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Real Exchange Rate and Economic Activity in Jamaica

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Abstract

This paper uses Bayesian VAR Analysis to empirically evaluate the relationship between the deviations of the real effective exchange rate from its equilibrium and Jamaica's GDP (and its components) over the period 1998 to 2020. The paper finds that an appreciation in the real exchange rate is generally associated with a fall in Jamaica's GDP, but the impact is small. The change in GDP is unambiguously reflected in real spending on net exports. The paper also finds that the tourism industry is resilient to losses in competitiveness, which may reflect the impact of factors that are not captured in our model.

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1.0. Introduction

Achieving sustainable economic growth and improving the livelihood of Jamaicans has been a principal objective of the Jamaican Government. One of the ways the Government has tried to achieve this objective is by enhancing the country's international trade competitiveness. The choice of exchange rate regime and the impact of changes in the real exchange rate is seen as macro-critical for a small open economy such as Jamaica, as it should affect the growth in the country's gross domestic product (GDP).

Between the first quarter of 1998 and the fourth quarter of 2020, there has been a sustained depreciation in Jamaica's nominal exchange rate with respect to the United States Dollar (USD). However, the real exchange rate generally appreciated between 1998 and 2009 as the inflation differential (US/Jamaica) outstripped the pace of depreciation in the nominal exchange rate. In the context of a series of IMF-supported economic reform programmes, the real exchange rate however depreciated, on average, between 2010 and 2020. Despite this, Jamaica's GDP growth has remained low, reflecting the combined effect of structural factors as well as a number of domestic and international shocks.

While a number of studies in the past have examined the impact of the Real Effective Exchange Rate (REER) on selected macroeconomic accounts, there remains a lack of consensus on how the exchange rate impacts economic growth in Jamaica. These observations highlight the need for an examination of the contribution of the real exchange rate to Jamaica's growth dynamics, an important issue in the debate about the choice of the country's exchange rate regime.

This paper uses a Bayesian Vector Autoregressive (BVAR) model to assess the impact of changes in the REER on GDP growth in Jamaica. The primary focus is to provide a detailed assessment of the impact of the REER on GDP and on the components of aggregate spending. Specifically, the paper assesses the relationship between the REER and real consumption, investment, exports (of goods and services) and imports (of goods and services) expenditure, along with selected components of imports and exports. This is intended to provide a detailed map to policymakers and other stakeholders in support of work to improve, if necessary, the efficacy of changes in relative prices.

The paper finds that while a loss (gain) in competitiveness leads to a fall (increase) in GDP in Jamaica, the effects are small. A one per cent real appreciation of the REER causes overall GDP to fall by as much as 0.02 per cent after two and half years. The decline in GDP is unambiguously reflected in decreases in real spending on imports and exports and, consequently, in a reduction in real net exports. This suggests that the real depreciation in the real effective exchange rate over the past 10 years has weakly supported economic activity and cannot be ruled out as a component of a strategy to support GDP growth. The paper also finds that tourism value added increases in response to a loss in competitiveness, which may reflect the impact of factors that have not been captured in our model.

The remainder of this paper is structured as follows. Section 2 provides a review of the relevant and recent literature on the topic. Section 3 provides some stylized facts while section 4 outlines the methodology and data to examine the effects of the REER on economic activity in Jamaica. Section 5 presents the findings of the analysis and section 6 concludes.

2.0. Literature Review

The implications of real exchange rates for the Jamaican economy are not well understood. The standard theoretical representation of the real exchange rate (RER) is the ratio of the price of non-tradable (P_n) to tradable (P_t) goods ($RER = \frac{P_n}{P_t}$), which represents relative profit (in the case of producers) or relative utilities (in the case of consumers) between the non-tradable and the tradable sectors. Changes in this relative price are signals to adjust resource or consumption allocation between the two class of commodities.

There is no perfect empirical measure of the RER and economists and policymakers often rely on the real effective exchange rate (REER) as an approximation. For this assessment, our definition of the REER follows that used by the Bank of Jamaica and is as follows:

$$Z = \left(\frac{S^d}{S^f}\right)\left(\frac{P^d}{P^f}\right)$$

where Z is the REER, P^d is domestic consumer price index (CPI), P^f is the foreign CPI, S^d is the domestic exchange rate and S^f is the foreign domestic exchange rate. Here, $P^f = e^{\left(\sum_{i=1}^{17}(lnP_i w_i)\right)}$

and $S^f = e^{(\sum_{i=1}^{17}(lnS_i\, w_i))}$; and w_i is the weight of country i and ln is the natural logarithm.[2] A decrease (increase) in the REER represents a gain (loss) in competitiveness, relative to Jamaica's trading partners.

The relationship between the REER and GDP has been examined both theoretically and empirically in the literature (see Alexander (1952), Ribeiro et al. (2020) and Bahmani-Oskooee & Xi (2011)) using a range of methods (vector auto-regressive (VAR) models, structural VAR (SVARs), general methods of moments (GMMs), error correction models (ECMs) and auto-regressive distributed lag (ARDL) models). There, however, remains a lack of consensus on how the exchange rate impacts economic growth.

The theoretical relationship between the REER and consumption and investment is ambiguous. Alexander (1952) suggested that if wages do not adjust fully to the inflationary effects of a real depreciation, income will be redistributed from workers to producers. With the real depreciation, workers would therefore reduce their consumption and producers would consume more. While Bahmani-Oskooee and Dan Xi (2012) and Bahmani-Oskooee et al. (2015) suggest that there could be a fall in consumption because workers tend to have a higher marginal propensity to consume than producers, this effect could be ambiguous if workers' consumption is buffered by additional non-labour income such as remittances. Bahmani-Oskooee and Hajilee (2010) showed that the effect on aggregate consumption could be based on the composition of low-skilled (or low-earning) vs high-skilled (or high-earning) workers where depreciation reduces the wages of low-skilled workers but increases the wages of high-skilled workers. For investments, higher profits incentivize more investment spending by firms. However, this will depend on the origin of the inputs as, where a project is funded from domestic sources, a real depreciation raises the cost of all inputs and reduces profits. The effect of the REER on investment then hinges on which of the effects dominate.[3]

Real exchange rate depreciation in principle makes foreign goods (or imports) more expensive relative to domestic goods, thereby generating the incentive for increases in domestic consumption

[2] The calculation of Jamaica's REER takes into consideration the relative exchange rates and prices of the top 17 trading partners; the USA being the main partner, which accounts for more than 50 per cent of trade.

[3] On the one hand, wages do not fully adjust to the inflationary pressures of currency depreciation and real income is shifted from workers to producers in the form of profits. This increase in profit serves as an incentive for producers to engage in greater investment. However, on the other hand, depreciation raises the cost of imported inputs, which may reduce producers' profits and by extension lower investment.

and growth in net exports. Theory however predicts that the effect of changes in the REER on the trade balance is ambiguous because of income and substitution effects. In the case of a real depreciation, domestic goods become relatively cheaper, which induces greater (lesser) demand for exports (imports). As indicated by Iossifov & Fei (2019), exports and imports depend on foreign and domestic income, respectively. The trade balance will improve in the context of a currency depreciation if, as per the Marshall-Lerner condition, the substitution effect dominates the income effect, leading to the sum of the elasticities being greater than unity.

Empirical studies on the impact of REER depreciation on GDP appear to support the prediction that real depreciation drives growth but, for developing countries, the impact is small (Ribeiro et al. (2020), Tarawalie (2010) and Alege & Okodua (2014)). Ribeiro, et al. (2020) employed a GMM model on a panel of developing countries to examine the relationship between the REER and economic growth and found that, when a country depreciates its currency in real terms by 10 per cent, economic growth increases by approximately 0.0065 percentage point. The latter two studies found that a depreciation in the REER leads to an increase in economic growth.

The empirical literature has, however, revealed competing findings for the impact of the REER on the expenditure components of GDP (Bahmani-Oskooee & Xi (2011, 2012), Iyke & Ho (2018), and Stucka (2004)). Bahmani-Oskooee & Xi (2012) utilized a panel dataset and found that exchange rate volatility had heterogeneous short-run and long-run effects. Their analysis found that an exchange rate depreciation *increased* consumption for Japan. In contrast, Iyke & Ho (2018) found negative short-run and long-run effects of the REER on consumption for Ghana. Stucka (2004) found a long-run relationship between the exchange rate and the trade balance for Croatia where a one (1) per cent depreciation led to an improvement in the trade balance between 0.94 per cent and 1.3 per cent after 2.5 years.[4] Iossifov & Fei (2019) estimated the long-run trade elasticities of exports and imports with respect to the real exchange rate in Turkey before and after the financial crisis of 2008. They found that, prior to the financial crisis, an appreciation of the REER led to an increase in real exports but did not have a significant effect on imports.[5] After including post-crisis data, REER depreciation contributed to a narrowing of the trade balance but its impact was lower than in the pre-financial crisis years.

[4] Accounting for the J-curve effect, the trade deficit of Croatia was estimated to improve between 2.0 and 3.3 per cent.
[5] The authors did not provide an explanation for the reason why net exports increased with an appreciation of the REER.

For Jamaica, a few studies have examined the impact of the REER on the macroeconomy. Henry & Longmore (2003) examined the nexus between current account dynamics and the REER in Jamaica. The study indicated that Jamaica's REER was not instrumental in determining key aspects of the current account. Franklin (2010) analysed the relationship between the REER and current account imbalances for Jamaica, with a view to determining the proportion of the Jamaican current account imbalance that can be corrected with a REER adjustment. The results showed that temporary shocks played a larger role in explaining the variation in the REER, while permanent shocks played a greater role in the explanation of the Jamaican current account. Further, the results highlighted that only a negligible portion of the current account imbalance could be corrected through a REER depreciation. A notable gap in these analyses is, however, an evaluation of the impact of the REER on Jamaica's GDP and on the spending components on GDP, one that this study addresses.

3.0 Stylized Facts

The real exchange rate for Jamaica remained broadly unchanged over the period 1998 to 2020, depreciating on average each year by 0.3 per cent (see Figure 1a, Appendix). For this period, real GDP growth averaged an annual rate of 0.7 per cent.

The REER displayed volatility between 1998 and 2013 before settling, to some extent, towards the latter part of the sample period. There was a general depreciation in the REER between 1998 and 2007 due to the depreciation of the Jamaican Dollar against the US dollar in a context where the currencies of Jamaica's main trading partners appreciated against the US dollar. Between 2008 and 2013, the real exchange rate largely exhibited an appreciating trend as the inflation differential (US/Jamaica) outstripped the pace of depreciation in the nominal exchange rate.

Prior to 2013, the Jamaican dollar was generally overvalued in the context of large and unsustainable external and fiscal deficits. For example, in 2011, prior to the formal start of the Government's economic reform programme, the current account deficit peaked at 13.0 per cent of GDP while the fiscal deficit reached a maximum of 12 per cent of GDP two years prior. Real GDP grew at a slower pace following the 2008/09 financial crisis (0.3%), relative to the pace of growth between 1999 and 2007 (1.3%) (prior to the crisis). It is in this context that the IMF advanced a

package of measures to promote growth, including structural reforms as well as greater exchange rate flexibility.

In the context of a series of IMF support economic reform programmes, the real exchange rate depreciated, on average by 6.4 per cent, between 2010 and 2020. Despite the adjustment in the real exchange rate over this period, however, Jamaica's GDP growth remained low.

There appeared to be a weak but appropriate relationship between GDP and the REER over the full sample period as evident in a small correlation coefficient between the two of -0.1.[6] The small size of the correlation appears to have been influenced by shocks to the economy caused either by adverse weather or other external events. Examples of the former include the May 2002 flood rains, hurricanes Ivan, Dean, Gustav and Sandy in 2004, 2007, 2008 and 2012, respectively, which compressed growth and occasioned increases in inflation.[7] The most pronounced external shock to have affected growth was the global financial crisis of 2008. Further, unsustainable fiscal and balance of payments accounts, as well as a high interest rate environment, served to dampen economy activity over the period prior to the global financial crisis. Notably, the relationship between the REER and consumption spending mirrors that of GDP over the sample period (see Figure 1b, Appendix).

The relationship between investment spending and the REER is somewhat difficult to discern due to the high level of volatility of investment spending over the sample period (see Figure 1c, Appendix). Between 2005 and 2007, at the time the REER was appreciating, there were significant investment in hotel properties as well as the Government's road infrastructure development project through Highway 2000.[8] Significant retrenchment in investment spending occurred between 2008 and 2010, concurrent with the appreciating REER, but more fuelled by the global financial crisis. The crisis also dampened public sector capital projects against the background of the Government's fiscal constraints. This volatility in investment nonetheless occasioned a correlation coefficient of -0.03 with the REER. The relationship between investment and the REER appeared

[6] Correlation calculated using 1 period lag for spending components.
[7] See BOJ Annual Reports for respective years.
[8] Among the hotels constructed and completed during the period are Sandals Whitehouse, Bahia Principe Hotels and capacity expansion at Couples Resort.

to have improved toward the end of the period as evident by a larger correlation coefficient of -0.3, as the economy underwent a period of economic transformation.

There also appears to be a weak and surprising negative correlation of 0.1 between the real imports of goods and services and the real exchange rate over the sample period. This unexpected correlation was influenced largely by the global financial crisis of 2008, which occasioned a large fall in imports, notwithstanding the appreciation of the REER (see Figure 1d, Appendix). However, when the sample period was partitioned, the relationship between the REER and real imports prior to the financial crisis was very positive, driven largely by increases in consumer goods imports. However, towards the end of the sample the negative association was occasioned by increases in consumer goods imports, notwithstanding the general depreciation in the REER. For export spending, its relationship between the REER mirrored that of GDP.

These observations point to the need to more formally evaluate the hypothesis that the real exchange rate matters for GDP growth in Jamaica.

4.0 Methodology

One popular technique for conducting macroeconomic analyses and forecasting with feedback effects is the vector autoregressive (VAR) model introduced by Sims (1980, 1992). While VAR models are useful, they suffer from lag length selection problems and overfitting, which leads to large standard errors and imprecise estimates (Lopreite & Zhu (2020)). Given these issues, VAR-derived inferences may not be accurate. To overcome some of the shortcomings of the VAR model, researchers have utilized a non-frequentist version of the VAR model, known as the Bayesian methods, to overcome the issues of overfitting and poor forecasting (Lopreite & Zhu (2020)). The BVAR model does this by parameter shrinking which leads to better dynamic analyses and inference (Koop & Korobilis, 2010).

Accordingly, this paper uses the BVAR method to analyse the effect of the REER on GDP and the expenditure components of GDP. The methodology follows closely the set up outlined by Ciccarelli & Rebucci (2003). Starting with a standard VAR model, specified as follows:

$$Y_t = \beta_1 Y_{t-1} + \cdots + \beta_p Y_{t-p} + Dz_t + \varepsilon_t \quad (1)$$

where Y_t is a $n \times 1$ vector of endogenous variables, β_i $(i = 1, \dots, p)$ and D are $n \times n$ and $n \times d$ matrices of parameters respectively, z_t is a vector of exogenous variables, p is the optimal lag length and ε_t is an independent and identically distributed variance-covariance matrix Σ $(\varepsilon_t \sim IID(0, \Sigma))$. Ciccarelli & Rebucci (2003) note that uncertainty "over the exact value of the model's parameters" can be reflected as the "probability distribution for the parameter vector". The Bayesian VAR method therefore requires calibrating the *prior* information such that it is not too vague or non-informative and the model's parameters are driven by signals rather than noise.

In specifying the Bayesian model, the standard VAR (1) can be written in a general form such as:

$$Y_t = X_t\beta + \varepsilon_t \qquad (t = 1, \dots, T) \qquad (2)$$

where $X_t = (I_t \otimes W_t)$ is $n \times nk$, $W_t = (Y'_{t-1} + \cdots + Y'_{t-p}, z'_t)'$ is $k \times 1$ and $\beta_t = vec(\beta_1, \dots, \beta_p, D)$ is $nk \times 1$. The parameters β and ε are unknown in this model and $\otimes$ is the Kronecker product. Given the probability density function (*pdf*) of the data conditional on the parameters (the information in the data in the form of likelihood function):

$$L(Y|\,\beta, \Sigma) \propto |\Sigma|^{-\frac{1T}{2}} exp\left\{-\frac{1}{2}\sum(Y_t - X\beta_t)'\,\Sigma^{-1}(Y_t - X\beta_t)\right\} \qquad (3),$$

and a joint prior distribution on the parameters, $p(\beta, \Sigma)$, the joint posterior distribution of the parameters conditional on the data is obtained by Bayes' rule:

$$p(\beta, \Sigma|\mathrm{Y}) = \frac{p(\beta,\Sigma)\,L(Y|\,\beta,\Sigma)}{p(Y)} \propto p(\beta, \Sigma)L(Y|\,\beta, \Sigma).$$

Considering the definition of the conditional probability, the joint *pdf* of the data and parameters $p(\beta, \Sigma, \mathrm{Y})$ can be specified as

$$p(\beta, \Sigma, \mathrm{Y}) = L(Y|\,\beta, \Sigma)\,p(\beta, \Sigma) = p(\beta, \Sigma|\mathrm{Y})p(Y)$$

Given $p(\beta, \Sigma, |\mathrm{Y})$ the marginal posterior distributions conditional on the data, $p(\,\Sigma|\mathrm{Y})$ and $p(\beta|Y)$ can be obtained by integrating out β and Σ from $p(\beta, \Sigma|\mathrm{Y})$. As noted by Ciccarelli & Rebucci

(2003) the location and dispersion of $p(\Sigma|Y)$ and $p(\beta|Y)$ can be analyzed to find point estimates of the parameters of interest and measures of precision relative to those obtained from the classical VAR.

As indicated above, a key component of the BVAR model is the use of *priors*. To get the best Bayesian inference it is crucial to choose the appropriate prior since if it is "loose" the likelihood of overfitting increases but if it is too constrained then the "data is not allowed to speak" (Lopreite & Zhu (2020)). Overall, it is important to compare the forecasting performance of the prior and choose the optimal prior, which has the smallest root mean square error (RSME).

The Litterman-Minnesota Prior for β is a prior normal distribution conditional upon the variance-covariance matrix Σ_ε. The assumption is made that the prior means of β are the same given the hyperparameter value of ε being set close to zero and the variance-covariance being non-zero. For this prior, the assumption is that Σ is unknown and is replaced by an estimate $\hat{\Sigma}$. For ease of understanding this prior, consider that the problem is to estimate a $k \times 1$ vector, β_i containing the parameters of the i^{th} equation in (2) when the variance of the error term $\sigma_{i,i}^2$ is known. Following Litterman (1980, 1986) it stands that:

$$p(\beta_i) = N(\bar{\beta}_i, \bar{\Omega}_i)$$

where $\bar{\beta}_i$ and $\bar{\Omega}_i$ denote the prior mean and variance-covariance matrix of β_i respectively. The residual variance-covariance matrix, Σ, under this prior is assumed to be fixed and diagonal, $\sigma_{i,i}^2 I_T$. By stacking the time observation of the i^{th} equation, (2) can be written as

$$Y_i = X\beta_i + \varepsilon_i \qquad (i = 1, \dots, n)$$

where Y_i and ε_i are $T \times 1$ vectors and X is the stacked version of X_t in (2).

Since the error terms are assumed to be independent, the likelihood function of (3) are the product of independent normal densities as follows:

$$L(Y|\beta, \Sigma) \propto \left|\sigma_{i,i}^2\right|^{-\frac{T}{2}} exp\left\{-\frac{1}{2\sigma_{i,i}^2} \sum (Y_i - X\beta_i)' \Sigma^{-1} (Y_i - X\beta_i)\right\} \qquad \text{(A1).}$$

The posterior distribution of the parameters of interest are given by:

$$p(\beta_i|Y) = p(\beta_i)pL(Y|\beta, \sigma_{i,i}^2)$$

and is proportional to:

$$\left|\sigma_{i,i}^2\right|^{-\frac{T}{2}} |\overline{\Omega}_i|^{-\frac{T}{2}} exp\left\{-\frac{1}{2}\left[\left(\beta_i - \bar{\beta}_i\right)' \overline{\Omega}_i{}^{-1} \left(\beta_i - \bar{\beta}_i\right) + \frac{1}{\sigma_{i,i}^2}(Y_i - X\beta_i)' (Y_i - X\beta_i)\right]\right\}$$

$$\propto exp\left\{-\frac{1}{2}\left[\left(\frac{1}{\sigma_{i,i}^2}(Y_i'Y_i - 2\, Y_i'X\beta_i + \beta_i'X'X\beta_i) + \beta_i'\overline{\Omega}_i{}^{-1}\beta_i - 2\,\bar{\beta}_i'\,\overline{\Omega}_i{}^{-1}\beta_i + \bar{\beta}_i'\,\overline{\Omega}_i{}^{-1}\bar{\beta}_i\right)\right]\right\}$$

$$\propto exp\left\{-\frac{1}{2}\left[\left(\beta_i'\left(\frac{1}{\sigma_{i,i}^2}X'X + \overline{\Omega}_i{}^{-1}\right)\beta_i - 2\left(\frac{1}{\sigma_{i,i}^2}X'Y + \overline{\Omega}_i{}^{-1}\bar{\beta}\right)'\beta_i\right)\right]\right\}$$

With respect to the integration for β_i, both $\left|\sigma_{i,i}^2\right|^{-\frac{T}{2}}$ and $|\overline{\Omega}_i|^{-\frac{T}{2}}$ are constants in the first proportionality statement above, while $Y_i'Y_i$ and $\bar{\beta}_i'\,\overline{\Omega}_i{}^{-1}\bar{\beta}_i$ are constants in the second proportionality statement. Completing the square gives the following solution:

$$p(\beta_i|Y) \propto exp\left\{-\frac{1}{2}\left[\left(\beta_i' - \overline{\Omega}_i{}^{-1}\bar{\beta}_i\right)'\overline{\Omega}_i{}^{-1}\left(\beta_i' - \overline{\Omega}_i{}^{-1}\bar{\beta}_i\right)\right]\right\}$$

with

$$\tilde{\beta}_i = \widetilde{\Omega}_i\left(\overline{\Omega}_i{}^{-1}\beta_i + \sigma_{i,i}^{-2}X'Y_i\right)$$

and

$$\widetilde{\Omega}_i = \left(\overline{\Omega}_i{}^{-1} + \sigma_{i,i}^{-2}X'X\right)^{-1}$$

That is, $p(\beta_i|Y) = N(\tilde{\beta}_i, \widetilde{\Omega}_i)$ where once $\overline{\Omega}_i{}^{-1}$, β_i, and $\sigma_{i,i}^{-2}$ are known, $\tilde{\beta}_i$ can be used as a point estimate.

As suggested by Ciccarelli and Rebucci (2003) there are four considerations to note for the Litterman-Minnesota Prior. First, based on the assumptions, there is "prior and posterior independence between the equations" which necessitates each equation to be estimated separately. The second is that Σ is a diagonal and fixed matrix where the diagonal elements are obtained from the estimation of a set of autoregressive models. The third is that the parameters, $\bar{\beta}_i$ and $\widetilde{\Omega}_i$ are unknown and specified in terms of few hyperparameters. Fourth, by assuming an infinite dispersion of the prior distribution around its mean, it means that $\overline{\Omega}_i^{-1} = 0$. That is, the posterior mean of β_i becomes $\tilde{\beta}_i = (X'X)^{-1} X'Y_i$, which is the OLS estimator of $\tilde{\beta}_i$.

Litterman (1986) assigned numerical values to the hyperparameters of the model on the presumption that macroeconomic series are represented well by random walk processes. In particular, Litterman (1986) assumes that **Π** is a degenerate random variable on the assigned values with the following structure for the diagonal elements of $\overline{\Omega}_i$.

$$var\left(\bar{\beta}_i\right) = \begin{cases} {\pi_6\pi_2}/{l^{\pi_4}} & for\ the\ i^{th}\ lagged\ endogenous\ variable \\ \left({\pi_6\pi_3}/{l^{\pi_4}}\right){\sigma_{i,i}^2}/{\sigma_{j,j}^2} & for\ the\ j^{th}\ lagged\ endogenous\ variable \\ \pi_6\pi_3\sigma_{i,i}^2 & for\ the\ deterministic\ \boldsymbol{a}nd\ exogenous\ variables \end{cases}$$

As denoted in Litterman (1986) the hyperparameters, π_6 controls the overall prior tightness (or uncertainty); π_2 controls the tightness of own lags, while π_3 controls the tightness of own lags relative to the tightness of lags of the other variables in the equation; π_4 controls the lag-decay in the prior variance with $l = 1, \dots, p$ denoting the variable's lags; π_5 controls the degree of uncertainty on the coefficients of the deterministic and/or exogenous variables in equation i, while the factors $\sigma_{i,i}^2$ and $\sigma_{j,j}^2$ measure the scale of fluctuations in variables i and j taking the unit of measure of different variables into account. Finally, the mean vector is specified as $\bar{\beta}_i = (0, \dots, 0, \pi_1, 0, \dots, 0)$ where π_1 is in the i^{th} position and represents the prior mean of coefficient on the first lag of the endogenous variable in equation i.

There are typically two steps taken before estimating a Bayesian VAR model. The first is to define the nature of Σ_ε with an estimate $\hat{\Sigma}_\varepsilon$. This is done by selecting one of three options: (i) Using the

estimate of the residual from an AR (1) model for each series; (ii) assuming that the variance-covariance matrix is diagonal, and all coefficients are set to zero; and (iii) using a standard VAR model to estimate Σ_{ε}.

The second step is to determine the values of the hyperparameters as outlined under the Litterman-Minnesota Prior, which means selecting the parameters that evaluate the true objective function.[9] These are usually $\lambda_1, \lambda_2, \lambda_3$, and λ_4 in the modern Bayesian methods literature. The first, λ_1 indicates the importance of sample and prior information – as λ_1 gets larger the prior is less informative and the estimate is similar to that of an unrestricted VAR (Lopreite & Zhu, 2020). This value is usually greater than zero and indicates the tightness of the random walk specification. As λ_1 goes to zero, the diagonal elements of the coefficient matrix for the first lag tends to one and all others tends to zero. The second, λ_2, determines importance for lags of variables. That is, how much does each variable's lag contribute to the variable's variation and how much does other variable's lag contribute to its variation. This hyperparameter ranges between zero and one, where a value of one implies equal contribution of each variable's lagged values and other variable's lagged value to its variation. The third, λ_3, relates to the importance of information contained in the exogenous variables for example, the constant. By imposing a value greater than zero for λ_3 the estimation is taking the information of cross variable lags and the exogenous variables as important. The fourth, λ_4, represents the lag decays where a value of one implies linear decay while a value less than one but greater than zero can take a harmonic or geometric decay (Lopreite & Zhu, 2020). Increasing the value of λ_4 shrinks the coefficients of higher order lags to zero by facilitating the parameters of these lags to vary less around the conditional mean of zero. The Bayesian VAR estimation priors are also complimented with (i) a sum-of-coefficients prior that adds observations to the start of the data to account for unit root issues, (ii) dummy-initial-observation prior which adds observation to account for cointegration, and (iii) a dummy-observation prior to increase the predictive power of the model.

[9] For the Minnesota prior there are 4 set of (residual) priors ($\lambda_1, \lambda_2, \lambda_3$, and λ_4). The first is set at (0.1) based on the belief that both prior and the information contained in the data should influence the estimation and which is consistent with the literature. The second hyperparameters has to do with the cross-variable lags. This was set to 0.99 indicating relatively equal influence of lags of equation k and equation m. The third is for the exogenous variable which is set to infinite "inf" indicating exogenous variables are important for the estimation. The fourth is lag decay which is set to 1 indicating linear decay. There is also an AR (1) coefficient prior, μ_1, which is set to 0 to indicate that the variables are entered in differences.

5.0 Models & Data[10]

In this paper, the BVAR is used to estimate 15 models. The data used in the models are listed in Table 1 (Appendix) while table 2 below provides a stylized depiction of the estimated models.[11] In addition to real GDP, the paper explores the impact of the REER on two alternative views of GDP (i.e. GDP without the Mining & Quarrying industry and Value Added for the tourism industry, proxied by the Hotel & Restaurants industry (Tourism GDP)). There is a view that tourism and mining in Jamaica are predominantly influenced by factors external to Jamaica. In this context, the analysis seeks to uncover whether the impact of the REER on these industries is different from other economic activities.

Table 2: Models

Models	Lags	MISREER	RR	Remit	LFPC	GDP	US GDP	TOT	Pindex
					Variables				
Model 1: GDP	4	(-)	(-)	(+)	(+/-)		(+)	(+)	(+)
Model 2: Non-Mining GDP	1	(-)	(-)	(+)	(+/-)		(+)	(+)	(+)
Model 3: Tourism GDP	1	(+/-)	(-)				(+)	(+)	(+)
Model 4: Consumption	4	(+)	(-)	(+)		(+)		(+)	(+)
Model 5: Investment	1	(+/-)	(-)					(+)	(+)
Model 6: Exports	1	(-)	(-)				(+)	(-)	(+)
Model 7: Imports	1	(+)	(-)	(+)		(+)		(+)	
Model 8: Net Exports	1	(+/-)	(+/-)				(+)	(+/-)	
Model 9: Consumer Goods	1	(+)	(-)	(+)		(+)		(+)	
Model 10: Raw Materials Goods	1	(+)	(-)			(+)		(+)	
Model 11: Capital Goods Imports	1	(+)	(-)			(+)		(+)	
Model 12: Fuel Imports	1	(+)	(-)	(+)		(+)		(+)	
Model 13: Exports of Goods	1	(-)	(-)				(+)	(-)	(+)
Model 14: Imports of Goods	4	(+)	(-)	(+)		(+)		(+)	
Model 15: Net Exports of Goods	1	(+/-)	(+/-)				(+)	(+/-)	

The models in this paper are specified as demand functions in which spending is a function of relative prices (real interest rates and the real exchange rate) and income (domestic GDP and foreign GDP). Given that most of Jamaica's exports are purchased by the USA, US GDP is used as a proxy for external income. The inclusion of the labour force is premised on the view that it is

[10] Issues relating to the compilation of the spending components of GDP are discussed in Appendix 2.

[11] The dependent variables are real GDP, real non-mining GDP, real non-tourism GDP, real consumption spending, real investment spending (gross capital formation), real exports spending, real imports spending and real net exports. For the data from the Balance of Payments, the dependent variables are real raw materials imports, consumer goods imports, capital goods imports, fuel imports, non-fuel imports, import of goods and export of goods. All the variables are deflated by their price indices and therefore are in real terms. The other independent variables are real interest rates (measured as 90-day Treasury bill rates minus inflation rate), real US GDP, remittances, population, terms of trade and labour force per capita (LFPC).

an important factor in the production process. Further, to account for other price factors, the terms of trades index (TOT) is included in all models. The models account for non-price factors by the inclusion of dummy variables to capture the global financial crisis and the Covid-19 pandemic, along with a political stability and absence of violence/terrorism index (Pindex) (See Figure 2 (Appendix)).[12,13] For the models of consumption (including consumer goods imports), the inclusion of remittances is important as Amuedo-Dorantes & Pozo (2006) and Combes & Ebeke (2011) have shown that it increases income as well as reduces income and consumption volatility.

The paper utilizes three measures of REER misalignment. The first (MISREER1) is calculated as the difference between the REER and its constant, long-run equilibrium. The second measure (MISREER2) is calculated as the deviation of the REER from its long-run equilibrium, where the long-run equilibrium is estimated using a Hodrick-Prescott (HP) filter. The third measure (MISREER3) is calculated as the difference between the REER and the Behavioural Equilibrium Exchange Rate (BEER), which is a measure of equilibrium REER that considers the economic fundamentals that are consistent with internal and external macroeconomic balances. In all these measures, deviations of the REER above (below) its equilibrium indicate overvaluation (undervaluation) of the exchange rate.

Following Clark & MacDonald (1994), Iimi (2006), Robinson (2010), Lebdaoui (2013), Comunale (2017), and Heriqbaldi et al. (2020), the standard determinants of the REER used in the paper are government spending, terms of trade, productivity and net foreign assets to GDP.[14] The BEER is

[12] The index appears to capture periods of social and economic instability. The index fell at the end of 2000 and remained negative between 2001 and 2011. The main cause for the negative index between 2001 and 2002 was the political instability in the country due to the upcoming elections in 2002. There also a decline in the index in 2010 in the context of civil unrest associated with the search for and capture of a major drug dealer. The index began to improve mid-2011 and remained positive for the remaining periods consistent with the period when the Government embarked on an economic reform programme which was supported by the IMF.

[13] Taken from the World Bank Governance Indicator database. This index is scored in units of normal distribution where values range from −2.5 to 2.5, with a higher value indicating an improvement in a country's governance. That is, the mean governance is set to zero and each positive (negative) score for a country means better (worse) governance than the average country.

[14] In most writings it is taken for granted that the rise of per-capita GDP leads to an appreciation of the real exchange rate. The explanation is twofold. From a demand perspective, an increase in relative wealth should lead to stronger demand for domestic non-traded goods and hence to an increase in their relative price. The supply perspective is based on the widely known Balassa-Samuelson effect (Lee et al., 2013; Zhang, 2017). Another popular explanation for long-run trends in equilibrium real exchange rates emphasizes the role of net foreign assets (NFA). The rationale is that a rise in this variable improves the interest income on the current account and should hence be counterbalanced by a deterioration in the trade balance. This, in turn, requires real exchange rate strengthening (Lane and Milesi-Ferretti, 2002). The third most commonly used explanatory variable in BEER regressions is terms of trade (tot). A rise in this fundamental should lead to higher wealth and an improved trade balance, and therefore to real exchange rate strengthening. Government spending was included following from Carrera and Restout (2008), which showed that an increase in government spending led to upward pressures on the relative price of non-traded goods and generated an appreciation of the real exchange rate.

determined from a log-linearized reduced form equation which estimates the coefficients associated with these variables as follows:

$$REER_t = \alpha_i + \beta_i' X_t + \varepsilon_t \qquad (4)$$

where $REER_t$ is the log of REER and X_t are the determinants as specified above.

The equilibrium exchange rate is calculated by using the estimated coefficients from a Johansen Cointegration test in equation 4, multiplied by the values of the determinants. These series are filtered using the HP filter, consistent with Comunale (2017) and Robinson (2010) and then combined to obtain the BEER as follows:

$$BEER_t = \widehat{\beta}' X_t^{HP} \qquad (5)$$

The misalignment is then computed as

$$MISREER3_t = \left(\frac{REER - BEER}{BEER}\right) \times 100$$

Why is it important to assess the impact on GDP of changes in the extent of REER misalignment? In a flexible exchange rate system, the equilibrium REER relates to that level that generates external and internal equilibrium (Cassino & Oxley, 2013).[15] The tradable sector (exports and imports) and the non–tradable sector respond to the real exchange rate differently, dependent on the degree of misalignment (Cheung et al., 2007). If a country's real exchange rate is undervalued/overvalued, the cost of a basket of goods produced by that country is lower/higher compared to the cost of the same basket produced by its trading partners, thus promoting export and internal growth/contraction (Auboin & Ruta, 2013). Overvaluation of the REER may also incentivize investors to speculate on the nominal exchange rate, thus promoting behaviour that is

[15] Internal equilibrium exists when the output gap is closed and there are no inflationary pressures in the economy. On the other hand, external equilibrium exists when the current account of the balance of payments is sustainable and the level of international reserves is consistent with the stability of the macroeconomy (Omotosho et al. 2013). The equilibrium exchange rate is affected by many factors, including fiscal policy, changes in technology, structural reforms, interest rates, and inflation.

antithetical to GDP growth. Accordingly, in principle, the degree of misalignment in the REER is an important determinant of the growth.

Our a-priori expectations are therefore that increases in overvaluation (or reductions in undervaluation) (which, for simplicity, we will refer to after this as real appreciation) will cause spending on GDP to fall as domestic goods and services become more expensive relative to Jamaica's main trading partners. For consumption spending, real appreciation is expected to occasion an increase in spending as foreign goods and services becomes cheaper. However, for investment spending, the effect of real appreciation is ambiguous as discussed earlier. Imports (and its components) are likely to increase from real appreciation as goods and services are relatively cheaper while the reverse is expected for exports. However, the impact on the trade balance is unclear as it depends on the magnitudes of the import and export elasticities.

Increases in interest rates (relative prices) are expected to result in a fall in GDP and its spending components. Remittances and foreign GDP (the income variables) are expected to cause GDP and its components to increase. Changes in the labour force per capita is expected to have a positive effect on GDP growth. While it is expected that an increase in the TOT should have a positive impact on GDP, its effect is ambiguous due to the varying nature of elasticities of exports and imports for each economy. An increase in PINDEX is expected to increase GDP.

The paper uses quarterly data from 1998Q1 to 2020Q4 to estimate the impact of the REER on Jamaica's GDP and its main expenditure components. Following unit root testing, all variables enter the models in their stationary form by taking first differences (see Table 3a and 3b, Appendix). In addition, all the variables, with the exception of real interest rates, remittances and labour force per capita are seasonally adjusted.

6.0 Evaluation and Results

Diagnostic checks were conducted for all the models which showed that their errors were largely stable, homoscedastic, uncorrelated and normal (see Tables 4a to 5c, Appendix).[16]

[16] While it varied across specification, serial correlation was present in no more than 6 of the 15 models.

To discriminate among the three class of models, we use root mean square errors (RMSE) as the measure of goodness of fit as well as the results from the diagnostic checks. While MISREER2 has one more model (six in total) with smaller RMSEs than MISREER1, the latter has the better results from the various diagnostic checks (see Table 6, Appendix). MISREER3 has the least models with the lowest RMSEs.

As they relate to the directional responses of GDP and its components to a shock to the REER, the results from the three sets of models are highly consistent as they relate to the general impact on GDP and are fairly consistent with the impact on the various spending and BOP components.[17] A summary of the results is shown in Table 7 (Appendix).

On the basis of this evaluation, the results of MISREER1 are reported as the principal finding of the paper in Figure 3 (Appendix). A one per cent real appreciation causes real GDP growth to reflect cumulative (or maximum) declines of 0.02 per cent per cent after a year and a half. While the magnitude of impact is small it is broadly consistent with the findings from studies on other small open economies (see for example Rodrik (2008)).[18] The main reasons for this generally small impact are weak institutions and the level of a country's development, which collectively tend to discourage the response of the private sector to relative price signals.

The spending channel through which this shock largely works appears to be net export spending, which declines by a maximum of 0.11 per cent by the 2nd quarter following the shock. This response is influenced by real spending on exports of goods and services, which falls by a maximum of 0.15 per cent by the 8th quarter. The response of *goods* exports is also consistent with a priori expectation. A one per cent real appreciation leads to real goods exports falling by a maximum of 0.025 per cent by the 4th quarter (see Figure 4, Appendix). These results confirm a prior expectation that an appreciation makes exports uncompetitive, which incentivises a real reduction in demand from foreign countries. In addition, in the face of a real appreciation, the cost

[17] While MISREER1 and MISREER3 results are consistent, 6 results from MISREER2 are counter to the results of MISREER1 and MISREER2. These differences are shown in net export spending, consumption spending, fuel imports, investment spending, gross exports of goods (BOP) and net export of goods (BOP). Notably, most of these outlier results from MISREER2 go against a priori expectations.

[18] Rodrik (2008) showed that a one per cent undervaluation led to an increase in GDP of 0.01 per cent and 0.02 per cent for Brazil and India, respectively.

of labour rises, relative to firms' revenues, implying that export-related profits fall in the face of the shock.

On the other hand, a REER appreciation causes spending on imports of *goods and services* to fall, which appears counterintuitive. Spending on *goods* imports however responds in the right direction in response to the appreciation, which suggests that the response of overall imports is influence by that of *services* import. A one per cent appreciation leads to a maximum increase in spending on goods imports of 0.15 per cent by the 2nd quarter. In particular, real spending on consumer goods, capital goods, fuel imports and non-fuel raw material imports all increase when the real exchange appreciates (Figure 5, Appendix).

That this increase does not happen in relation to *services* import could mean that the substitution effect associated with an appreciation of the REER outweighs the income effect, such that more local services are demanded relative to foreign services when the relative price of foreign services falls.[19,20]

The temporal response of net exports to changes in the real exchange rate reflects the relative responses of real export and imports in that real spending on exports decline at a faster rate than imports.

For the other components of spending, the results show that the real appreciation induces increases in real consumption spending and investment spending, albeit insufficient to offset the impact on overall GDP from the decline in net export spending. In response to the shock to the REER, real consumption spending increases by 0.035 per cent by the 4th quarter. This response is mirrored in real spending on consumer goods imports, which increases by 0.02 per cent over the same horizon (see Figure 5, Appendix). Real spending on fuel imports also increases in response to the shock

[19] As an example, presume that the appreciation is driven by a reduction in foreign prices which causes real incomes in Jamaica to rise. While this change in relative prices should induce Jamaicans to buy more foreign services, they in fact use the additional income to purchase proportionally more domestic services.

[20] A less profound answer to this puzzle may be found in the quality of data on services imports. While accounting for an average of 16% of GDP over the sample period, services imports do not exhibit significant volatility as is the case for goods imports.

but the data does not allow for a decomposition of fuel imports into consumption and raw material imports.

For investments, the real appreciation increases growth in this category of spending by 0.025 per cent by the 4th quarter (see Figure 6, Appendix). This response is mirrored in the impulses for real spending on capital goods imports, fuel imports, and, to a lesser extent, raw materials imports. In response to the one per cent appreciation, capital goods imports and fuel imports increase by a maximum of 0.17 per cent and 0.08 per cent after a year, respectively. Raw materials imports increase by a maximum of 0.025 per cent over the same horizon. Given that a large proportion of the inputs into production are imported, businesses take advantage of the appreciation and demand more capital - and other operating - inputs.

The impulse responses from the alternative measures of GDP (i.e. GDP without mining, and value added for the tourism industry) are shown in Figure 7 (Appendix). The results show that, in response to the appreciation, the tourism industry grows. This strongly suggests that the industry is resilient in face of the higher cost. This finding may be attributed to greater than normal promotional activities by industry players and the Jamaica Tourist Board during periods of strain, which are geared towards attracting additional visitors to the Islands and are not captured directly in the model. As expected, Non-Mining GDP falls in response to the shock.

7.0 Conclusion

The purpose of this study is to assess the impact of deviations of the REER from its equilibrium path on GDP growth in Jamaica. Specifically, this paper assesses the relationship between misalignments in the REER and real consumption, investment, exports and imports expenditure, along with the components of imports and exports.

The main finding of the paper is that real depreciation has a positive impact on Jamaica's real GDP, but the effect is small. This suggests that the real depreciation over the past 10 years has weakly supported economic activity and cannot be ruled out as a part of a strategy to support GDP growth in the medium term. The impact of movements in the REER on GDP growth appears to work principally through real net export spending, a response that finds support in the behaviour of goods imports and goods exports that causes the trade balance to improve in the face of real

depreciation. Along with maintaining relative price competitiveness, attention to the structural impediments to growth (including access to educational opportunities and crime) will help to deliver faster growth.

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Appendix

Figure 1a: Real Effective Exchange Rate and Real GDP Spending Growth Rate (Annual change)

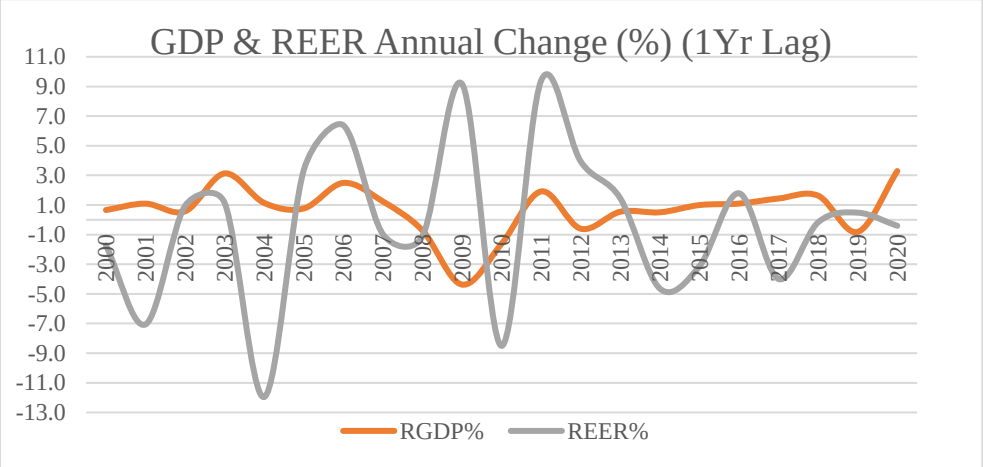


Figure 1b: Real Effective Exchange Rate and Real Consumption Spending Growth Rate (Annual change)

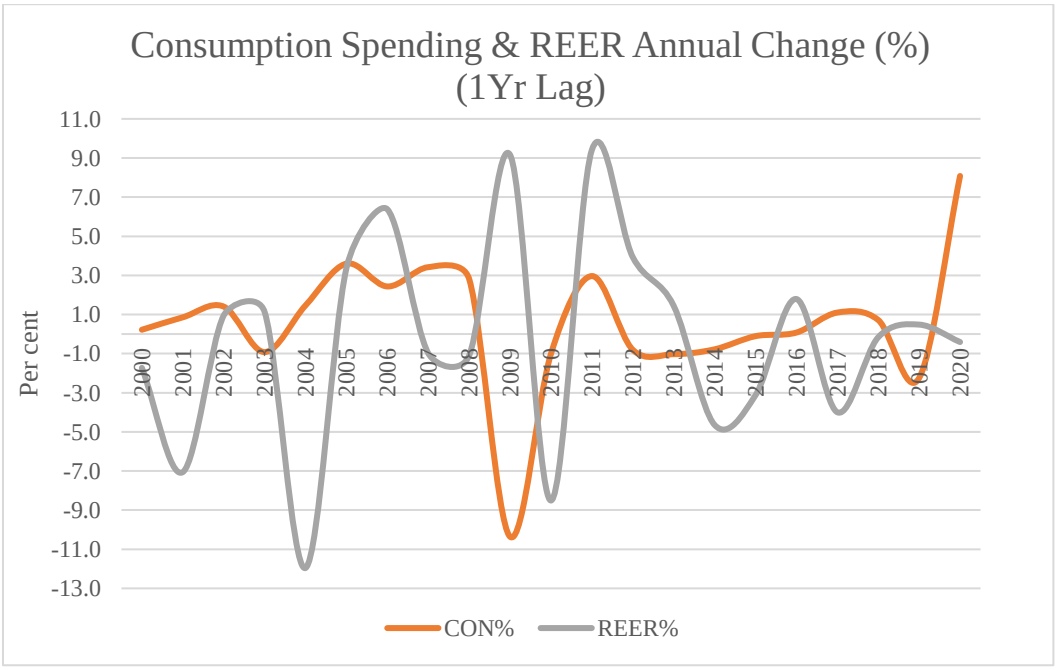


Figure 1c: Real Effective Exchange Rate and Real Investment Spending Growth Rate (Annual change)

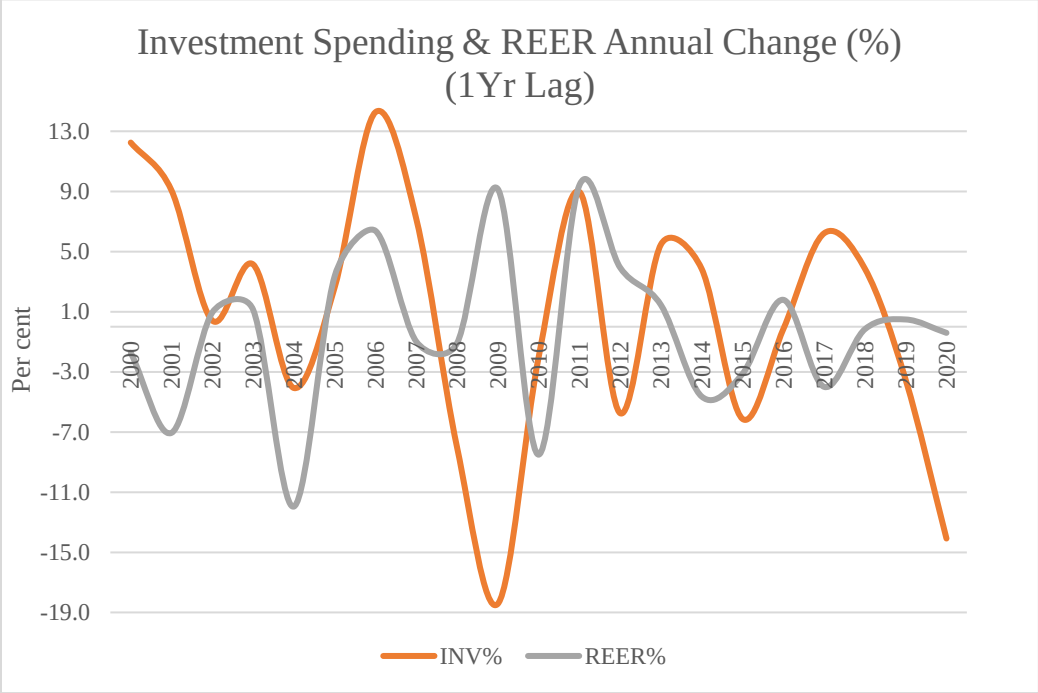


Figure 1d: Real Effective Exchange Rate and Real Imports Spending Growth Rate (Annual change)

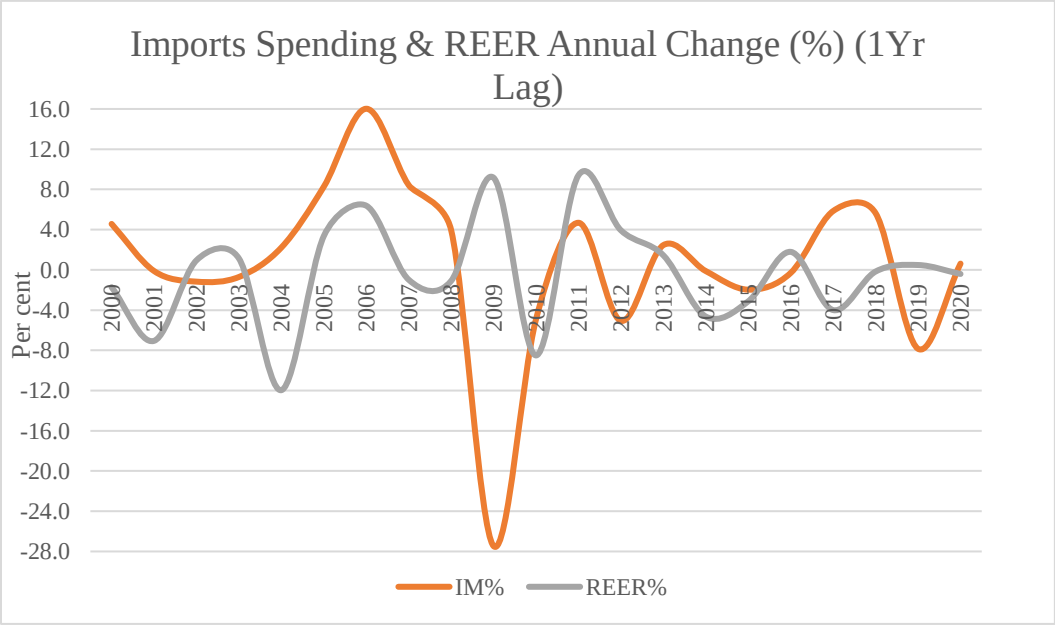


Table 1: Variables, Nomenclature and Descriptions

Variables	Nomenclature	Definition
GDP	DLGDP_SA	Gross domestic product by expenditure in constant J$
Non-Mining GDP	DLNMGDP_SA	Non-Mining Real GDP
Tourism Production	DLTOUR_SA	Value Added Constant Prices Production
Consumption	DLCONS_SA	Sum of private and government expenditure in constant J$
Investment	DLINV_SA	Investment expenditure in GDP in constant J$
Exports	DLX_SA	The value of goods and services export in constant J$
Imports	DLM_SA	The value of goods and services import in constant J$
Net Exports	DLNX_SA	Ratio of Exports to Imports
Exports of Goods	DLXGDS_SA	Value of exports of goods deflated by US export price index
Imports of Goods	DLMGDS_SA	Value of imports of goods deflated by US import price index
Net Exports of Goods	DLNXGDS_SA	Ratio of exports of goods to imports of goods
Consumer Goods	DLCGDS_SA	Value of consumer goods imported deflated by US consumer goods price index
Raw Materials	DLRM_SA	Value of raw materials imports deflated by US raw materials price index
Capital Goods	DLKGDS_SA	Value of capital goods imports deflated by US capital goods price index
Fuel Imports	DLFUEL_SA	Value of fuel imports deflated by US fuel price index
Non-Fuel Imports	DLNONFUEL_SA	Value of non-fuel imports deflated by the consumer price index
REER	DLREER_SA	Real Effective Exchange Rate
Labour Force Per Capita	DLFPC	Labour Force Participation to Population
US GDP	DLUSGDP	Real Gross Domestic Product of the United States (seasonally adjusted)
Real Interest Rate	DRR	Real Interest Rate: Difference between Treasury Bills (88-93 days) and inflation rate
Remittances	DLREMIT	Remittances inflows deflated by consumer price index
Terms of Trade	DTOT	Ratio of exports price index to import price index
Pindex	DPINDEX	Political Stability and Absence of Violence/Terrorism
Government Spending	LGOV	Government Spending in constant $J
Productivity	LPROD	Real GDP per worker
Net Foreign Assets	NFA_GDP	Net Foreign Assets as a percent of real GDP

Figure 2: Jamaica - Political Stability and Violence Index

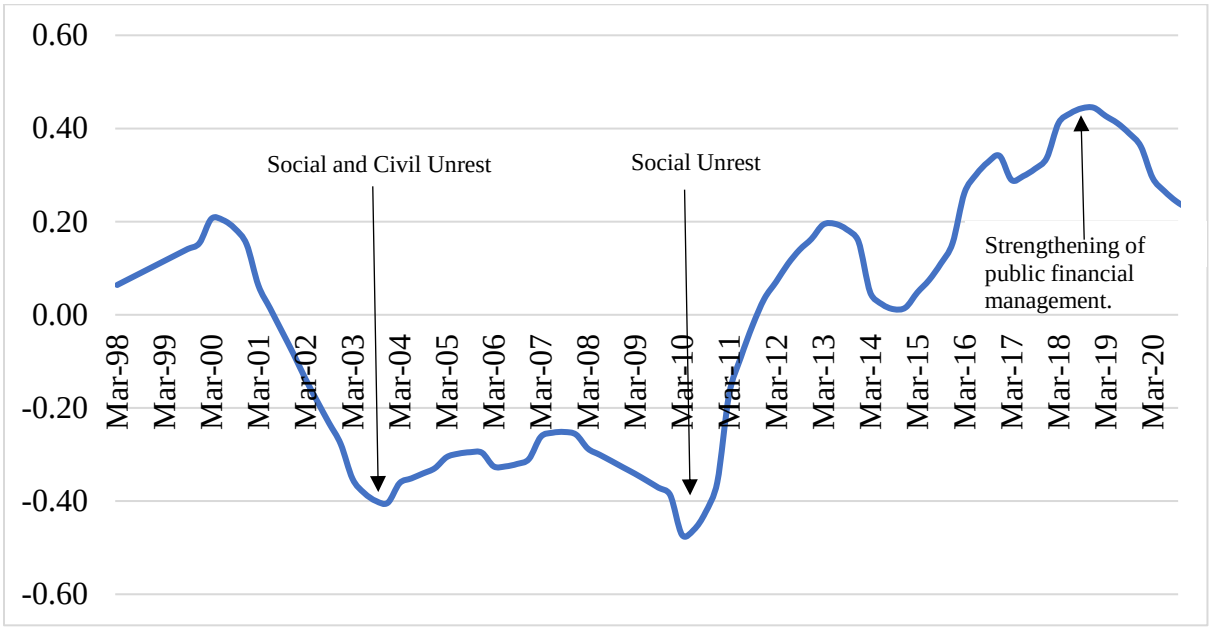


Table 3a: Phillips-Perron Unit Root Test

	Phillips-Perron Test (P values)					
	Levels			First Difference		
Variables	With Constant	With Constant & Trend	Without Constant & Trend	With Constant	With Constant & Trend	Without Constant & Trend
LGDP_SA	0.07	0.03	0.97	0.00	0.00	0.00
LNMGDP_SA	0.10	0.07	0.89	0.00	0.00	0.00
LTOUR_SA	0.00	0.00	0.63	0.00	0.00	0.00
LCONS_SA	0.00	0.01	0.67	0.00	0.00	0.00
LINV_SA	0.00	0.00	0.76	0.00	0.00	0.00
LX_SA	0.17	0.38	0.84	0.00	0.00	0.00
LM_SA	0.16	0.41	0.64	0.00	0.00	0.00
LNX_SA	0.09	0.15	0.38	0.00	0.00	0.00
LCGDS_SA	0.10	0.33	0.77	0.00	0.00	0.00
LRM_SA	0.01	0.01	0.53	0.00	0.00	0.00
LKGDS_SA	0.00	0.01	0.68	0.00	0.00	0.00
LFUEL_SA	0.00	0.00	0.72	0.00	0.00	0.00
LNONFUEL_SA	0.71	0.22	0.06	0.00	0.00	0.00
LXGDS_SA	0.64	0.15	0.07	0.00	0.00	0.00
LMGDS_SA	0.14	0.32	0.52	0.00	0.00	0.00
LNXGDS_SA	0.35	0.00	0.47	0.00	0.00	0.00
LREER_SA	0.13	0.35	0.50	0.00	0.00	0.00
LREER1_SA	0.49	0.79	0.27	0.02	0.07	0.00
LUSGDP_SA	0.84	0.21	1.00	0.00	0.00	0.00
LREMIT	0.81	0.65	1.00	0.00	0.00	0.00
LFPC	0.57	0.22	0.75	0.00	0.00	0.00
RR	0.12	0.09	0.01	0.00	0.00	0.00
TOT	0.65	0.31	0.81	0.00	0.00	0.00
Pindex	0.66	0.68	0.20	0.00	0.00	0.00

Table 3b: Augmented Dickey-Fuller Test

	Augmented Dickey-Fuller Test (P values)					
	Levels			First Difference		
Variables	With Constant	With Constant & Trend	Without Constant & Trend	With Constant	With Constant & Trend	Without Constant & Trend
LGDP_SA	0.36	0.72	0.97	0.00	0.00	0.00
LNMGDP_SA	0.20	0.28	0.89	0.00	0.00	0.00
LTOUR_SA	0.52	1.00	0.63	0.00	0.00	0.00
LCONS_SA	0.02	0.08	0.67	0.00	0.00	0.00
LINV_SA	0.08	0.32	0.76	0.00	0.00	0.00
LX_SA	0.41	0.68	0.84	0.00	0.00	0.00
LM_SA	0.10	0.26	0.64	0.00	0.00	0.00
LNX_SA	0.28	0.43	0.38	0.00	0.00	0.00
LCGDS_SA	0.26	0.69	0.77	0.00	0.00	0.00
LRM_SA	0.20	0.31	0.53	0.00	0.00	0.00
LKGDS_SA	0.03	0.11	0.68	0.00	0.00	0.00
LFUEL_SA	0.00	0.00	0.72	0.00	0.00	0.00
LNONFUEL_SA	0.71	0.28	0.06	0.00	0.00	0.00
LXGDS_SA	0.47	0.30	0.07	0.00	0.00	0.00
LMGDS_SA	0.14	0.34	0.52	0.00	0.00	0.00
LNXGDS_SA	0.27	0.00	0.47	0.00	0.00	0.00
LREER_SA	0.04	0.15	0.50	0.00	0.00	0.00
LREER1_SA	0.43	0.76	0.27	0.02	0.07	0.00
LUSGDP_SA	0.98	0.22	1.00	0.00	0.00	0.00
LREMIT	0.66	0.46	1.00	0.00	0.00	0.00
LFPC	0.98	0.86	0.75	0.00	0.00	0.00
RR	0.29	0.21	0.01	0.00	0.00	0.00
TOT	0.65	0.21	0.81	0.00	0.00	0.00
Pindex	0.49	0.27	0.11	0.03	0.01	0.00

Table 4a: Tests for Normality, Heteroskedasticity and Stability: REER Misalignment 1

Models	Normality Test			Heteroskedasticity			Stability
	Jarque-Bera	df	P-value	Chi-sq	df	P-value	
Model 1: GDP	75.09	16.00	0.00	3095.16	3060.00	0.32	Stable
Model 2: Non-Mining GDP	129.78	16.00	0.00	2398.20	2412.00	0.58	Stable
Model 3: Tourism GDP	513.71	12.00	0.00	919.50	945.00	0.72	Stable
Model 4: Consumption	12.73	12.00	0.39	1462.58	1449.00	0.40	Stable
Model 5: Investment	13.88	10.00	0.18	937.23	930.00	0.43	Stable
Model 6: Exports	86.19	12.00	0.00	471.56	567.00	1.00	Stable
Model 7: Imports	16.73	12.00	0.16	1041.87	1029.00	0.38	Stable
Model 8: Net Exports	15.88	10.00	0.10	816.72	870.00	0.90	Stable
Model 9: Consumer Goods	16.93	12.00	0.15	725.18	777.00	0.91	Stable
Model 10: Raw Materials Goods	17.91	10.00	0.06	776.56	840.00	0.94	Stable
Model 11: Capital Goods Imports	18.11	10.00	0.05	676.38	735.00	0.94	Stable
Model 12: Fuel Imports	15.15	12.00	0.23	967.94	987.00	0.66	Stable
Model 13: Exports of Goods	40.22	12.00	0.00	663.94	777.00	1.00	Stable
Model 14: Imports of Goods	9.02	12.00	0.70	1649.40	1617.00	0.28	Stable
Model 15: Net Exports of Goods	13.39	10.00	0.20	847.71	840.00	0.42	Stable

Table 4b: Tests of Normality, Heteroskedasticity, and Stability: REER Misalignment 2

Models	Normality Test			Heteroskedasticity			Stability
	Jarque-Bera	df	P-value	Chi-sq	df	P-value	
Model 1: GDP	79.43	16.00	0.00	3093.43	3060.00	0.33	Stable
Model 2: Non-Mining GDP	58.67	16.00	0.00	2494.93	2484.00	0.43	Stable
Model 3: Tourism GDP	486.40	12.00	0.00	1013.62	1113.00	0.98	Stable
Model 4: Consumption	17.58	12.00	0.13	628.63	651.00	0.73	Stable
Model 5: Investment	28.29	10.00	0.00	815.13	840.00	0.72	Stable
Model 6: Exports	31.57	12.00	0.00	944.71	1029.00	0.97	Stable
Model 7: Imports	20.25	12.00	0.06	996.02	1071.00	0.95	Stable
Model 8: Net Exports	15.72	10.00	0.11	641.78	630.00	0.36	Stable
Model 9: Consumer Goods	18.71	12.00	0.10	843.79	903.00	0.92	Stable
Model 10: Raw Materials Goods	17.19	10.00	0.07	602.17	690.00	0.99	Stable
Model 11: Capital Goods Imports	12.64	10.00	0.24	687.70	645.00	0.12	Stable
Model 12: Fuel Imports	17.87	12.00	0.12	810.73	861.00	0.89	Stable
Model 13: Exports of Goods	52.25	12.00	0.00	1075.83	1113.00	0.78	Stable
Model 14: Imports of Goods	16.63	12.00	0.16	762.07	819.00	0.92	Stable
Model 15: Net Exports of Goods	16.63	10.00	0.08	775.27	780.00	0.54	Stable

Table 4c: Tests of Normality, Heteroskedasticity, and Stability: REER Misalignment 3

Models	Normality Test			Heteroskedasticity			Stability
	Jarque-Bera	df	P-value	Chi-sq	df	P-value	
Model 1: GDP	84.61	16.00	0.00	3046.33	3024.00	0.38	Stable
Model 2: Non-Mining GDP	171.02	16.00	0.00	2332.03	2376.00	0.74	Stable
Model 3: Tourism GDP	309.22	12.00	0.00	1167.99	1113.00	0.12	Stable
Model 4: Consumption	42.06	12.00	0.00	1543.90	1470.00	0.09	Stable
Model 5: Investment	24.77	10.00	0.01	891.25	885.00	0.43	Stable
Model 6: Exports	28.28	12.00	0.01	1041.24	1029.00	0.39	Stable
Model 7: Imports	29.63	12.00	0.00	1154.20	1176.00	0.67	Stable
Model 8: Net Exports	16.32	10.00	0.09	686.18	750.00	0.95	Stable
Model 9: Consumer Goods	15.69	12.00	0.21	598.17	672.00	0.98	Stable
Model 10: Raw Materials Goods	16.34	10.00	0.09	887.76	915.00	0.73	Stable
Model 11: Capital Goods Imports	12.86	10.00	0.23	656.35	735.00	0.98	Stable
Model 12: Fuel Imports	33.10	12.00	0.00	835.40	882.00	0.87	Stable
Model 13: Exports of Goods	52.28	12.00	0.00	1321.61	1281.00	0.21	Stable
Model 14: Imports of Goods	14.79	12.00	0.25	1492.39	1512.00	0.64	Stable
Model 15: Net Exports of Goods	15.54	10.00	0.11	844.92	840.00	0.45	Stable

Table 5a: Tests for Serial Correlation: REER Misalignment 1

Models	Lag	Q-Stats	Prob.	Models	Lag	Q-Stats	Prob.
GDP	1	0.87	0.35	Non-Mining GDP	1	3.47	0.06
	4	2.84	0.59		4	12.51	0.01*
	8	5.03	0.76		8	14.40	0.07
	12	7.33	0.84		12	15.27	0.23
Tourism GDP	1	0.00	0.99	Consumption	1	0.15	0.70
	4	11.76	0.02*		4	5.70	0.22
	8	13.09	0.11		8	9.77	0.28
	12	13.55	0.33		12	23.75	0.02*
Investment	1	2.61	0.11	Exports	1	1.88	0.17
	4	5.36	0.25		4	5.17	0.27
	8	6.36	0.61		8	7.35	0.50
	12	9.65	0.65		12	9.20	0.69
Imports	1	3.12	0.08	Net Exports	1	4.48	0.03*
	4	5.07	0.28		4	8.03	0.09
	8	7.32	0.50		8	14.93	0.06
	12	14.51	0.27		12	16.04	0.19
Consumer Goods	1	0.01	0.93	Raw Materials	1	6.23	0.01*
	4	1.32	0.86		4	6.91	0.14
	8	7.23	0.51		8	7.66	0.47
	12	17.71	0.13		12	12.22	0.43
Capital Goods	1	3.45	0.06	Fuel	1	0.77	0.38
	4	9.08	0.06		4	4.75	0.31
	8	12.25	0.14		8	5.44	0.71
	12	13.13	0.36		12	8.05	0.78
Exports Goods	1	5.68	0.02*	Imports Goods	1	2.35	0.13
	4	6.55	0.16		4	6.09	0.19
	8	10.48	0.23		8	6.82	0.56
	12	13.21	0.35		12	7.21	0.84
Net Exports Goods	1	8.05	0.01*				
	4	8.08	0.09				
	8	9.71	0.29				
	12	11.20	0.51				

**Serial Correlation at the 5% level*

Table 5b: Tests of Serial Correlation: REER Misalignment 2

Models	Lag	Q-Stats	Prob.	Models	Lag	Q-Stats	Prob.
				Non-Mining			
GDP	1	0.68	0.41	GDP	1	4.34	0.04*
	4	2.77	0.60		4	10.36	0.04*
	8	6.03	0.64		8	12.97	0.11
	12	8.03	0.78		12	14.79	0.25
Tourism GDP	1	0.68	0.41	Consumption	1	0.29	0.59
	4	13.14	0.01*		4	6.43	0.17
	8	14.58	0.07		8	8.73	0.37
	12	14.74	0.26		12	25.27	0.01*
Investment	1	3.32	0.07	Exports	1	0.56	0.45
	4	4.69	0.32		4	6.06	0.20
	8	6.18	0.63		8	7.95	0.44
	12	8.75	0.73		12	19.99	0.07
Imports	1	1.90	0.17	Net Exports	1	1.29	0.26
	4	2.80	0.59		4	2.71	0.61
	8	5.62	0.69		8	4.39	0.82
	12	6.57	0.89		12	5.16	0.95
Consumer Goods	1	0.01	0.91	Raw Materials	1	5.15	0.02*
	4	0.34	0.99		4	5.46	0.24
	8	0.75	1.00		8	8.46	0.39
	12	5.53	0.94		12	9.67	0.65
Capital Goods	1	3.18	0.08	Fuel	1	0.76	0.38
	4	4.03	0.40		4	6.94	0.14
	8	4.68	0.79		8	8.13	0.42
	12	5.47	0.94		12	12.90	0.38
Exports Goods	1	5.62	0.02*	Imports Goods	1	1.49	0.22
	4	5.97	0.20		4	4.24	0.38
	8	7.26	0.51		8	5.35	0.72
	12	9.33	0.68		12	8.67	0.73
Net Exports Goods	1	9.87	0.00*				
	4	9.88	0.04*				
	8	11.22	0.19				
	12	12.13	0.44				

**Serial Correlation*

Table 5c: Tests of Serial Correlation: REER Misalignment 3

Models	Lag	Q-Stats	Prob.	Models	Lag	Q-Stats	Prob.
				Non-Mining			
GDP	1	0.75	0.39	GDP	1	2.19	0.14
	4	2.46	0.65		4	10.10	0.04*
	8	5.61	0.69		8	12.16	0.14
	12	7.91	0.79		12	12.93	0.37
Tourism GDP	1	0.72	0.40	Consumption	1	0.13	0.72
	4	12.83	0.01*		4	0.72	0.95
	8	13.96	0.08		8	1.88	0.98
	12	15.23	0.23		12	12.79	0.39
Investment	1	2.67	0.10	Exports	1	0.15	0.70
	4	5.24	0.26		4	8.45	0.08
	8	6.27	0.62		8	12.05	0.15
	12	9.75	0.64		12	20.32	0.06
Imports	1	1.12	0.29	Net Exports	1	7.91	0.01*
	4	2.66	0.62		4	9.59	0.05
	8	4.16	0.84		8	14.31	0.07
	12	4.66	0.97		12	15.16	0.23
Consumer Goods	1	0.18	0.68	Raw Materials	1	5.93	0.02*
	4	0.34	0.99		4	6.87	0.14
	8	2.91	0.94		8	7.68	0.47
	12	13.15	0.36		12	11.20	0.51
Capital Goods	1	4.28	0.04*	Fuel	1	2.35	0.13
	4	10.04	0.04*		4	4.16	0.39
	8	12.97	0.11		8	4.58	0.80
	12	13.54	0.33		12	6.10	0.91
Exports Goods	1	5.43	0.02*	Imports Goods	1	2.35	0.13
	4	6.01	0.20		4	3.28	0.51
	8	7.97	0.44		8	6.01	0.65
	12	10.65	0.56		12	8.79	0.72
Net Exports Goods	1	7.99	0.01*				
	4	8.08	0.09				
	8	9.76	0.28				
	12	11.15	0.52				

**Serial Correlation*

Table 6: Models Root Mean Square Error

Models	**MISREER1**	**MISREER2**	**MISREER3**
	Root Mean Square Error		
Model 1: GDP	1.014	1.000	1.001
Model 2: Non-Mining GDP	0.746	0.721	0.744
Model 3: Tourism GDP	3.318	3.250	3.075
Model 4: Consumption	2.278	1.944	1.972
Model 5: Investment	4.945	4.608	4.905
Model 6: Exports	1.338	1.900	1.975
Model 7: Imports	3.689	1.238	0.808
Model 8: Net Exports	1.369	1.817	1.556
Model 9: Consumer Goods	3.960	3.712	3.890
Model 10: Raw Materials Goods	7.795	8.044	7.858
Model 11: Capital Goods Imports	11.788	11.443	11.560
Model 12: Fuel Imports	6.176	6.406	8.441
Model 13: Exports of Goods	7.595	7.045	6.856
Model 14: Imports of Goods	4.776	6.388	4.580
Model 15: Net Exports of Goods	3.810	3.842	3.971

Table 7: BVAR Summary Results - Accumulated Response of Dependent Variables to 1% Shock to MISREER1, MISREER2 and MISREER3

	MISREER1	MISREER2	MISREER3
Model 1: GDP	Negative (-0.02%, 10 qtrs.)	Negative (-0.02%, 4 qtrs.)	Negative (-0.06%, 10 qtrs.)
Model 2: Non-Mining GDP	Negative (-0.02%, 7 qtrs.)	Negative (-0.01%, 10qtrs.)	Negative (-0.08%, 9 qtrs.)
Model 3: Tourism GDP	Positive (0.07%, 8 qtrs.)	Positive (0.05%, 10 qtrs.)	Positive (0.25%, 2 qtrs.)
Model 4: Consumption	Positive (0.04%, 2 qtrs.)	Negative (-0.02%, 10 qtrs.)	Positive (0.12%, 2 qtrs.)
Model 5: Investment	Positive (0.04%, 2 qtrs.)	Negative (-0.09%, 10 qtrs.)	Positive (0.04%, 2 qtrs.)
Model 6: Exports	Negative (-0.15%, 8 qtrs.)	Negative (-0.04%, 10 qtrs.)	Negative (-0.36%, 9 qtrs.)
Model 7: Imports	Negative (-0.11%, 9 qtrs.)	Negative (-0.20%, 10 qtrs.)	Negative (-0.32%, 9 qtrs.)
Model 8: Net Exports	Negative (-0.11%, 2 qtrs.)	Positive (0.11%, 10 qtrs.)	Negative (-0.32%, 9 qtrs.)
Model 9: Consumer Goods	Positive (0.03%, 2 qtrs.)	Negative (-0.18%, 10 qtrs.)	Positive (0.06%, 2 qtrs.)
Model 10: Raw Materials Goods	Positive (0.02%, 7 qtrs.)	Positive (0.05%, 2 qtrs.)	Positive (0.14%, 8 qtrs.)
Model 11: Capital Goods Imports	Positive (0.17%, 2 qtrs.)	Positive (0.20%, 10 qtrs.)	Positive (0.16%, 8 qtrs.)
Model 12: Fuel Imports	Positive (0.11%, 2 qtrs.)	Negative (0.23%, 10 qtrs.)	Positive (0.28%, 2 qtrs.)
Model 13: Exports of Goods	Negative (-0.02%, 4 qtrs.)	Positive (0.08%, 2 qtrs.)	Negative (-0.15%, 10 qtrs.)
Model 14: Imports of Goods	Positive (0.15%, 2 qtrs.)	Negative (-0.16%, 10 qtrs.)	Positive (0.14%, 2 qtrs.)
Model 15: Net Exports of Goods	Negative (-0.37%, 2 qtrs.)	Positive (0.31%, 10 qtrs.)	Negative (-0.77%, 10 qtrs.)

Figure 3: Accumulated Response of GDP, Real Exports, Real Imports and Net Exports Spending Growth Rates to 1% Growth in MISREER1 (Overvaluation)

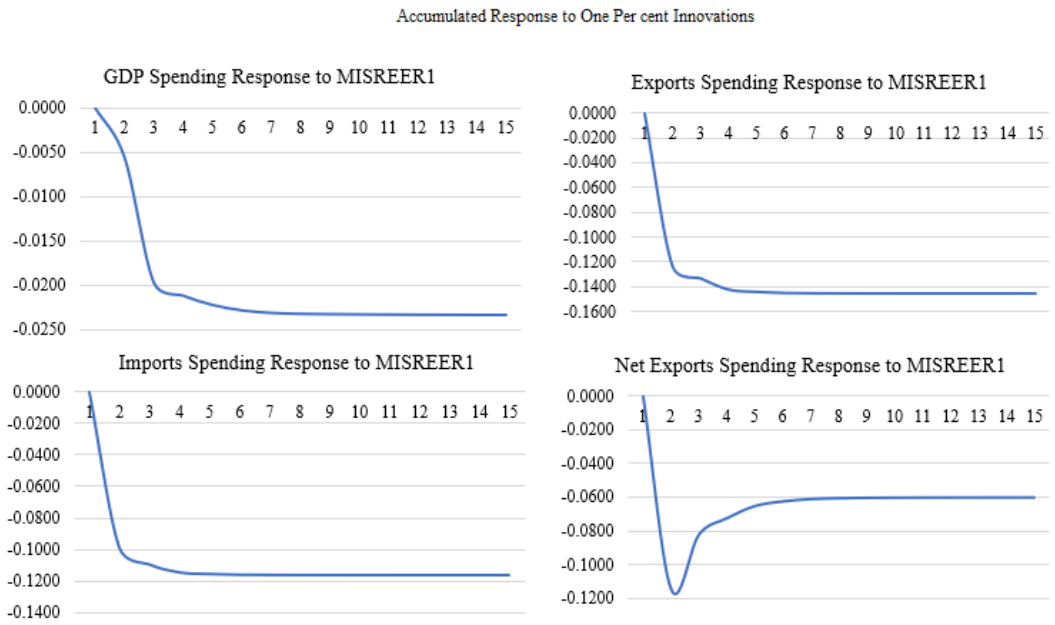


Figure 4: Accumulated Response of Gross Exports of Goods (BOP), Gross Imports of Goods (BOP) and Net Exports of Goods (BOP) Growth Rates to a 1% Growth in MISREER1 (Overvaluation)

Figure 5: Accumulated Response of Real GDP Spending, Consumption and Components of Consumption Growth Rates to a 1% Growth in MISREER1 (Overvaluation)

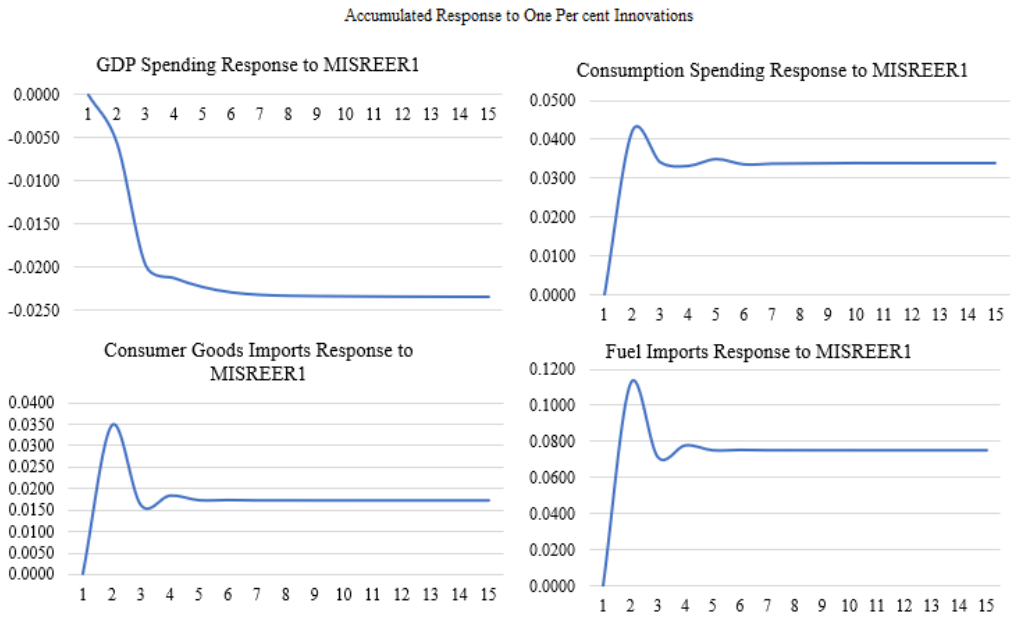


Figure 6: Accumulated Response of Investment and Investment Components Growth Rates to a 1% Growth in MISREER1 (Overvaluation)

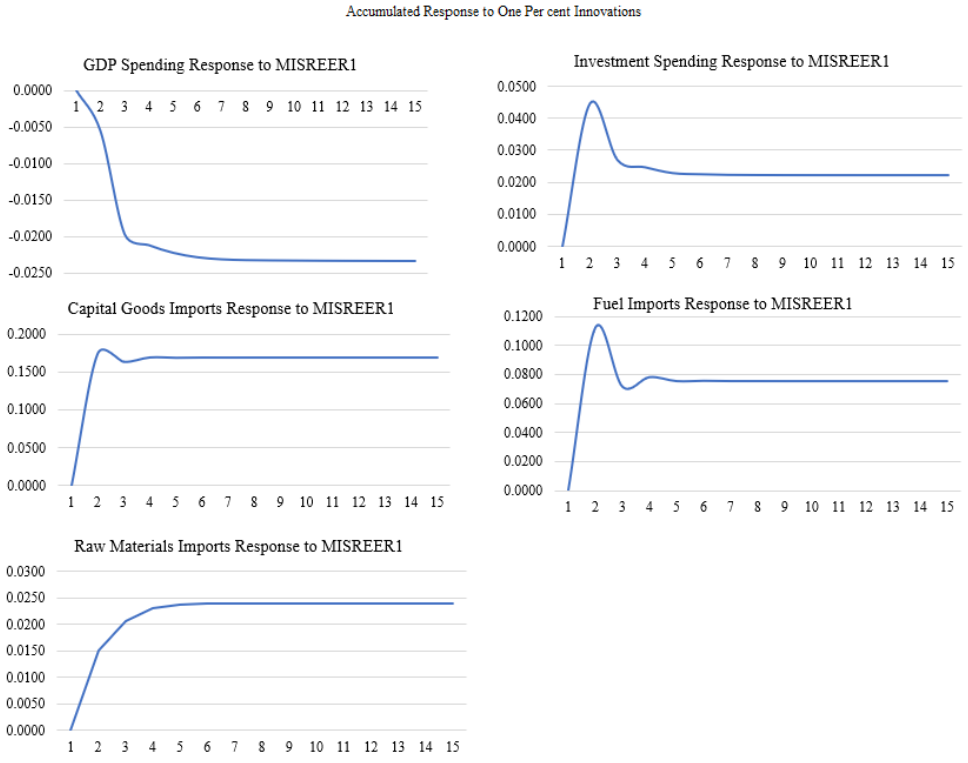
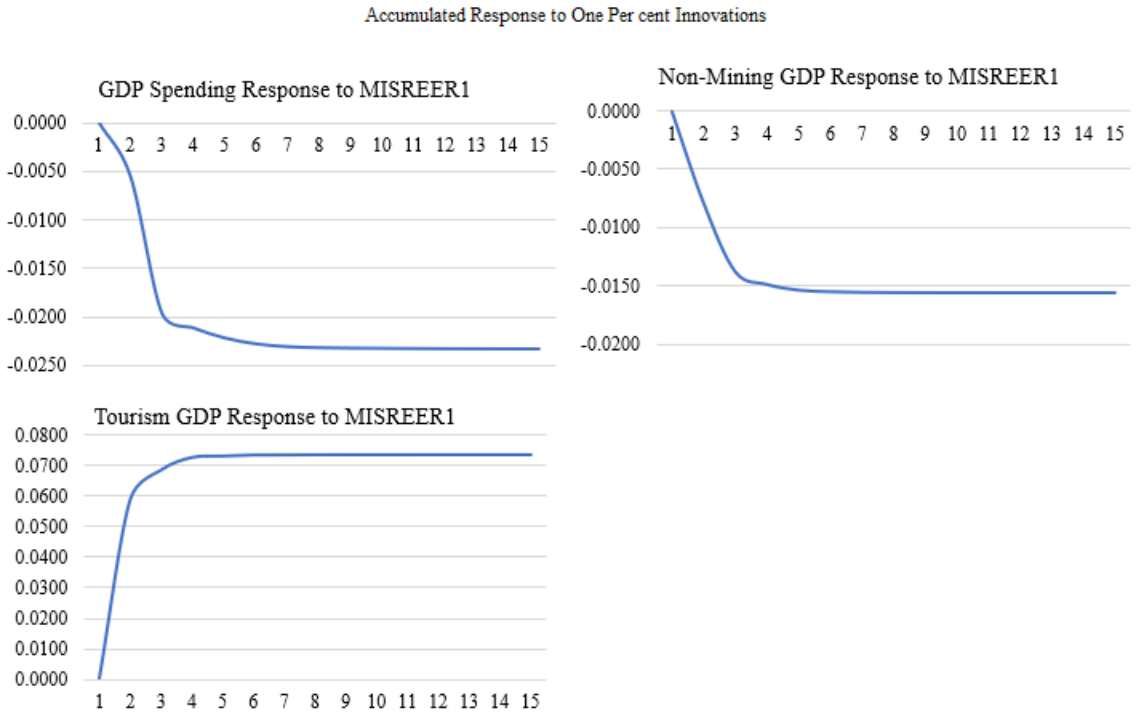


Figure 7: Accumulated Response of Real GDP Spending, Non-Mining GDP, and Tourism GDP Growth Rates to 1% Growth in MISREER1 (Overvaluation)



Appendix 2

Data Issues

While the paper assesses the impact of the REER on real spending in Jamaica, the country does not yet have a published series on GDP by expenditure nor does it have trade deflators. In an attempt to produce robust results from the estimation employed in this paper, the authors used splicing techniques and research done by Serju (2004) to create a real GDP by expenditure series for the period under review. [21] Proxies for export price deflators were also identified for goods export. This section describes the procedures that were used to obtain appropriate estimates for the spending variables.

The splicing technique was used to create the real spending components of GDP series using estimates of real expenditure taken from Serju (2004) for the period 1998Q1 to 2002Q4 along with estimates of real expenditure for the period 2003Q1 to 2020Q4 created from a framework developed by the Real Sector Sub-Unit (RSSU) at the Bank of Jamaica that is built on the indicators developed by Serju (2004). This framework uses ratio analysis and correlation analysis to estimate the spending components of GDP. The splicing method used the derived growth rates for the real spending series computed by Serju (2004) to extend, backward, the series computed by RSSU to 1998Q1. For the remaining periods of the sample, the expenditure series, except consumption spending, uses the data developed by RSSU. Indicators for investment used by the RSSU includes the value added for the construction industry, capital goods imports and raw material import. For imports and exports spending, the indicators are export of goods & services and import of goods & services (balance of payments). For consumption spending, the series was expanded using data from the electronic means of payments for Jamaica and the CPI as the deflator. Finally, to ensure the robustness of the estimates, the aggregated real GDP by expenditure series was created to ensure that its value is equal to the production side real GDP that is published by the Statistical Institute of Jamaica.

A weighted export price index was created to deflate the exports of goods (balance of payments). This index was formed from the weights of Jamaica's main export categories, Mining & Quarrying, Food, Beverages & Tobacco and Refined Petroleum Products.[22] In creating the index, the West Texas Intermediate (WTI) crude oil prices and alumina prices are used as proxies for price developments in the Refined Petroleum Products and Mining & Quarrying export categories, respectively. Using Jamaica's CPI basket, a Manufacture Food CPI was created as a proxy for price developments in the export category for Food, Beverages & Tobacco. Respective indices were created for the WTI and alumina prices using 2007 as the base year. The weighted export price index was created using the weights of the main export categories, which were normalised to 100, with the calculated price indices.

[21] Serju, P., 2004. Estimating Quarterly Expenditure-Based GDP for Jamaica: A General Kalman Filter Approach. Bank of Jamaica, Working Paper. The paper presents a tentative attempt at developing a quarterly real GDP series for Jamaica by evaluating sets of indicators that are consistent, both methodologically and empirically, with annual data available from the Statistical Institute of Jamaica. A state space model was used to interpolate the annual benchmarks. Appropriate deflators were employed to convert the series to real values.

[22] These categories accounted for 92.5% of goods export in 2019.