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ESTIMATION OF THE PASS-THROUGH EFFECT OF INTERNATIONAL FOOD AND ENERGY PRICES ON DOMESTIC PRICES: THE CASE OF BARBADOS

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Abstract

Barbados as a small, very open economy possesses a high dependence on imported goods for production and consumption purposes. As a result, the inflationary process in Barbados is influenced largely by foreign price inflation. Previous research has focused primarily on the determinants of retail price inflation in Barbados and not explicitly on the estimation of the speed of pass-through effects of international commodity prices on domestic inflation. Using quarterly data for the period 1985:Q1 to 2015:Q4, the study estimates a VECM, generalised impulse responses and variance decompositions to capture the speed and magnitude of international commodity price fluctuations. The findings indicate a relatively slow speed of adjustment of domestic prices from disturbances away from equilibrium. International energy prices were found to exhibit a faster rate of pass-thorough to domestic prices in the short-run, while the reverse was found for international food prices in the long run

Keywords: Barbados, energy prices, food prices, vector error correction model, pass-through

JEL Codes: O54; E31; F14; Q43

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1. Introduction

The unique structural characteristics of small, very open economies (SVOEs) result in a high dependence on imported goods for production and consumption purposes. As a consequence, the inflationary process in these economies is influenced largely by foreign price inflation, principally transmitted through the costs of imports to the prices of supply side factors, more commonly referred to as cost push factors, and to a lesser extent demand side influences[1].Indeed, previous empirical research on inflation in Barbados suggest the major determinants impacting on the price formation process is "imported" inflation, with weak impacts from changes in real incomes, wages, taxes and nominal interest rates (see Holder and Worrell (1985); Downes (1985)). Cumberbatch (1997) provides a useful survey of previous work on Barbados and reached similar conclusions from the empirical investigation conducted over the period 1961 to 1993.

While there is consensus on the direct economic impact of fluctuations in international commodity prices in SVOEs, the existing research on Barbados to date has not explicitly investigated the linkages between international commodity price shocks and headline domestic inflation. Such an examination would be of particular relevance, as policy officials would be more adequately equipped to not only gauge the potential impacts of external price developments on domestic inflation, but would also allow for the better timing of related policy initiatives. It is, therefore, the intention of this study to build on this previous research by estimating the pass-through effects of international oil and food prices on domestic inflation over the past thirty years. In accordance with the bulk of the previous work for both developed and developing countries, the empirical investigation is undertaken using standard vector autoregression (VAR) methodologies with the application of quarterly data over the sample period 1986-2015.

In this regard, structural vector autoregressive models (SVARs) are employed to conduct the empirical analysis, as these models uses economic theory and allow for flexibility in the identification and grouping of the commodity price shocks by source (see Cuando, Soojin and Perez de Garcia (2015) and Peersman (2005) for developed economies and Jongwanich and Park (2011) and Catik and Karacuka (2012) for developing economies). Hooker (2002) posits that one

[1]The weak impact of demand pull factors is premised on the well-established view that in SVOEs excess aggregate demand tends to affect the balance of payments position rather than fuel inflation.

of the critical considerations in using SVARs is the choice of imposing short-run verses long-run restrictions, with the latter based on established theoretical grounds.

The central findings suggest that international energy prices exert a stronger long-run impact on domestic inflation, compared to international food prices. Therefore, a 10 percent increase in international energy and food prices is estimated to lead to higher domestic inflation of 7.5 percent and 3.4 percent, respectively. In the short run, the impact is much lower at 0.6 percent and 0.2 percent, respectively.

Following the introduction, the next section provides a review of selected empirical literature from both developed and developing countries. Section 3 describes the trends in domestic price inflation over the past three decades and the proximate events that may have sparked the sudden changes in domestic inflation. Section 4 presents the data sources and the empirical methodology. The empirical results are presented in section 5 and the conclusions are provided in section 6.

2. Brief Review of Related Empirical Literature

This section presents a brief review of the vast empirical literature on this issue, with the aim of identifying a suitable empirical approach from the previous work on both developed and developing countries. The majority of the existing research favours a combination of an augmented Phillips curve specification and structural vector autoregressive (SVAR), the latter having the advantage of allowing for the identification and grouping of the specific commodity price shocks in the empirical specification.

Using a simple four variable VAR, comprising oil prices, consumer inflation, output growth and the short-term interest rate, Peersman (2005) found that by relaxing the zero contemporaneous assumption of other economic shocks on oil prices, as well as the traditional approach of ordering oil prices first in the empirical VAR specification, the impact of oil price shocks are found to be negligible and insignificant, in contrast to being highly significant and negative using conventional methods of imposing restrictions. In addition, Peersman (2005) argues that the forecast results from the related impulse response functions are largely influenced by the order of specification of the unrestricted VAR and the choice of restrictions employed. More

specifically, the short-run restrictions are not usually based on theoretical considerations, in contrast to the long-run restrictions which are justified by economic theory.

In addition to the direct effects on the general price level, indirect inflationary effects may also arise because higher energy input costs are typically passed on from producers to consumers, which in turn may potentially lead to higher wage demands (see Peersman and Robays (2009)).These authors expanded their investigation of oil price shocks in the Euro area to include the impact of oil price innovations on nominal wages and unemployment to capture second-round effects. They found that oil price innovations resulting from supply and global economic shocks impact consumer prices more readily than oil-specific demand shocks, due to an off-setting appreciation in the Euro. Furthermore, Euro area inflation reacts more sluggishly to the prevalence of second round effects.

While the majority of the empirical literature has traditionally utilised sign restrictions in an effort to identify oil, demand and supply shocks, Valcarel and Wohar (2013) posits that this approach is open to criticism. In particular, Fry and Pagan (2011) found that the use of sign restrictions generates a wide range of impulse responses, over which the speed of pass-through effects may differ, resulting in a multiple model problem.

In response to such critiques Valcarel and Wohar (2013) avoid the model identification issue by imposing long-run, instead of short-run restrictions, which is consistent with the earlier work of (Peersman, 2005). Therefore, imposing long-run restrictions in a Bayesian VAR framework, Valcarel and Wohar (2013) surmise that the volatility in oil prices is not congruent with the volatility in overall domestic inflation in the United States, owing to a shift from the significance of supply-side to demand-side shocks. The suggestion being that the relationship has changed as a result of shifts in the global energy market, which are linked to advancements such as fuel efficiency gains and the emergence of energy alternatives.

Also employing the SVAR technique, Blanchard and Gali (2007) and Blanchard and Riggi (2013) illustrate that the macroeconomic impact of oil price shocks has waned overtime, consistent with the previous work of De Gregorio et al. (2007) and Valcarel and Wohar (2013). In both cases, these studies provide evidence that declining wage rigidities, oil intensities and appropriate monetary policies, targeting low and stable rates of inflation were found to be of significance in explaining the decreasing pass-throughheffect of oil prices to domestic inflation.

Furthermore, Jongwanich and Park (2011) revealed that the magnitude and the speed of the pass-through in the case of both global food and oil prices is reduced or delayed in accordance with government policy measures, such as subsidies and price controls and that Asia's inflation surge in the 2007-2008 was driven primarily by demand pull factors, rather than cost push factors.

Catik and Karacuka (2012) provide further evidence in support of the impact of policy on the transmission of international commodity price fluctuations to domestic inflation. Under the framework of a Markov Regime Switching VAR, the pass-through effect from oil prices to domestic inflation in Turkey was found to be insignificant under both high inflation and low inflation regimes, where high taxes and exchange rate movements distort the relationship between domestic and international prices.

These findings contradict the preceding work by Dedeoglu and Kaya (2014), which used a rolling-window recursive VAR model to indicate that the oil price pass-through to domestic prices was increasing because of the significance of oil inputs in the overall business cost structure, thereby making firms more responsive to commodity price fluctuations. The use of both consumer and producer prices allows for a more detailed analysis of the influence of international oil prices on inflation. For instance, it was noted that the impact of oil prices on producers was nearly twice as high as the impact on consumers, highlighting the difficulty producers may experience to directly pass on higher costs to consumers in a low inflation environment. A corollary to this finding is the role the regulatory environment plays in either allowing or restricting the pass-through of international price fluctuations to domestic prices. In the case of India, during the period 1994-2010, Mandal et al. (2012) found that a higher pass-through effect to domestic inflation and industrial output followed the deregulation of petroleum products, which resulted in the immediate and full price adjustments to oil price fluctuations, increasing the sensitivity of domestic prices to external price pressures. These results support the use of fiscal policy to mitigate persistent external inflationary pressures and their adverse impact on domestic economic output, the benefits of which have to be weighed against the fiscal burden associated with oil price subsidisation.

Asghar and Naveed (2015) using the ADRL technique approached the issue of identifying the pass-through impact of international commodity prices in much the same way as Chou and

Tseng (2011). The findings suggest that in the long run oil prices have a positive impact on inflation, while exchange rate appreciation has a negative impact. The approach taken, however, in neglecting to split the sample or make use of rolling windows, was unable to make any assertions with respect to the declining pass-through relationship observed by most of the work mentioned previously.

3. Trends in International and Domestic Price Inflation Over the Past Three Decades

This section describes the historical trends and related developments in the international commodity markets and the subsequent movements in international energy, food domestic inflation rates[2]. The Barbados economy is highly susceptible to the fluctuations in international prices given the high dependence on imports, particularly imports of consumer, capital goods and fossil fuels.[3]

Figure 1 displays the long-term trends in the domestic, global energy and food inflation over the period 1986 to 2015. Over this period, the domestic inflation rate rose on average by 3.6 percent, compared to increases of 6 percent and 3.3 percent in international energy and food prices, respectively. It can be observed from Figure 1 at least five notable spikes in the domestic inflation rate, ranging from 7.4 percent in 1992 to 9.4 percent in 2011. The key question that arises is to what extent can these spikes in domestic inflation be traced to the transmission in the international energy and food prices?[4]

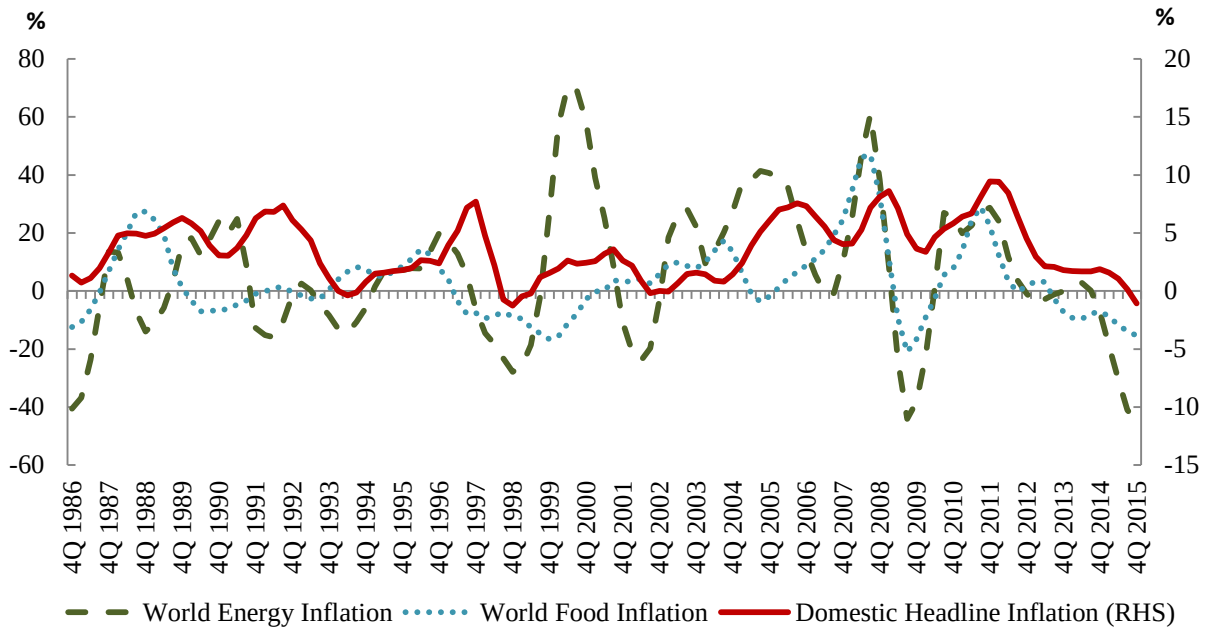
During the early 1990s, domestic inflation was on average higher than international energy and food price inflation. In 1992, retail price inflation rose to 7.4 percent, following the dramatic and immediate disruption of the supply of oil in Kuwait resulting from the Iraqi invasion in August 1990. The uptick in the price of oil was short-lived because of the United States rapid military intervention and restoration of order in about two months. The domestic inflation exhibited a gradual downward trajectory with the fall in both international energy and food prices.

[2] The estimation of the international energy and food inflation rates is described in Section 4 - Data and Methodology.

[3] Between 1986 and 2015, the imports of fuel products and consumer goods account for almost 55 percent of total retained imports (proxied by the difference between total imports and re-exports). Imports of food and beverages alone represent an average of 17 percent and fuel imports 13 percent, respectively. In particular, during the years 2011 and 2012, when there was the precipitous rise in international oil prices, imports of fuel accounted for almost one-third of retained imports.

[4] The combined weight of the food and fuel sub-components of the retail price index is 40 percent.

Figure 1: Trends in International Food, Energy and Domestic Inflation, 1986 - 2015



Source: Barbados Statistical Service

During 1997, the domestic inflation rate jumped to 7.7 percent, which was primarily attributed to the introduction of a 15 percent value-added tax (VAT) at the beginning of the year. The VAT replaced an indirect tax structure consisting of eleven taxes: a consumption tax, an import surcharge, a hotel and restaurant sales tax, a travel ticket tax, an entertainment tax, a tax on quarriable minerals, a surcharge on overseas telephone calls, a surcharge on residential rents, a service tax on pleasure cruises, a stamp duty on imports and an airline business tax.

The next decade witnessed substantial volatility in international energy prices. The most significant of these fluctuations occurred during the second quarter of 2000, with the 12-month average international energy inflation ratepeaking at 71 percent. This sharp price increase resulted from the mounting pressures on world oil inventories[5]. Between 2003 and 2008, world energy prices continued to increase, influenced largely by instability in the Middle East amid the tensions from the 2003 US-Iraq war and civil unrestin Venezuela and Nigeria. In the ensuing

[5]In 1999, world oil consumption averaged 74.7 million barrels per day, while world oil supply averaged 73.9 million barrels per day. The persistence of these demand pressures spilled over into 2000, thereby pushing up the price, but was however short lived due to the Organization of Petroleum Exporting Countries' response of increasing oil production.

period, average crude oil prices surged to a high of $124 per barrel in the second quarter of 2008. The effects of this significant increase in world oil prices preceded the jump in domestic headline inflation to 8.6 percent in the first quarter of 2009. In 2011, domestic inflation rose to 9.4 percent, following persistent increases in both international energy and food prices, which peaked at 27 percent and 29 percent, respectively during the third quarter of 2010, compounded by a further increase in the VAT rate to 17.5 percent.

An inspection of the trends in Figure 2 illustrates the strong correlation between the fluctuations in international energy prices and domestic energy inflation, which can be attributed to the efficiency of the system for the pricing of electricity by the application of the Fuel Clause Adjustment (FCA)[6]. Furthermore, an examination of Table 1 indicates a high correlation of 0.63 between these variables.

[6]The FCA was approved by the Public Utilities Board (PUB) for use by the Barbados Light & Power (BL&P) in 1965 for commercial and industrial customers, before being extended to all customers in 1973. Carter et al.(2013)notes that the formula equates to the ratio of the projected cost of fuel and the projected billing sales of electricity in a given month. Any balances that occur from forecast errors with respect to projected fuel prices are subtracted or added, to the next month's fuel costs. Since its introduction, the FCA has been modified on two occasions. The first occurred in 1983, where regulatory approval was given to modify the calculation of the FCA, with the estimated fuel cost from each month based on price projections, rather than purely the under or over recovery of the previous month to minimize spikes in any one given month. In 2009, PUB's predecessor; the Fair Trading Commission approved a further change by allowing for the transfer of the energy charge (variable non-fuel energy related costs), thereby facilitating the pass-through of all fuel costs. The application of the FCA has been touted as being an appropriate instrument for the pricing of electricity as it eliminates the need for cost hearings, the process of which would introduce lags with respect to pricing of electricity and associated market changes.

Figure 2: International Energy Inflation and Domestic Energy Inflation

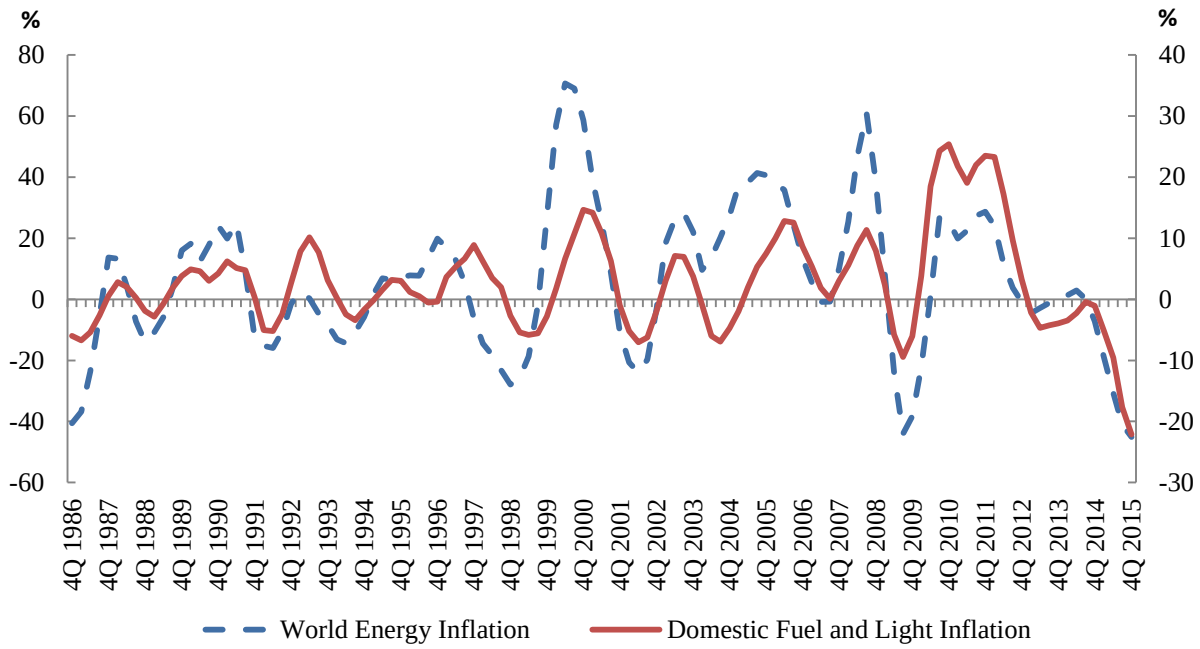


Table 1: Correlations between International Energy, Food and Domestic Inflation[7]

	International Energy Prices	International Food Prices	Domestic Headline Inflation	Domestic Fuel & Light Inflation	Domestic Food Inflation	Domestic Core Inflation
International Energy Inflation	1.00	0.36*	0.31*	0.63*	0.27*	0.13***
International Food Inflation	0.36*	1.00	0.34*	0.33*	0.34*	0.15**
Domestic Headline Inflation	0.31*	0.34*	1.00	0.59*	0.76*	0.77*
Domestic Fuel & Light Inflation	0.63*	0.33*	0.59*	1.00	0.28*	0.48*
Domestic Food Inflation	0.27*	0.34*	0.76*	0.28*	1.00	0.20**
Domestic Core Inflation	0.13***	0.15**	0.77*	0.48*	0.20**	1.00

Source: Author Calculations using data from the Barbados Statistical Service
Note:***,**,* denotes statistical significance at the 10%, 5% and 1% level.

It is also noteworthy that the correlation between international energy and food prices was relatively low over the sample period. There can be little dispute about the significance of

[7] To account for the lagged impact fluctuations of international commodity prices would have on the price levels observed the retail price index, a step-wise approach was used with respect to determining the appropriate amount of lags that should be imposed on the exogenous variables of international energy and food inflation. In most cases correlation coefficients increased up to 2 lags (six months), with the exception of world food to domestic food inflation, where the coefficient suggests that 3 lags are appropriate.

international fuel prices as a key component of production and transport costs, particularly for the international transshipment of food. This correlation increased to 0.9 after 2007which is a period associated with the intensified interest in solid biofuels against a backdrop of high international fuel prices. Headley and Shenggen (2008) identified surging biofuel demand, particularly as it relates to the price of maize, as an explanation for the 2005-2008 global food crisis.

4. Data and Methodology

This study uses quarterly data for the period 1985Q1 to 2015Q4. The retail price index (RPI) was obtained from the Central Bank of Barbados Online Statistic Database. The historical inflation series used in the empirical model is a product of a splicing process, since the published RPI has undergone three periods of rebasing[8]. International energy and food prices were proxied by indices taken from the World Bank Commodity Price Data, Global Economic Monitor Commodities. The international energy index comprises the following: international coal (4.7), crude oil (average of Brent, Dubai and West Texas Intermediate) (84.6) and natural gas prices (10.8). The international food index includes cereals (11.3), vegetables oil and meals (16.3) and other food (12.4). Quarterly real GDP data were obtained from the Central Bank of Barbados Economic Outlook model, while the nominal weighted average lending rates for the period under investigation were procured from the Bank's Online Statistics Database. All variables with the exception of the interest rate were introduced into the system in their logarithmic forms in levels.

The seasonal component in the log of real GDP series was removed using the Eviews9.5 seasonal adjustment option, TRAMO/SEATS, resulting in a smoothed trend of quarterly GDP (LRGDP_TRD). The remaining representations are as follows: weighted average lending rate (IR), international food and energy prices (LWRLD_FOOD) and (LWRLD_ERGY), respectively and the headline domestic retail price index is represented by (LHRPI).

The *a priori* expectation is that the influence of the independent variables LRGDP_TRD,LWRLD_FOOD and LWRLD_ERGYon domestic retail prices is positive. The interest rate variables are also expected to impact positively on domestic prices through the

[8]The spliced RPI was derived according to the formula: Spliced Index = Items of Old Index * Items of New Index/ Items of Old Index

indirect channel of higher borrowing cost passed on to customers by businesses. The assumption underlying the impact of economic activity on domestic inflation is through the spending channel, as increases in aggregate spending are assumed to place upward pressure on the demand for imports.

Since time series variables are involved, it is appropriate to examine the stationarity properties of the individual data series, since this knowledge can determine the validity of the empirical model. Thus, the first step of the empirical investigation is to test for non-stationarity of the variables, which is done using the Augmented Dickey-Fuller test. Next, is the determination of the type of vector autoregressive (VAR) process, according to the following: if the variables are all stationary, then a VAR in levels is appropriate. If the variables are non-stationary or I(1),and are not cointegrated, then a VAR in first differences is valid. If the variables are all I(1) and cointegrated, then a restricted VAR in first differences, i.e., a vector error correction model (VECM) is appropriate. The Johansen (1988) test for cointegration is conducted, which allows for the determination of a maximum number of cointegrating relationships, with little or no prior knowledge of their association. In the presence of only one cointegrating relation, the VECM in its single equation format called error correction model (ECM) can be represented by

$$\Delta LHRPI_t = \alpha_0 + \alpha_1 ECT_{t-1} + \sum_{i=1}^{n} \beta_i \, \Delta LHRPI_{t-i} + \sum_{i=1}^{n} \beta_i \, \Delta LRGDP\_TRD_{t-i} + \sum_{i=1}^{n} \beta_i \, \Delta IR_{t-i} + \sum_{i=1}^{n} \beta_i \, \Delta LWRLD\_FOOD_{t-i} + \sum_{i=1}^{n} \beta_i \, \Delta WRLD\_ERGY_{t-i} + e_t \quad (1)$$

Where the variables are defined as above, t is time index, Δ represents the first difference, *ECT* stands for the cointegrating variable or vector, e is the usual error term, and the rest are parameters.

The lagged ECT, that is ECT_{t-1}, represents the deviation from equilibrium in period t and the parameter α_1 measures the response of overall price levels in each period to departures from equilibrium. This parameter is expected to be negative, greater than minus one, and statistically significant in the presence of a cointegrating relationship. As implicitly pointed out above, the full VECM corresponding to the above equation contains 5 equations with each variable in turn playing the role of a dependent variable. In matrix form, the VECM (with restrictions) can be represented as follows:

$$\begin{pmatrix} \Delta LHRPI_t \\ \Delta LRGDP\_TRD_t \\ \Delta IR_t \\ \Delta LWRLD\_FOOD_t \\ \Delta LWRLD\_ERGY_t \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \end{pmatrix} (1 \quad 0 \quad \beta_{13} \quad \beta_{14} \quad \beta_{15}) \begin{pmatrix} LHRPI_{t-i} \\ LRGDP\_TRD_{t-i} \\ IR_{t-i} \\ LWRLD\_FOOD_{t-i} \\ WRLD\_ERGY_{t-i} \end{pmatrix} \quad (2)$$

To account for the possibility that any linear combination of cointegrating vectors can form a linear stationary relationship, as expressed by Johansen (1991) and Pesaran & Shin (2002) as well as to avoid indeterminacy, parametric restrictions were employed, where β_{11} =1 and $\beta_{12} = 0$, with β_{11} being the normalising restriction. In the case of β_{12}, the restriction is based on the theoretical grounds of there being a weak or no direct effect of real economic activity on domestic price levels. Indeed, the premise here is that the determination of domestic prices in Barbados, a small, open fixed exchange rate economy, largely influenced by external shocks in the global commodities market, rather than by domestic economic activity, where the process is constrained by factors such as income inelastic demand. To test these restrictions and determine whether all the cointegrating vectors have been identified, the null hypothesis of β_{11} =1 and $\beta_{12} = 0$, where tested using the Likelihood Ratio statistic (see Boswijk (1995)).

5. Empirical Results

Table 2 displays the results of the Augmented Dickey Fuller (ADF) unit root tests. All the variables were determined to be integrated of order one or stationary in their first differences.

Table 2: Augmented Dickey Fuller Unit Root Tests, 1986-2015

Variables	Deterministic terms	Levels	1st Difference
LHRPI	Constant, trend	-1.79	-8.36*
LRGDP	Constant, trend	-2.14	-7.70*
IR	Constant, trend	-2.30	-6.69*
LWRLD_ERGY (structural break)	Constant, trend	-3.07	-7.05*
LWRLD_FOOD (structural break)	Constant, trend	-2.34	-8.31*

Note:***,**,* denotes statistical significance at the 10%, 5% and 1% level.
For a discussion of unit root test with structural breaks see Perron (1989), Vogelsang & Perron(1998) and Banerjee et al. (1992).

The Johansen cointegration results suggest using two lags as optimal lag structure, as determined by Akaike Information Criterion (AIC), with one cointegrating vector. In addition, the linear model with intercept and no trend was found to be the most adequate model to capture the long-run dynamics of the system.

Unrestricted Error Correction Model

The presence of one cointegrating relationship suggests the use of a Vector Error Correction Model (VECM), which aids in differentiating between the short and long-run dynamics of the cointegrating relationship, and capturing the response of domestic price levels in each period to departures from the long-run equilibrium. The results from the unrestricted ECM (not reported) suggest that all of the variables impact positively on domestic price levels, with the exception of LRGDP, which was found to be statistically insignificant. Generally, these results are consistent with previous work on inflation in Barbados, where inflation was deemed to be positively impacted by the price of tradables.

Based on a visual inspection of the residuals, the possibility of including dummies to address notable outliers was also considered. The choice of the appropriate number of dummies was balanced against a desire to maintain model stability and ultimately the reliability of the underlying unrestricted ECM. Amongst the most notable outliers are those observed in the headline retail price index series 1997:Q1, which is representative of a shock introduced through the implementation of the VAT. The final dummy introduced into the system accounts for the notable negative shock that features in both the international food and energy prices indices in 2008:Q4. This dummy reflects a period when international prices would have plummeted due to contracting demand stemming from the mounting pressures linked to the global financial crisis and long-run demand responses to previously high prices[see Hamilton (2009)].The dummies were found to be statistically significant at the 5% and 10% level, while the previously discussed test for the appropriate lag structure and autocorrelation continue to suggest that an unrestricted ECM(2) is an appropriate model. Geamanu (2014) argues that stability of the system is necessary to ensure that shocks are temporary and disappear over time, where the absence of stability implies that the standard errors for the impulse-responses are not valid. The results from using the inverse roots of the characteristic AR polynomial reveal that all roots lie within the unit circle, lead to the conclusion that the estimated VAR is stable.

Restricted Error Correction Model

Johansen (1991) suggests that in a multivariate setting, it is possible that any linear combination of cointegrating vectors can form a linear stationary variable. Therefore we imposed identifying restrictions to avoid indeterminacy and to adequately identify the long-run relationships. The normalising restriction in this instance is the headline retail prices index. With respect to the other variables in the system, previous research and the results from the previously discussed unrestricted ECM suggest that no restrictions are placed on the indices for world food and energy prices.

The decision on the remaining parametric restrictions for interest rate (IR) and real income (LRGDP) were informed by the likelihood ratio test of identifying restrictions. The only valid constraint was found to be when domestic price levels (LHRPI) were assumed not to be impacted by LRGDP in the long run, such that (β_{12}=0). The test for constraining the weighted average interest rates on loans indicate that this constraint could be rejected, suggesting that nominal interest rates impact positively on price levels in the long run. Table 3 provides parameter estimates for the cointegrating relationship of the restricted ECM, which proposes that all of the unconstrained explanatory variables impact positively on domestic retail prices in the long run.

Table 3: Estimates of Cointegrating Relationship of Restricted ECM

	C	LRGDP	IR	LWRLD_FOOD	LWRLD_ERGY
LHRPI	1.096	0.000	0.136 (3.784)	0.340 (1.620)	0.754 (6.853)

Note: The figures in brackets are t statistics.
Adj. R^2= 0.39; F Stat = 7.08; LM=18.11(0.84), Joint-Het =383.79 (0.186), Norm= 353.62 (0.00)

Table 4: Short-run Dynamics of Domestic Retail Prices (LHRPI)

Lag	C	ECT	ΔLHRPI	ΔLRGDP	ΔIR	ΔLWRLD_FOOD	ΔLWRLD_ERGY
0	0.010 (8.121)						
1		-0.020 (-4.471)					0.017 (2.127)
2			-0.231 (-2.929)			0.057 (3.260)	

Note: The figures in brackets are t statistics.
Adj. R^2= 0.42; F Stat = 15.64;DW=2.087, ARCH(2) =0.764 (0.675), LM=0.429 (0.652), Reset(2)=0.200, Norm= 26.51 (0.00)

The various diagnostic tests indicate no serial correlation or heteroscedasticity and a visual analysis of the residuals along with the actual and fitted RPI trends reveal that the model at this stage performs reasonably well.

The negative and very significant error correction term (ECT) corroborates the earlier conclusion that there is a valid cointegrating relationship. The ECT suggests a relatively slow adjustment of domestic prices following shocks, where just 0.02 percent of the variation is corrected for in the following period on a quarterly basis[9]. In their monthly analysis of price rigidity in Barbados, Craigwell et al. (2011), however, provides some support to the findings of this paper, by noting that that the estimated inflation persistence or the correlation of price movements with changes in the previous month is quite low, where past price adjustments have only a small impact on current changes. Indeed, the authors found that categories such as food and clothing and furniture had relatively low levels of inflation persistence, where it was estimated that it would take more than a year for a one unit shock to the index for 'meals away from home' to dissipate by half.

The comparison of the long and short-run results for international food and energy prices presents an interesting dynamic with respect to understanding price formation process in Barbados. In the short-run, variations in international food prices result in higher proportional changes in domestic RPI levels, compared to changes in international energy prices, where a 10 percent increase in both international food and energy prices lead to an estimated a 0.6 percent and a 0.2 percent increase in domestic price levels, respectively. This finding is consistent with Moore, Lewis-Bynoe, and Morgan (2012), who found that food price episodes (in the short run?) increase the probability of an inflation start by 3.9 percent, compared to a 2.6 percent increase in probability stemming from oil prices. The results are reversed in the long run, with a 10 percent increase in international food and energy prices resulting in 7.5 percent and 3.4 percent increases in domestic price levels.

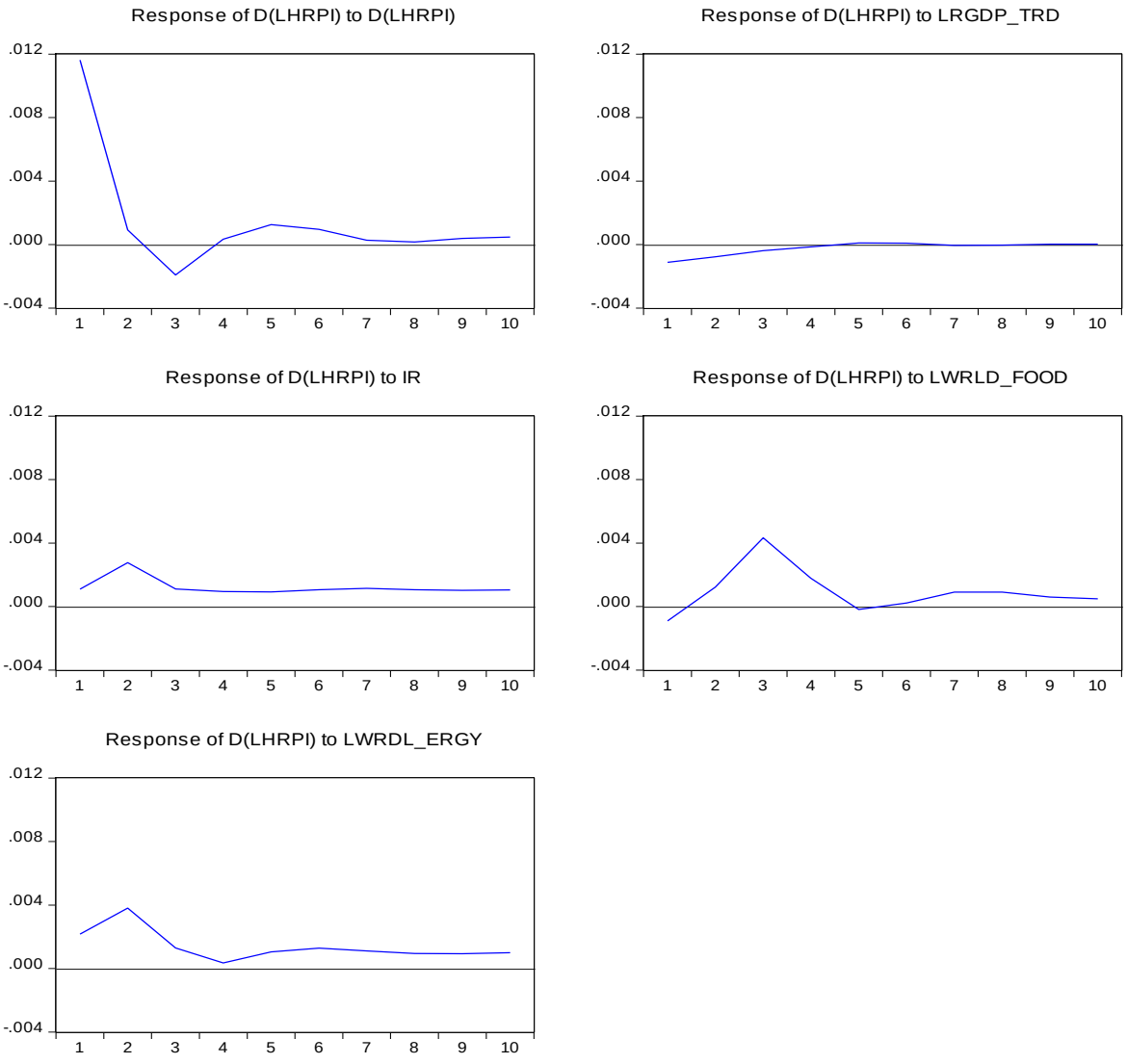
Intuitively, these empirical results are consistent with the underlying composition of the retail price index and the structure of the Barbadian economy. The Food subcomponent accounts for 34 percent of the retail price index, indicating a stronger short run impact. The dominance of the energy subcomponent in explaining the long-run result is indicative of its role as a major input in

[9]Using annual data, Cumbertbatch (1995) and Downes et al. (1987) estimated speed of adjustments of 0.76 percent and 0.83 percent, respectively on an annual basis.

the productive capacity of the Barbadian economy. Increases in international energy prices are, therefore, best viewed as having a multiplicative influence on the retail prices in Barbados. This is especially true even if one considers that international energy prices impacts on the domestic food prices as a result of shipping and transportation costs, as well as electricity cost incurred by suppliers which are invariably passed on to consumers in the form of mark-ups.

Impulse Response Functions

Figure 3: Impulse Responses of LHRPI to Generalised 1 S.D. Innovations



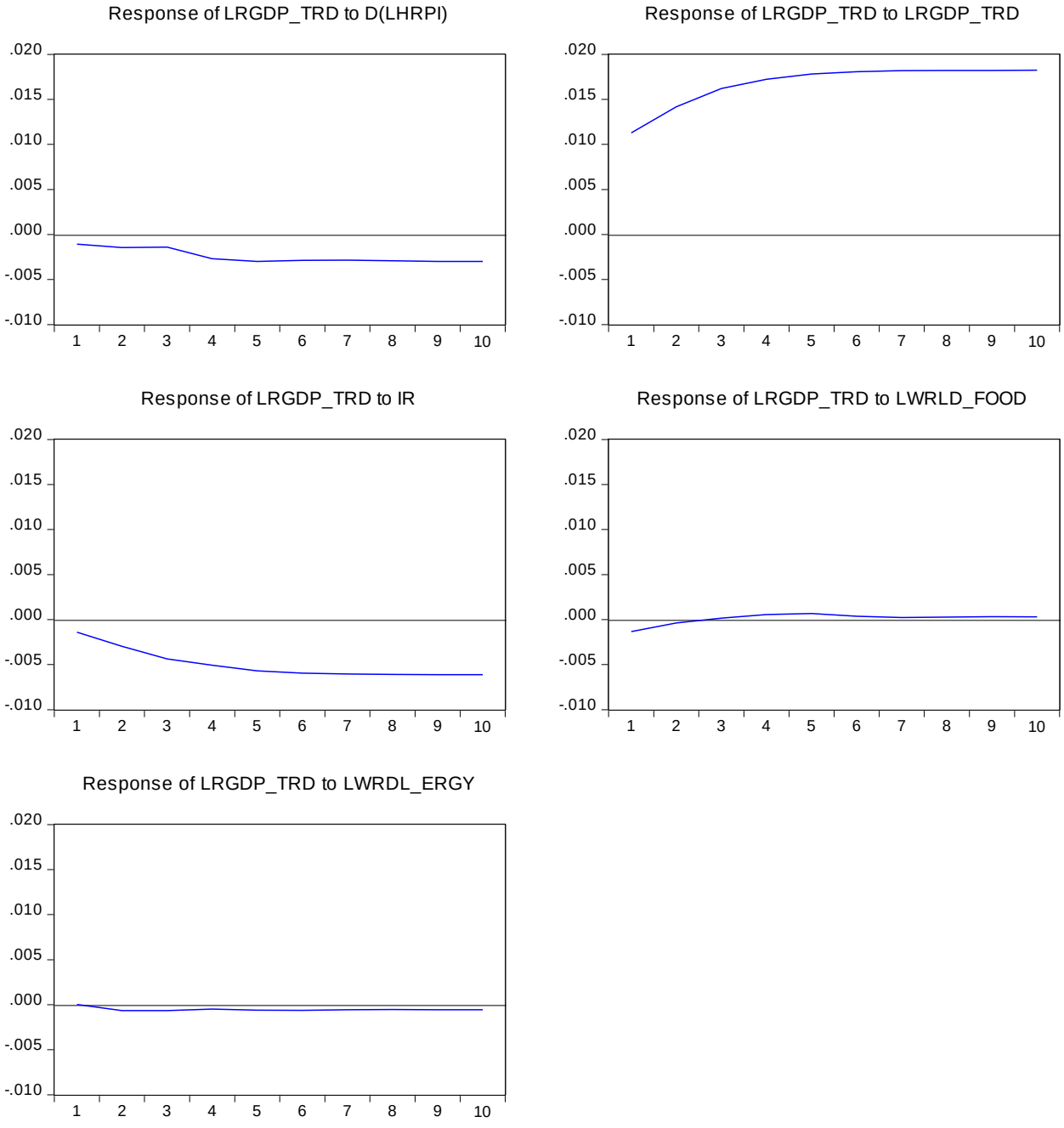
An evaluation of the impulse responses in Figure 3 using the generalized impulse definition suggests that a one standard deviation shock to international food and energy prices have similar

impacts on changes in the domestic prices. The impact of a one standard deviation in international food prices can be observed to have peaked in the third period, equating to nine months, while the reaction from a shock from world energy prices peaks in approximately six months. Additionally, the effects of these shocks can be observed to dissipate in about fifteen months with respect to food prices, while shocks from oil prices are generally more long lived.

As discussed previously, the immediate pass-through of energy prices can be attributed to the efficiency at which international price changes are passed on to the domestic consumer via the FCA. This result compares favourably with Misati (2013) who found that shocks from oil prices to domestic inflation occurred with a lag of three quarters and were found to persist beyond 10 quarters in the case of Kenya. In addition, Khan and Ayaz (2014), in the case of Pakistan, posit that after a three month interval the response of inflation to oil price starts to accelerate peaking at 11 to 12 months before dying out slowly.

Similarly, the response of price changes to a one standard deviation in interest rates, which peaks in the second period and persist in an analogous fashion to shocks from oil prices, suggest that the weighted average interest rate can be potentially viewed as being a cost-push factor in price formation process of the economy. In this regard, positive shocks to the weighted average lending rate should have a contractionary impact on domestic economic activity (see Figure 4).

Figure 4: Impulse Responses of LRGDP to Generalised 1 S.D. Innovations



Interestingly, as depicted in Figure 4, real economic activity is shown not to respond in any meaningful way to shocks in international commodity prices. This reflects the widely-held view that SVOEs are price takers and changes in aggregate demand impacts the balance of payments and not domestic prices (see Lorde et al. (2010) and Moore (2011) in the cases of energy).

Indeed, the heavy dependence on the importation of food and fuel has had a significant impact on the SVOEs current account balance.

On the other hand, economic activity is impacted negatively and for a prolonged period by shocks to changes in domestic prices. This apparent disconnect between international commodity prices and the influence of domestic prices on the local economy, may be characteristic of competitive forces within the domestic economy. While import demand can be said to be relatively price inelastic, final consumer demand may be sensitive to price changes originating domestically. The implication is that the current study should be used to expand upon the potentially influence of domestic factors by considering the impacts of tax changes and the effect of core inflation on the domestic economy.

Table 5: Variance Decomposition for LHRPI

Period	LHRPI	LRGDP_TRD	IR	LWRLD_FOOD	LWRDL_ERGY
1	100.0000	0.000000	0.000000	0.000000	0.000000
2	91.64964	0.127077	2.652950	0.302956	5.267375
3	77.67136	0.383574	5.412189	5.579788	10.95309
4	67.07202	0.483997	7.775944	10.94396	13.72408
5	60.68154	0.438200	9.758427	12.97570	16.14614
6	55.35254	0.372645	11.47871	14.05002	18.74609
7	50.41492	0.326178	12.96808	15.21737	21.07344
8	46.18988	0.290766	14.23454	16.28992	22.99490
9	42.70481	0.259434	15.31421	17.10517	24.61638
10	39.77939	0.232243	16.23996	17.73376	26.01464

The analysis of the variance decomposition results presented in Table 5 show that within one year a shock to international food and energy prices account for 10.9 percent and 13.7 percent of the variations in domestic retail prices, and nominal interest rates account for approximately 7.8 percent. These proportional rates continue to increase, with international energy prices accounting for 26 percent of the variation in domestic retail prices, providing further credence to the notion that its impact on the domestic economy is multiplicative in nature. Further research should therefore focus on disentangling the path of this pass-through, by considering indirect or

second-round effects, through the study of other drivers of domestic inflation, such as taxation and retailer markups.

6. Conclusion

This paper uses a VECM in conjunction with generalized impulse responses and variance decompositions to estimate the speed and magnitude of the pass-through of international food and energy price fluctuations on domestic retail price inflation. In addition, the paper attempts an initial inference about the impact of these fluctuations on domestic economic output, using quarterly data from 1985:Q1 to 2015:Q4. The central findings of this study suggest a relatively slow speed of adjustment of domestic prices from disturbances away from equilibrium. Furthermore, international energy prices appear to have a faster rate of pass-thorough, compared to international food prices. International food prices have a stronger short- run impact relative to international energy prices, with the roles reversed in the long run. The authors purpose that this is representative of the multiplicative role energy plays in the determination of domestic price levels in the predominantly services based Barbadian economy.

While the impulse responses of the domestic retail price index support this notion, as it relates to the speed and persistence of the response of domestic retail prices to external shocks, they also reveal that international commodity price shocks do not impact domestic economic activity in any meaningful way. Rather, there seems to be a hidden influence that can be construed as being domestic in origin and which warrants further investigation into aspects such as drivers of core inflation in Barbados. Based on these results, the study recommends that there is continued focus on appropriate measures geared towards reducing the Barbados' dependence on imported fossil fuel products. Given the significance of international food prices, the study also recommends fostering greater local food production, as well as leveraging potential safeguards under trade agreements in recognition of the Barbados' geographical and natural resource constraints.

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