I assume that government spending is a shock variable, following an AR(1) process.

A.5. Market Clearing Conditions and Composite Goods

Aggregate consumption and investment goods are the following CES composites of foreign and home consumption goods and investment goods respectively:

$$C_t = \left(\gamma_c^{1/\lambda_c} C_{h,t}^{(\lambda_c-1)/\lambda_c} + (1-\gamma_c)^{1/\lambda_c} C_{f,t}^{(\lambda_c-1)/\lambda_c} \right)^{\lambda_c/(\lambda_c-1)} \tag{A.19}$$

$$I_t = \left(\gamma_i^{1/\lambda_i} I_{h,t}^{(\lambda_i-1)/\lambda_i} + (1-\gamma_i)^{1/\lambda_i} I_{f,t}^{(\lambda_i-1)/\lambda_i} \right)^{\lambda_i/(\lambda_i-1)} \tag{A.20}$$

where λ_i and λ_c determine the elasticity of substitution between foreign and home goods for investment and consumption, respectively, and γ_i and γ_c represent the shares of domestic goods in the investment and consumption aggregate, respectively. The demand for domestic and foreign goods and the price indices corresponding to the two equations above are given by,

$$C_{h,t} = \left(\frac{P_{h,t}}{P_t}\right)^{-\lambda_c} \gamma_c C_t \quad , \quad C_{f,t} = \left(\frac{P_{f,t}}{P_t}\right)^{-\lambda_c} (1-\gamma_c)\, C_t \tag{A.21}$$

$$I_{h,t} = \left(\frac{P_{h,t}}{P_{i,t}}\right)^{-\lambda_i} \gamma_i I_t \quad , \quad I_{f,t} = \left(\frac{P_{f,t}}{P_{i,t}}\right)^{-\lambda_i} (1-\gamma_i)\, I_t \tag{A.22}$$

$$P_t = \left(\gamma_c P_{h,t}^{1-\lambda_c} + (1-\gamma_c)\, P_{f,t}^{1-\lambda_c}\right)^{1/(1-\lambda_c)} \tag{A.23}$$

$$P_{i,t} = \left(\gamma_i P_{h,t}^{1-\lambda_i} + (1-\gamma_i)\, P_{f,t}^{1-\lambda_i}\right)^{1/(1-\lambda_i)} \tag{A.24}$$

Output in the economy equals the sum of home goods consumption, government and investment expenditures,and the exports of consumption and investment goods,

$$Y_t = N_t C_{h,t} + I_{h,t} + G_t + N_t^* C_{f,t}^* + I_{f,t}^* \tag{A.25}$$

where $Y_{f,t}$, imports, are consumed or invested so that,

$$Y_{f,t} = N_t C_{f,t} + I_{f,t} \tag{A.26}$$

For US and the G-6 bloc the import demand of Jamaica does not enter the resource constraint. I should also point out here that aggregate consumption and investment and the corresponding price indices consist of three types of goods for Jamaica: locally produced goods, imports from the US and imports from the G-6 bloc. These are described in equations (1) through (4) in the text.

A.6. Optimality Equations

The utility maximization with respect to deposit holdings produces the following Euler equation:

$$E_t\left[\widetilde{\beta}\frac{\Lambda_{t+1}}{\Lambda_t}\frac{R_t^d}{\pi_{t+1}}\right]=1 \tag{A.27}$$

where the Lagrange multiplier Λ_t measures the marginal utility and the marginal budget costs of consumption.

Here there is no arbitrage between domestic bond holdings and deposits so that, $R_t = R_t^d$. Combining the above equation with the optimality condition for capital produces the following expression for credit spreads:

$$E_t\left[\widetilde{\beta}\frac{\Lambda_{t+1}}{\Lambda_t}\left(\varepsilon_{k,t}R_t^k-\frac{R_t}{\pi_{t+1}}\right)\right]=1 \tag{A.28}$$

The arbitrage between domestic and foreign bonds is described by the following UIP condition:

$$E_t\left[\widetilde{\beta}\frac{\Lambda_{t+1}}{\Lambda_t\pi_{t+1}}\left(R_t-\varepsilon_{d,t}^c\varepsilon_{d,t}\frac{E_{t+1}}{E_t}R_t^*\right)\right]=0 \tag{A.29}$$

The corresponding condition for Jamaica (equation (5) in the text) includes the common shock $\varepsilon_{d,t}^c$ and a shock that captures the riskiness of holding Jamaican bonds relative to US bond holdings.

Labor supply decisions and wage setting behavior are given by the two optimality conditions below:

$$\varepsilon_{c,t}\left[(C_t-\lambda C_{t-1})\exp\left(\xi\frac{L_t^{1+\sigma_l}}{1+\sigma_l}\right)\right]^{1-\sigma}\xi L_t^{\sigma_l}=\Lambda_t\Omega_t\frac{W_t}{P_t} \tag{A.30}$$

$$\left(\frac{\pi_{w,t}}{\gamma\pi_{t-1}^{\iota_w}\pi^{1-\iota_w}}-1\right)\frac{\pi_{w,t}}{\gamma\pi_{t-1}^{\iota_w}\pi^{1-\iota_w}}=E_t\left[\widetilde{\beta}\frac{\Lambda_{t+1}}{\Lambda_t}\left(\frac{\pi_{w,t+1}}{\gamma\pi_t^{\iota_w}\pi^{1-\iota_w}}-1\right)\frac{\pi_{w,t+1}}{\gamma\pi_t^{\iota_w}\pi^{1-\iota_w}}\frac{\pi_{w,t+1}}{\pi_{t+1}}\frac{N_{t+1}}{N_t}\frac{L_{t+1}}{L_t}\right] \tag{A.31}$$

where the Lagrange multiplier Ω_t corresponds to the budget constraint of labor intermediaries and it is given by,

$$\Omega_t=W_t(i)\left(\frac{L_t(i)}{L_t}\right)^{1/\Theta_{L,t}} \tag{A.32}$$

The intermediate goods producers maximize profits subject to the final goods producers' demand. This maximization with respect to labor, capital and the utilization rate yields the following equations:

$$\Omega_{h,t}P_{h,t}(1-\alpha)\left(Y_t+(\eta\gamma)^t f\right)=W_tL_t \tag{A.33}$$

$$\Omega_{h,t}\frac{P_{h,t}}{P_t}\alpha\left(\frac{Y_t+(\eta\gamma)^t f}{K_t}\right)=MPK_t+\frac{\kappa_z}{1+\varpi}\left(Z_t^{1+\varpi}-1\right) \tag{A.34}$$

$$\Omega_{h,t}\frac{P_{h,t}}{P_t}\alpha\left(\frac{Y_t+(\eta\gamma)^t f}{K_t}\right)=\kappa_z Z_t^{1+\varpi} \tag{A.35}$$

where Lagrange multiplier $\Omega_{h,t}$ corresponds to the budget constraint of final goods producers.

Domestic goods' price and import price inflation evolve according to the following equations:

$$\left(\frac{\pi_{h,t}}{\gamma\pi_{t-1}^{\iota_h}\pi^{1-\iota_h}}-1\right)\frac{\pi_{h,t}}{\gamma\pi_{t-1}^{\iota_h}\pi^{1-\iota_h}}=E_t\left[\frac{\widetilde{\beta}\Lambda_{t+1}}{\Lambda_t}\left(\frac{\pi_{h,t+1}}{\gamma\pi_t^{\iota_h}\pi^{1-\iota_h}}-1\right)\frac{\pi_{h,t+1}Y_{t+1}}{\gamma\pi_t^{\iota_h}\pi^{1-\iota_h}Y_t}\right]+\Omega_{h,t}\left(\frac{\Theta_{h,t}-1}{\kappa_{ph}}\right)\varepsilon_{h,t} \tag{A.36}$$

$$\begin{aligned}\left(\frac{\pi_{f,t}}{\gamma\pi_{f,t-1}^{\iota_f}\pi^{1-\iota_f}}-1\right)\frac{\pi_{f,t}}{\gamma\pi_{f,t-1}^{\iota_f}\pi^{1-\iota_f}}&=E_t\left[\widetilde{\beta}\frac{\Lambda_{t+1}}{\Lambda_t}\left(\frac{\pi_{f,t+1}}{\gamma\pi_{f,t}^{\iota_f}\pi^{1-\iota_f}}-1\right)\frac{\pi_{f,t+1}}{\gamma\pi_{f,t}^{\iota_f}\pi^{1-\iota_f}}\frac{\pi_{f,t+1}}{\pi_{t+1}}\frac{Y_{f,t+1}}{Y_{t+t}}\right]\\&+\left(\frac{\Theta_{f,t}-1}{\kappa_{pf}}\right)\frac{E_tP_{h,t}^*}{\kappa_{pf}P_{f,t}}\varepsilon_{f,t}\end{aligned} \tag{A.37}$$

where $\pi_{f,t}=P_{f,t}/P_{f,t-1}$ denotes import price inflation.

The profit maximization problem of capital producers generates the following equation:

$$\begin{aligned}&q_t\left(1-\varphi\left(\frac{I_t}{\eta\gamma I_{t-1}}-1\right)\frac{I_t}{\eta\gamma I_{t-1}}-\frac{\varphi}{2}\left(\frac{I_t}{\eta\gamma I_{t-1}}-1\right)^2\right)\\&+E_t\left[\widetilde{\beta}\varphi\frac{\Lambda_{t+1}}{\Lambda_t}q_t\left(\frac{I_t}{\eta\gamma I_{t-1}}-1\right)\frac{I_t^2}{\eta\gamma I_{t-1}^2}\right]=\frac{P_{i,t}}{P_t}\end{aligned} \tag{A.38}$$

A.7. The log-linearized model

This section lists the equation that describe the log-linearized form of the model. Each variable below denotes the deviation of the corresponding variable from its steady state value. The upper case variables represent steady state values.

Relative demand for domestic goods:

$$c_t=\frac{\lambda/\gamma}{\lambda/\gamma+1}c_{t-1}+\frac{1}{\lambda/\gamma+1}E_tc_{t+1}+\frac{(1-\lambda/\gamma)}{\sigma(\lambda/\gamma+1)}\left[(\sigma-1)\xi\left(l_t-E_tl_{t+1}\right)-(r_t-E_t\pi_{t+1})\right] \tag{A.39}$$

$$c_t=\gamma_c c_{h,t}+(1-\gamma_c)\,c_{f,t} \tag{A.40}$$

$$c_{h,t} - c_{f,t} = \lambda_c \left(p_{f,t} - p_{h,t}\right) \tag{A.41}$$

$$i_t = \gamma_i i_{h,t} + \left(1 - \gamma_i\right) i_{f,t} \tag{A.42}$$

$$i_{h,t} - i_{f,t} = \lambda_i \left(p_{f,t} - p_{h,t}\right) \tag{A.43}$$

Inflation:

$$\pi_t = \gamma_c \pi_{h,t} + \left(1 - \gamma_c\right) \pi_{f,t} \tag{A.44}$$

$$p_{i,t} = \gamma_i p_{h,t} + \left(1 - \gamma_i\right) p_{f,t} \tag{A.45}$$

$$\pi_{w,t} - \iota_w \pi_{t-1} = \widetilde{\beta} \left(E_t \pi_{w,t+1} - \iota_w \pi_t\right) - \frac{\left(1 - \xi_w\right)\left(1 - \xi_w \widetilde{\beta}\right)}{6\xi_w} \left\{ w_t - \left[\sigma_l l_t + \frac{\left(c_t - \frac{\lambda}{\gamma} c_{t-1}\right)}{1 - \lambda/\gamma} \right] \right\} \tag{A.46}$$

$$\pi_{w,t} = w_t - w_{t-1} + \pi_t \tag{A.47}$$

$$\pi_{h,t} - \frac{\iota_h}{1 + \iota_h \widetilde{\beta}} \pi_{h,t-1} = \frac{\widetilde{\beta}}{1 + \iota_h \widetilde{\beta}} \pi_{h,t+1} - \frac{\left(1 - \xi_h\right)\left(1 - \xi_h \widetilde{\beta}\right)}{3.5\xi_h \left(1 + \iota_h \widetilde{\beta}\right)} \left[p_{h,t} + \alpha \left(z_t + k_t - l_t\right) - w_t\right] + \varepsilon_{h,t} \tag{A.48}$$

$$\pi_{h,t} - \pi_t = p_{h,t} - p_{h,t-1} \tag{A.49}$$

$$\pi_{f,t} - \frac{\iota_f}{1 + \iota_f \widetilde{\beta}} \pi_{f,t-1} = \frac{\widetilde{\beta}}{1 + \iota_f \widetilde{\beta}} \pi_{f,t+1} - \frac{\left(1 - \xi_f\right)\left(1 - \xi_f \widetilde{\beta}\right)}{3.5\xi_f \left(1 + \iota_f \widetilde{\beta}\right)} \left[p_{f,t} - rer_t - p^*_{h,t}\right] + \varepsilon_{f,t} \tag{A.50}$$

Production and resource constraint:

$$y_t = \phi_p \left[\alpha \left(z_t + k_t\right) + \left(1 - \alpha\right) l_t\right] \tag{A.51}$$

$$mpk_t = -\left(z_t + k_t - l_t\right) + w_t \tag{A.52}$$

$$z_t = \frac{1}{\varpi} mpk_t \tag{A.53}$$

$$k_t = \left[\left(1 - \delta\right)/\eta\gamma\right] k_{t-1} + \left[1 - \left(1 - \delta\right)/\eta\gamma\right] i_t \tag{A.54}$$

$$r_{k,t} = \left[\left(1 - \delta\right) \widetilde{\beta}/\eta\gamma\right] q_t + \left[1 - \left(1 - \delta\right) \widetilde{\beta}/\eta\gamma\right] mpk_t - q_{t-1} \tag{A.55}$$

$$y_t = \gamma_c \frac{C}{Y} c_{h,t} + \gamma_i \frac{I}{Y} i_{h,t} + \frac{G}{Y} \varepsilon_{g,t} + \left(1 - \gamma_c\right) \frac{C}{Y} c^*_{f,t} + \left(1 - \gamma_i\right) \frac{I}{Y} i^*_{f,t} \tag{A.56}$$

where $\varepsilon_{g,t}$ is the government spending shock.

The financial economy:

$$E_t r_{k,t+1} + \varepsilon_{k,t} = r_t - E_t \pi_{t+1} \tag{A.57}$$

$$r_t = \rho r_{t-1} + (1-\rho)\left[r_\pi \pi_t + r_y y_t + r_{\Delta y}\left(y_t - y_{t-1}\right)\right] + \varepsilon_{r,t} \tag{A.58}$$

$$rer_t - rer_{t-1} = d_t + \pi_t^* - \pi_t \tag{A.59}$$

$$r_t = r_t^* + d_{t+1} + \varepsilon_{d,t}^c + \varepsilon_{d,t} - \phi^{nfa} nfa_t \tag{A.60}$$

where nfa represents the net stock of foreign assets that changes according to the trade balance. Following standard practice, this variables is used to close the model and the parameter ϕ^{nfa} set equal to a small number (0.001).

Appendix B. Data, Calibration, Prior Distributions and Posterior Estimates

(for online publication)

To estimate the model I use 6 data series for each region and the GDP weighted US Dollar/G-6 and the US Dollar to Jamaican Dollar exchange rate The 6 data series are the gross domestic product, government expenditures, import prices, GDP deflator, interbank short-term interest rate and the medium term interest rate. Each series is demeaned, seasonally adjusted and log differenced (interest rates are linearly de-trended instead). The data definitions and sources are provided in Table B.1.

Some model parameters can be pinned down by using state variables' steady state values. These parameters, i.e., level parameters, are calibrated to fixed values prior to estimation. The discount factor, $\tilde{\beta}$ for example, is fixed to 0.995, which implies a 2 percent real interest rate (annualized) for the US and G-6 bloc. This parameter is set equal to 0.97 for Jamaica to match average short term interest rates (12%). The intertemporal elasticity of substitution parameter, σ, takes the value of 1, implying unit elasticity. The per capita output and population growth rate rates, γ and η, are fixed to 1.005 and 1.0025, so that there is 2 and 1 percent annualized growth rate of output and population along the balanced growth path. The wage and price mark up rates, ϕ_w and ϕ_p, are fixed to 1.5 and 1.25 respectively as in Smets and Wouters (2007). The capital income share and the depreciation parameters, α and δ, are set equal to 0.3 and 0.0025, respectively. The investment and consumption share parameters, γ_i and γ_c, are fixed to 0.9 implying that imports are of consumption and investment in US and G-6. For Jamaica I follow a similar calibration but I also set the shares of imports from US and the G-6 region equal to each other given that they are roughly the same in the data. The level parameter, ξ, is set equal to $\xi = \dfrac{(1-\alpha)}{\phi_w (1-\lambda/\gamma)(C/Y)}$ so that there is unit labor supply at steady state.

Table B.2 shows the parameters' prior distributions. These distributions follow those in Smets and Wouters (2007) and Gilchrist et al. (2009) for the closed economy features of the model. The habit persistence parameter, λ for example, has a beta distribution with a mean and standard deviation of 0.7 and 0.1, respectively. The Frisch-elasticity parameter σ_l has a normal prior with a mean and standard deviation of 2 and 0.75, respectively. The parameter regulating investment adjustment costs, φ, has a normal prior with mean and standard deviation of 4 and 1.5, respectively. The mean value of 0.5 for the capacity utilization elasticity parameter, ψ, implies unit elasticity of utilization. The price rigidity parameters, ξ_h, ξ_f and ξ_w, have beta priors with mean 0.5 (implying an average of 2 quarter price and wage stickiness) and standard deviation 0.1. The indexation parameters, ι_h, ι_f and ι_w, also have beta priors with a mean and standard deviation of 0.5 and 0.15, respectively. The steady state price mark up, ϕ_p, has a normal prior with mean and standard deviation of 1.25 and 0.1, respectively.

For the Taylor rule parameters, I assume that the response coefficient on output and output growth, r_y and $r_{\Delta y}$, have normal distributions with mean 0.25 and standard deviation 0.12. The parameter regulating the response to inflation, r_π, similarly has a normal distribution with a mean of 1.5 and standard deviation 0.25. Finally, the interest rate smoothing parameter, ρ, has a normal distribution with mean and standard deviation of 0.75 and 0.1, respectively.

I assume that all shock persistence parameters have beta priors with mean 0.5 and standard deviation 0.2, and that the priors for their standard deviations are inverse gamma distributions with mean 0.005 and infinite variance. These are fairly uninformative priors.

References

Gilchrist, S., Ortiz, A., Zakrajsek, E., 2009. "Credit Risk and the Macroeconomy: Evidence from an Estimated DSGE Model," mimeo, Boston University.

Smets, F., Wouters, R., 2007. "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach," American Economic Review, 97, 586-606.

Table B.1. Data definitions and sources

Variable	Description	Data Source
US and G-6		
Output	Real Gross Domestic Product by Expenditure in Constant Prices,Gross Domestic Product, National Currency, Seasonally adjusted	Federal Reserve Economic Data
Government Expenditures	Government Final Consumption Expenditures and Gross Investment in Constant Prices, Seasonally adjusted, National currency	Federal Reserve Economic Data
GDP Deflator	Gross Domestic Product: Implicit Price Deflator, Index, Seasonally adjusted	Federal Reserve Economic Data
Interest rate	Immediate Rates: Less than 24 Hours: Call Money/Interbank Rate	Federal Reserve Economic Data
Import prices	Nominal Imports of Goods and Services / Real Imports of Goods and Services (in 2010 prices)	Federal Reserve Economic Data
Medium term rates	3-Month or 90-day Rates and Yields: Interbank rates	Federal Reserve Economic Data
Exchange rate	US Dollar to National Currency Spot Exchange Rate	Federal Reserve Economic Data
Jamaica		
Output	Total Value Added at Basic Prices	Statistical Institute of Jamaica
Government Expenditures	Total Government Revenue - Total Government Budget Surplus	Statistical Institute of Jamaica
GDP Deflator	Gross Domestic Product: Implicit Price Deflator, Index, Seasonally adjusted	Bank of Jamaica
Import prices	Index, 2006=1	Bank of Jamaica
Medium term rates	3-Month or 90-day Rates and Yields: Interbank rates	Federal Reserve Economic Data
Exchange rate	US Dollar to National Currency Spot Exchange Rate, Sales rate	Bank of Jamaica

Table B.2. Posterior estimates and prior distributions of structural parameters

	Prior Densities	Posterior Means: Jamaica	US	G-6
λ	B (0.7, 0.1)	0.98	0.99	0.98
σ_l	N (2, 0.75)	1.78	2.37	1.96
ψ	B (0.5, 0.2)	0.14	0.64	0.24
φ	N (4, 1.5)	4.21	6.23	2.76
ι_h	B (0.5, 0.15)	0.51	0.57	0.48
ι_f	B (0.5, 0.15)	0.57	0.51	0.56
ι_w	B (0.5, 0.15)	0.05	0.16	0.03
ξ_h	B (0.5, 0.1)	0.59	0.81	0.57
ξ_f	B (0.5, 0.1)	0.51	0.64	0.55
ξ_w	B (0.5, 0.1)	0.93	0.73	0.93
λ_c	G (1, 0.2)	4.85	0.06	5.29
λ_i	G (0.25, 0.2)	0.19	0.19	0.23
ρ	N (0.75, 0.1)	0.90	0.81	0.96
r_π	N (1.5, 0.25)	1.13	1.37	1.26
r_y	N (0.25, 0.12)	0.07	0.15	0.02
$r_{\Delta y}$	N (0.25, 0.12)	0.68	0.45	0.63

Note: The table reports the posterior mean estimates and prior distributions of the structural parameters. N, B, and G are the Normal, Beta, and Gamma and distributions.

Table B.3. Posterior estimates and prior distributions of shock process parameters

	Prior Density	Posterior mean values of shock parameters			
		Jamaica	US	G-6	Common
Persistence parameters					
government exp.	B (0.5, 0.2)	0.69	0.89	0.54	
interest rate	B (0.5, 0.2)	0.45	0.40	0.41	0.68
price, domestic	B (0.5, 0.2)	0.24	0.40	0.19	
price, foreign	B (0.5, 0.2)	0.71	0.74	0.81	
credit spread	B (0.5, 0.2)	0.22	0.18	0.37	0.59
depreciation	B (0.5, 0.2)	0.19	0.98		0.33
Shock standard deviations					
government exp.	IG (0.5%, inf)	0.048	0.003	0.025	
interest rate	IG (0.5%, inf)	0.004	0.004	0.003	0.082
price, domestic	IG (0.5%, inf)	0.003	0.001	0.001	
price, foreign	IG (0.5%, inf)	0.007	0.003	0.003	
credit spread	IG (0.5%, inf)	0.177	0.187	0.127	0.002
depreciation	IG (0.5%, inf)	0.105	0.003		0.082

Notes: The table displays the posterior mean estimates and the prior distributions of shock process parameters. IG and B denote inverse gamma and beta distributions.