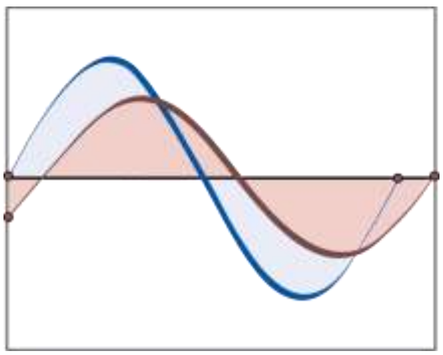
CENTRAL BANK OF TRINIDAD & TOBAGO

Working Papers

WP 03/2018 September 2018



The Economic Impact of Energy Price Shocks on a Small Open Petroleum Economy

Stefan Edwards and Timothy Woolford
Research Department

The recent downturn in the Trinidad and Tobago economy coincided with a period of low energy commodity prices, reinforcing the notion of the country's over-reliance on the energy sector. This phenomenon of energy sector over-reliance has been widely examined in several forums over the course of recent years. This paper goes further however, by constructing an energy price index from the WTI oil price and Henry Hub natural gas price. This index will be used to measure its impact on the rest of the macro economy, through proxies for fiscal conditions, the financial sector and economic activity in the energy and non-energy sectors. A structural vector autoregressive (SVAR) model was used with monthly data spanning the period February 2001 to May 2017. Results suggested that when energy prices remained low, several respondent variables also remained constrained or declined. Conversely, it was found that positive responses of the estimated variables depended on energy prices remaining significantly higher than the average level of the energy price index. The model also suggested that greater flexibility in the foreign currency market as well as 'normal' credit expansion constituted an appropriate monetary response to constrained energy prices.

JEL Classification: E5, E6

Keywords: energy price index, flexibility in the foreign currency market, credit expansion

The Economic Impact of Energy Price Shocks on a Small Open Petroleum Economy

Stefan Edwards
Timothy Woolford

I. Introduction

The recent downturn in the Trinidad and Tobago economy coincided with a period of low energy commodity prices. Prior to the fall-off in prices in 2015, oil and gas prices hovered near US$90 per barrel and US$4 per mmbtu respectively. The high commodity price environment augured well for economic prosperity. From 2010 onward however, several energy sector companies scaled up their planned maintenance activity in a bid to ensure proper health and safety standards were met and maintained. This period of emphasized maintenance coincided with delayed investments in natural gas production, periods of maturing oil field acreage and declining reserves. This was further compounded by the supply glut created in the oil market by the exploitation of traditionally infeasible shale reserves in the United States, which have since emerged as key assets in the global energy sector.

That all of these factors culminated into the energy sector conditions that drove the downturn of the Trinidad and Tobago economy, highlights to some extent the reliance placed on the energy sector. This phenomenon of energy sector over-reliance has been widely examined in several forums over the course of recent years. This body of work however seeks to take the analysis further by examining the impact of constrained energy prices on the rest of the macro economy. More specifically, we seek to extend our analysis beyond the real sector impact and examine the relationships between a constrained price scenario, fiscal conditions and the financial sector. In doing so, we seek to ascertain the policy constraints that an oil exporting economy faces under a low price scenario. By extension we also seek to uncover the appropriate policy response for Trinidad and Tobago under the aforementioned constraint.

To accomplish this we develop a structural vector autoregression (SVAR) model, using an energy price index derived from the WTI oil price and Henry Hub natural gas price in order to measure its impact on the rest of the macro economy. Firstly, the responses of government expenditure, as well as a variable developed to measure fiscal space, are outlined. Secondly, the impact of energy price shocks on the financial sector is assessed using proxies for conditions in the foreign exchange market and for banking sector behavior. Lastly, the impact of energy price shocks on energy and non-energy output is measured through the response of growth indices constructed from sectoral output data. The model used monthly data spanning the period February 2001 to May 2017.

Through our analysis we conclude that a central bank can create economic stimulus via management of the financial sector variables. Interestingly we find that this mechanism comes at the expense of a tradeoff between the strengthening of the fiscal positon versus that of the real sector. We however deduce that what amounts to a de facto currency depreciation in the context of a measured expansion in loans will facilitate a stronger fiscal position at the expense of lower levels of non-energy sector growth, but that this scenario is more concurrent with longer run macroeconomic sustainability in Trinidad and Tobago.

II. Literature Review

Several authors have attempted to describe the recent collapse of oil prices. Baffes et al (2015) characterized the sharp drop-off in oil prices between June 2014 and January 2015 as a result of several years of supply expansion, demand contraction, lowered geopolitical risk, changing OPEC objectives and an appreciating US dollar. Koh (2015) supported this position citing similar attributable factors to the oil price demise seen in recent years through applying panel VAR techniques using data from 40 oil exporting countries between 1973 and 2010 to show that output as well as government consumption would fall in response to an adverse price shock. The impact was translated into reduced inflationary, balance of payments and fiscal pressure in oil importing countries, while also supporting growth. Conversely, fiscal and external positions in developing oil exporting countries were expected to weaken, along with reduced growth. The output response was noticeably smaller in countries where there were flexible exchange rates as compared to those with fixed exchange rate regimes. In the case of the latter, the bulk of macroeconomic adjustments came in the form of fiscal contractions, on account of constraints to monetary policy brought about by a fixed exchange rate regime. Such countries, in a time of crisis require contractionary monetary policy in order to maintain the predetermined rate of exchange. This places the impetus on fiscal policy to bear the greater burden in stabilizing the economy. The presence of sovereign wealth funds however tempers the effect of fiscal contractions on output as they allow space to finance budget deficits.

Rodrik (2008) expands on the exchange rate discussion. The paper used panel regressions to examine the experience of seven developing countries to deduce a link between undervaluation of a nation's currency and economic growth. He argues that systemic devaluation of the currency speeds up the structural changes in an economy in a manner that promotes economic growth. Therefore, the depreciation of the real exchange rate in itself does not directly affect growth, but rather does so indirectly through the structural changes that it brings about. Ultimately, this suggests that an economy's reaction to an adverse price shock hinges on the structural make-up of the economy.

Seers (1964) makes the case that economic models tailored toward industrial economies were inappropriate for analyzing exporters of primary products. In this regard he asserts the need for models tailored toward the specific dynamics of an economy. There are, however essential characteristics that petroleum-based economies would possess. According to this framework it is of utmost importance that petroleum-based exports are of great volume and value. Additionally, government expenditure must be strongly tied to the revenues of said petroleum companies which are more than likely foreign-owned.

Such economies, according to this model are also vulnerable to adverse shocks. Under such conditions they become more susceptible to exchange rate depreciation, capital flight and a call for the protection of local industry. Underlying tensions between petroleum economies, trade unions, manufacturers and the unemployed also tend to be exposed in times of economic adversity. According to Seers, such economies tend to have a *"… potentially explosive character."* Seers' framework identifies employment levels as the most important aggregate in discussing the economics of the petroleum economy. The view held is that income levels are not as serious a concern in such economies as the persistence of chronic structural unemployment.

Further, government spending tends to be more capital intensive than labour intensive. In this regard, a government would more quickly spend on *"highways and housing schemes"* than seek to enlarge the goods-producing capacity of the economy. Such expenditures are seen as more politically beneficial. Additionally, there often exists a fear that undertaking the latter form of investment will expose them to risk of failure. Bruce and Girvan (1972) however sought to dispute Seers' model. They argue that though he attempted to establish the workings of the petroleum economy as unique, he inherently failed. His assumption that employment was the key concern in such economies was flawed in that employment levels were determined by levels of national income. They argue essentially that there is no clear distinction between the Open Petroleum Economy and the conventional Open Keynesian System.

Bruce and Girvan also argued that Seers assumed a state where the marginal propensity to save was identical to the marginal propensity to invest. This condition however was not deemed a necessary feature of any economy and there was no concrete evidence to suggest that the two rates would be identical. It was however ceded that any difference in the two rates would likely be marginal. However, in a state of disequilibrium (either trade surplus or deficit) the two main instruments that would come into play to restore balance would be the use of monetary and fiscal policy. Monetary policy, they argue would be ineffective as under the Keynesian approach investment is insensitive to interest rates. Even if it was, it would imply that investments were correlated to the levels of national income, thereby highlighting its significance in any economic framework.

Further to this, existing literature also suggests that open petroleum economies are vulnerable to the occurrence of Dutch Disease. Bruno and Sachs (1982) cited this phenomenon as the shift of an economy's productive resources from the tradeable goods sector to non-tradeable goods sector. This shift is associated with wealth increases following booming demand on account of higher wealth in resource rich countries. Using simulation models the authors deduced that the net effect of the energy sector in a multi sector open economy is to reduce long run production of other tradables.

III. Data

The data used in the model consist of seven variables at a monthly frequency spanning February 2001 to March 2017. All variables were transformed via log-differencing. Firstly, an energy price index is used as the source of structural shocks in the model. This index is simply calculated as the product of the monthly WTI oil price and the Henry Hub price for natural gas. In order to identify differing macroeconomic effects of variance in energy prices on Trinidad and Tobago, two versions of this index are utilized. The first, simply denoted as E_IN is the 12-month moving average value of the index. This index is essentially taken to contain all the variability associated with energy prices. The second version of this index limits the data points exceeding the upper threshold of one standard deviation above the mean i.e., the 12 period moving average of the E_IN, and is denoted as E_IB. The results of the model depend in a large part on the difference in the effect of these two alternative scenarios on the rest of the variables in the model.

Firstly, the energy sector is included in the model with estimates of output that span the reference period. Indices of monthly sectoral growth were developed for several subsectors of economic activity. The weighting system used in calculations of the Central Bank's Quarterly Index of Economic Activity was applied to the growth rate of each indexed variable and were then summed according to whether they belonged to the energy or non-energy sectors. A 12-month moving average of the respective estimated series was taken. The subsectors comprising the energy output estimate were Natural Gas Production, Crude Oil Production, Production of Methanol and Production of Ammonia. The energy sector output estimate was denoted simply as ENERGY.

Secondly, a condition estimating fiscal space is used to measure the impact of the changes in the energy price index on the domestic fiscal conditions in Trinidad and Tobago. The condition, denoted (I_E) is utilized in the model to give a sense of whether expenditure becomes excessive. It is taken as the ratio of the hypothetical level of the calculated budget constraint (I) and actual expenditure (E), thus the I_E variable is equal to I/E. The I_E variable is based on a hypothetical budget constraint that takes into account both the budget constraint of the Treasury combined with the effect of changes to high powered money on this constraint (Walsh, 2010). That is, the I_E variable reflects the sum of the changes to government revenue, debt and seigniorage[1]. The I_E variable therefore reflects a sustainability condition on expenditure, in that it provides a hypothetical limit on government spending that current fiscal conditions allow.

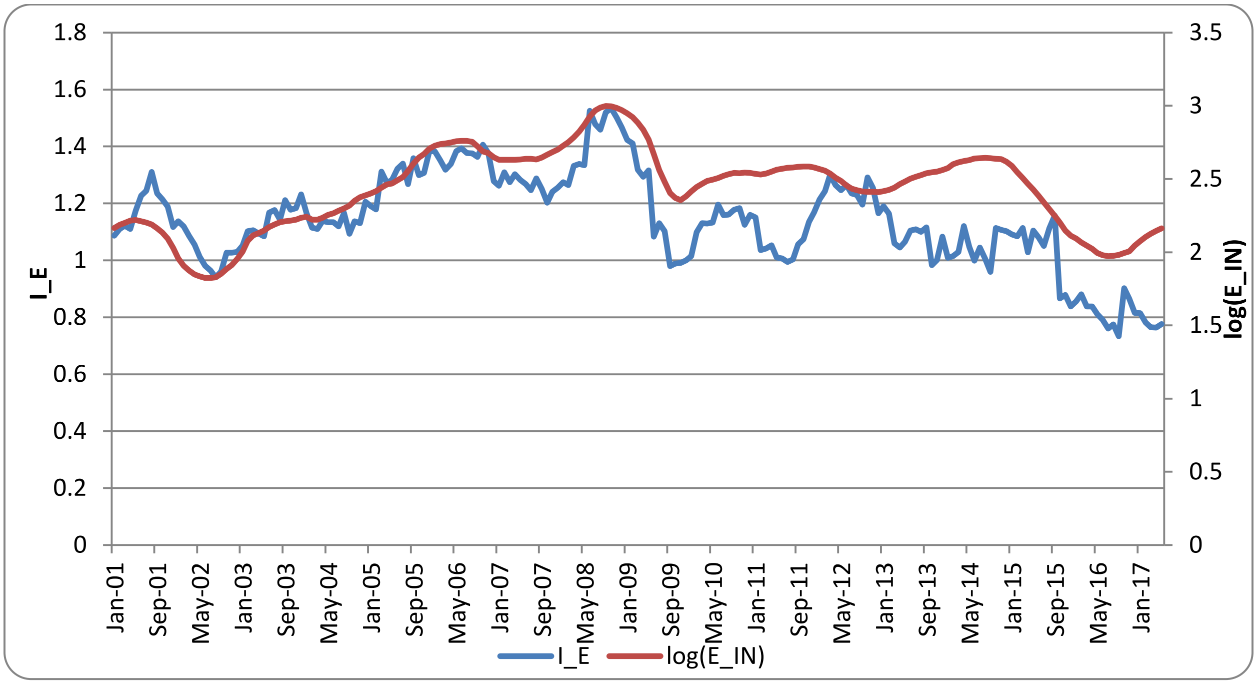
A reasonable apriori expectation for the I_E variable is that it would respond positively to changes in the energy price indices. The relationship between energy prices and fiscal conditions is shown in Figure 1 below, which describes the evolution of the logarithm of the 12-month moving average of the energy price index, versus the I_E variable. Notably, the only instance in which the I_E ratio moved below unity for an extended period, i.e. reflected that actual

[1] As proxied by changes to Base Money (M-0).

expenditure has exceeded the limit prescribed as sustainable, was in response to the energy price decline that began in late 2014.

Figure 1

Energy prices vs. Fiscal Conditions



Source: Central Bank of Trinidad and Tobago

The model assumes the effects of energy prices would be transmitted to the financial sector via two channels. Firstly, the effects would be felt in the market for foreign exchange. The main source of foreign exchange in the financial sector is conversions by transnational energy companies. More fully, total public supply of foreign currency comes from the purchases (P) of all authorized dealers from all economic sectors. Additionally, tax and royalty revenue from transnational energy companies make up the largest source of the official reserves of the Central Bank. The Central Bank occasionally intervenes with sales of foreign exchange to the financial sector (I) that are funded from its official reserves in order to maintain an orderly market for foreign exchange. Supply of foreign exchange is therefore deeply enmeshed with energy sector revenues, and thus energy prices should affect the market for foreign exchange, in that increased prices should increase supply and vice versa. Foreign exchange market supply conditions are modeled through the identity (I+P/P). This ratio measures the relative importance of the Central Bank sales of foreign currency to authorized dealers relative to the total supply of foreign currency, and is denoted INT.

Following this, the behavior of the sub-section of the financial market operating in domestic currency is also considered. The ratio of deposits to loans, denoted as D_L in the model, is used to describe the behavior of the domestic commercial banking system. Commercial banks optimize the level of loans and deposits on their balance sheets with respect to costs, risks and subsequently, profit. The ratio should therefore capture the behavior of the commercial banks in response to changes in energy prices. These effects can be expected to be more indirect, though foreign exchange conversions as well as fiscal conditions can be expected to affect levels of domestic liquidity, and may thus affect the ratio of deposits to loans. In this case, the expected response in the D_L variable would be negative, but the totality of the a priori effect of energy prices on the banking sector is not clear, and the rationale for including this variable is investigative.

Similar to the method used to estimate energy sector activity, estimates for manufacturing sector activity as well as distribution sector activity were included to reflect the effect of a negative shock in energy prices on the non-energy sector. The manufacturing sector output estimate included DRI Production and Domestic production of cement, whereas the distribution sector activity estimate included Total sales of New Motor Vehicles and Local Sales of Cement. They were denoted MANUF and DIST respectively.

IV. Methodological Considerations and Model

An SVAR model is set up as follows:

$$Ay_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + B\varepsilon_t \qquad \text{eq. 1}$$

where y_t is a K-dimensional vector of observable variables, ε_t is a K-dimensional vector of structural innovations with mean zero and identity covariance (Lutkehpol, 2005). The *KxK* matrix A sets the contemporaneous feedback effects among the observable endogenous variables, and its diagonal elements are normalized to one. The vector y_t therefore contains the macroeconomic variables discussed above and can be denoted as **y_t = [E_IN, ENERGY,I_E, INT, D_L, MANUF, DIST]**. The vector of structural shocks ε_t can thus be denoted **$\varepsilon_t = [\varepsilon_t^{E\_IN}, \varepsilon_t^{ENERGY}, \varepsilon_t^{I\_E}, \varepsilon_t^{INT}, \varepsilon_t^{D\_L}, \varepsilon_t^{MANUF}, \varepsilon_t^{DIST}]$**. The denoted structural form corresponds with a reduced form error term $u_t = A^{-1} B\varepsilon_t$, which can be estimated from the data. This can be done conventionally by imposing a set of identifying linear restrictions on A and B to find a unique relation.

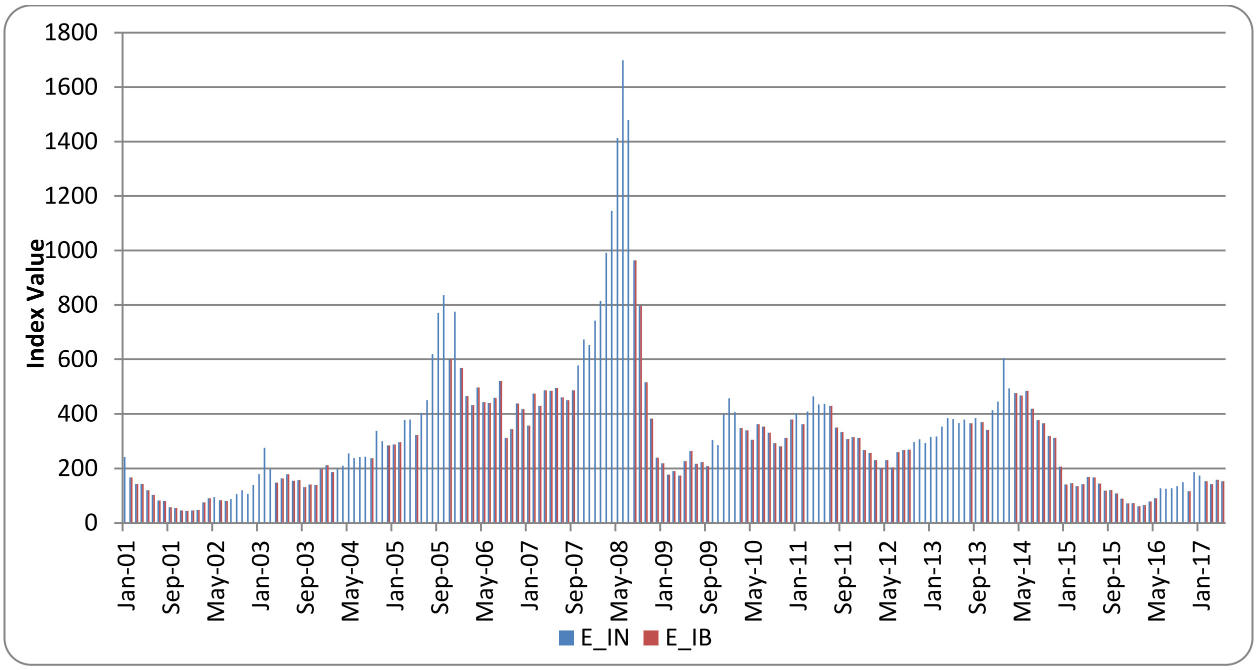
The model aims to establish uniqueness between the scenarios of high and low energy prices in order to estimate the effects of the differing conditions on the subsequent economic variables.

One way to do this would be to identify a change in regime of the series under consideration denoted by a breakpoint that separates partitions of the series characterised by differing conditional means or variances (Perron and

Vogelsang, 1991; Rigobon, 2003; Lanne and Lutkepohl, 2006). A potential issue arises however with the use of a single breakpoint. While only a single regime shift was identified by breakpoint testing, it may leave several structural breaks unidentified and lead to a loss of information (Glynn, 2007). As shown in Figure 1 above, fiscal conditions only became unsustainable in response to the energy price declines that occurred in 2014. This notable development is however not detected by a breakpoint test applied to the energy price index (E_IN), which identifies August 2008 as the main structural break in the series[2]. In lieu of a more stringent method to reveal structural breaks, this exercise adopts a threshold based approach. The alternate scenarios of the energy index variables are considered as shown in Figure 2 below:

Figure 2

The Alternate Energy Price Scenarios and the Moving Average of the Energy Price Index



Source: Central Bank of Trinidad and Tobago

All values shown in the chart are taken into consideration in denoting the E_IN variable, whereas all values denoted E_IB make up a truncated energy index, which represent all values below the upper standard deviation limit of the 12-period moving average of the E_IN variable. The one-standard deviation threshold applied reveals several more instances in the series where increases in the value of the energy price index significantly exceeded the set threshold, showing that limiting analysis to just two regimes would be restrictive. Instead, the full and truncated energy index series are treated as alternate scenarios, with the truncated series being considered a counterfactual.

[2] See Appendix A for Dickey-Fuller Unit Root Breakpoint Test.

The E_IN and the E_IB series therefore provide the origins of the structural shocks in their respective scenarios, and the results are compared.

The following relations between the reduced form residuals and the structural innovations were assumed based on the expected sequence of economic activity and the correspondent flow of funds in an open petroleum economy[3]:

$U_t^{E\_IB} = \varepsilon_t^{E\_IB}$ (Energy Price Index)

$U_t^{ENERGY} = \varepsilon_t^{ENERGY} + U_t^{E\_IB}$ (Energy Production)

$U_t^{I\_E} = \varepsilon_t^{I\_E} + U_t^{E\_IB} + U_t^{ENERGY}$ (Fiscal Space)

$U_t^{INTERV} = \varepsilon_t^{INTERV} + U_t^{E\_IB} + U_t^{ENERGY}$ (Forex Interventions)

$U_t^{D\_L} = \varepsilon_t^{D\_L} + U_t^{ENERGY} + U_t^{F\_SP} + U_t^{INTERV}$ (Ratio of Deposits to Loans)

$U_t^{MANUF} = \varepsilon_t^{MANUF} + U_t^{E\_IN} + U_t^{ENERGY} + U_t^{I\_E} + U_t^{INTERV} + U_t^{D\_L}$ (Manufacturing Activity)

$U_t^{DIST} = \varepsilon_t^{DIST} + U_t^{ENERGY} + U_t^{I\_E} + U_t^{INTERV}$ (Distribution Activity)

If we consider that the AB system contains $2K^2$ elements, we understand that $2K^2 - {}^1/_2K(K+1)$ restrictions are required in total to identify the model. A minimum of using a Cholesky decomposition on the matrix A as well as ensuring all off diagonal elements of matrix B are zero would satisfy this condition and make the model 'just-identified'. Coefficient significance was also used as a guiding rule of thumb in determining which elements further to those not in the outlined flow of funds relations should be restricted. Initial iterations of the model restricted the matrix A^{-1} according to the outlined relations. The off diagonal upper triangular elements were all restricted to zero, as the model does not consider feedback effects. Complementary to the outlined relations, the insignificant lower triangular elements outside of the specified relations were restricted to zero as well, while any extra significant coefficients outside the specified system were included in order to minimize the resulting degrees of freedom. The following AB-type macro-system resulted for the E_IN scenario:

[3] As a matter of course, the RHS elements of these equations would be subject to the typical AB-matrix coefficients, with the U_t elements subject to the A coefficients and the ε_t elements subject to the B coefficients.

$$U_t \begin{bmatrix} u_t^1 \\ u_t^2 \\ u_t^3 \\ u_t^4 \\ u_t^5 \\ u_t^6 \\ u_t^7 \end{bmatrix} = A^{-1} \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ \alpha_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ \alpha_{31} & \alpha_{32} & 1 & 0 & 0 & 0 & 0 \\ \alpha_{41} & \alpha_{42} & \alpha_{43} & 1 & 0 & 0 & 0 \\ 0 & \alpha_{52} & \alpha_{53} & \alpha_{54} & 1 & 0 & 0 \\ \alpha_{61} & \alpha_{62} & \alpha_{63} & \alpha_{64} & \alpha_{65} & 1 & 0 \\ \alpha_{71} & \alpha_{72} & \alpha_{73} & \alpha_{74} & 0 & 0 & 1 \end{bmatrix} \cdot B \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_{77} \end{bmatrix} . \varepsilon_t \begin{bmatrix} E\_IN_t \\ ENERGY_t \\ I\_E_t \\ INT_t \\ D\_L_t \\ MANUF_t \\ DIST_t \end{bmatrix} \text{eq.2}$$

The model is over-identified with 3 degrees of freedom. For the observable variables, the matrix A represents the matrix of coefficients, the matrix B is the matrix of covariances, the matrix U_t represents the *k*-dimensional reduced form vector of errors and the matrix ε_t represents the vector of structural shocks. The restrictions imply that the deposits to loans ratio does not respond to energy prices owing to the restricted relation of the E_IN variable in the INT equation to zero. By the same reasoning, the distribution sector remains unaffected by the behavior of commercial banks and manufacturing sector activity. The following system was outlined for the E_IB scenario:

$$U_t \begin{bmatrix} u_t^1 \\ u_t^2 \\ u_t^3 \\ u_t^4 \\ u_t^5 \\ u_t^6 \\ u_t^7 \end{bmatrix} = A^{-1} \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ \alpha_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ \alpha_{31} & \alpha_{32} & 1 & 0 & 0 & 0 & 0 \\ \alpha_{41} & \alpha_{42} & 0 & 1 & 0 & 0 & 0 \\ 0 & \alpha_{52} & \alpha_{53} & \alpha_{54} & 1 & 0 & 0 \\ \alpha_{61} & \alpha_{62} & \alpha_{63} & \alpha_{64} & \alpha_{65} & 1 & 0 \\ 0 & \alpha_{72} & \alpha_{73} & \alpha_{74} & 0 & \alpha_{76} & 1 \end{bmatrix} \cdot B \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_{55} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_{66} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_{77} \end{bmatrix} . \varepsilon_t \begin{bmatrix} E\_IB_t \\ ENERGY_t \\ I\_E_t \\ INT_t \\ D\_L_t \\ MANUF_t \\ DIST_t \end{bmatrix} \text{eq.3}$$

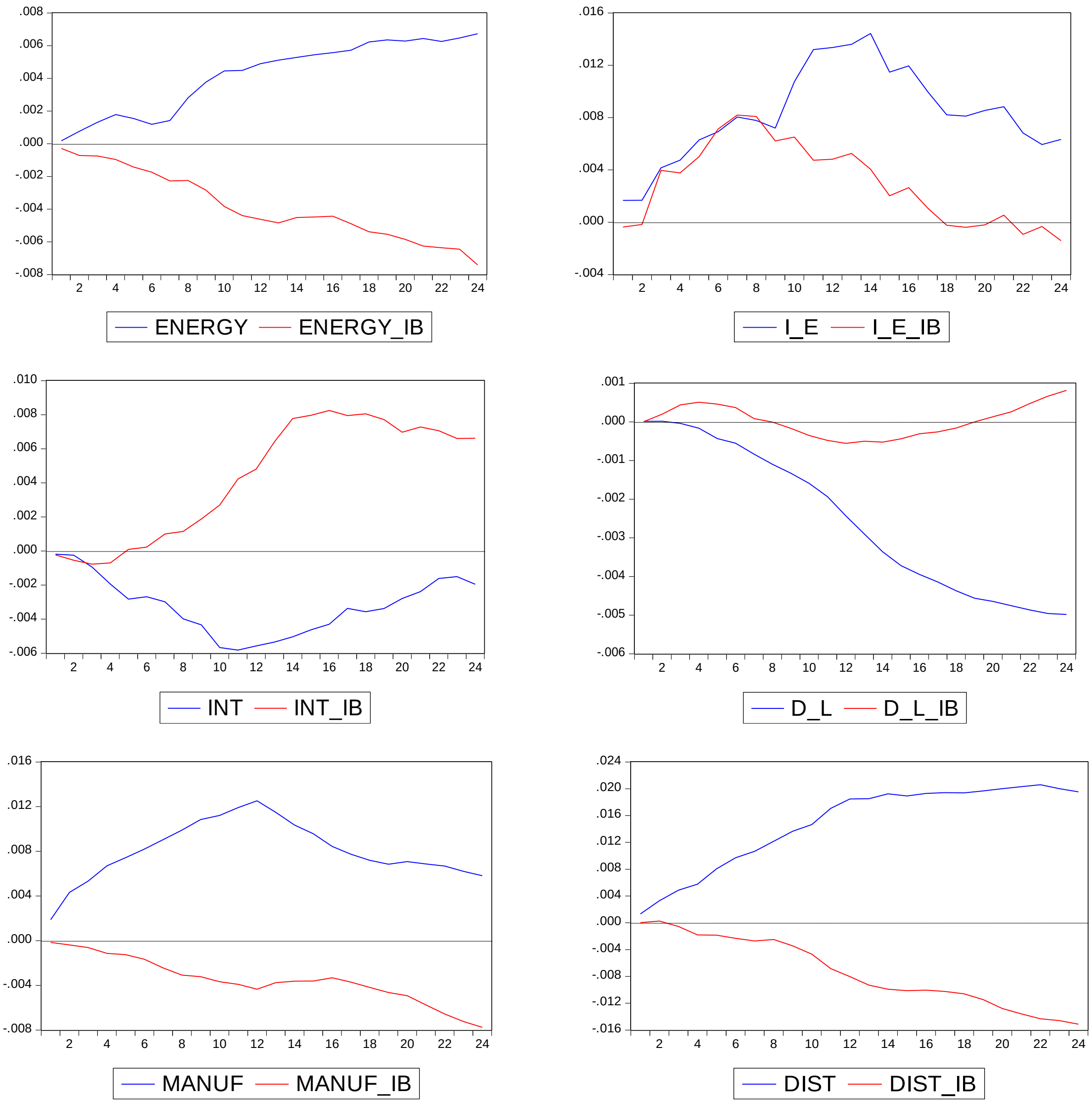
The model is over-identified with four degrees of freedom. Interventions in this case are unaffected by fiscal conditions, the domestic currency financial sector is unaffected once again by energy prices and the distribution sector is unaffected by energy prices as well as the deposits to loans ratio.

The simulated scenario E_IB, removes the values above one standard deviation of a 12-month moving average of the energy price index calculated as the product of the WTI oil price and Henry Hub natural gas price. The rationale for assessing a model based on E_IB was delineating the response of the subsequent variables in the model to shocks associated with a series that is not characterized by the highest value combinations of the oil and gas prices. That is, shocks delivered under this model setup were constrained with respect to their extremity. This provided a benchmark to measure the unconstrained (E_IN) scenario against, in order to determine the effect the values of the energy price index above one standard deviation of the mean had on the subsequent variables in the model.

The impulse response functions (IRF's) derived from both scenarios are shown in Figure 3 below:

Figure 3

Cumulative Impulse Response Functions for E_IN and E_IB scenarios



Source: Author's calculations.

From the above impulse responses, it is shown that energy production increases in the unconstrained price (E_IN) scenario and declines in the constrained price (E_IB) scenario. When energy prices include their extreme positive values under the unconstrained scenario, energy sector activity (ENERGY) increases dramatically, but in the scenario where energy prices do not exceed one standard deviation above the mean (ENERGY_IB), energy sector activity declines. These developments are in line with a priori expectations. Cumulative fiscal space (I_E) grows rapidly in the E_IN scenario, settling at a much higher level over the reference period. Fiscal space however declines in the E_IB scenario, reaching a more constrained position by the end of the reference period. These responses seem to reflect cyclicality in fiscal conditions with respect to energy prices, similar to the scenarios outlined in Seers (1964) and Bruce and Girvan (1972). In the context of the model and the method by which the I_E variable was developed, unsustainable fiscal conditions can be roughly defined as the case where expenditure exceeds fiscal space. Thus in the unconstrained scenario the path of the IRF implies that expenditure has at least shifted nearer to a level that can be considered unsustainable.

Under unconstrained price conditions, the ratio of total supply of foreign currency to public supply (INT) declines after the structural shock, ostensibly as supply (purchases from the public by the authorized dealers) increases, before nearly reverting to its original position by the end of the reference period. However, the IRF of INT responds in the opposite fashion and increases under constrained price conditions. This is concurrent with the expectation that the public supply of foreign currency would be curtailed when energy prices decline. The implication is that the supply of foreign currency is constrained if information from energy prices above one standard deviation of its moving average is truncated from the energy price index. The positive profile of the INT_IB impulse response function likely reflects increased interventions concurrent with the aim of maintaining an orderly foreign currency market.

Under unconstrained conditions the deposit to loan ratio (D_L) declines significantly throughout the reference period. This scenario includes increasing energy production as well as improved fiscal conditions, which imply increasing fiscal expenditure in the scenario as well. This decreases the likelihood that deposits, driven by Government payments, are declining. The implication is that the movement of the ratio is therefore driven by increasing loans, meaning that lending conditions respond positively to energy prices. However, in the constrained scenario, the ratio fluctuates around zero over the reference period. Deposit creation may slow, following lowered Government payments resulting from declining energy production and fiscal conditions. However, the implication in this scenario is that credit slows to a greater degree. Additionally, an increasing ratio of deposits to loans implies a buildup of excess reserves. The conclusion here is that credit growth is stymied if energy prices do not exceed one standard deviation above its mean.

Similarly, both manufacturing activity (MANUF) and distribution sector activity (DIST) increase significantly in response to an energy price shock under unconstrained conditions. They both decline, however if energy prices do not exceed a standard deviation of the mean. There is thus an implication that the rest of the real economy is linked to energy prices, as both manufacturing and distribution sector activity seem to be stymied by energy prices that are not above one standard deviation of the mean.

V. The Constrained Scenario

The results shown in Figure 3 imply that the larger part of positive economic results in Trinidad and Tobago since the early 2000's has been driven by a combination of oil and gas prices that can be described as statistically 'high'. Since mid-to-late 2014 however, energy prices, particularly oil prices have declined dramatically. The average monthly WTI price declined from US$97.90 per barrel over 2013 to US$43.14 per barrel in 2016. The decline has been considered a structural shift in many quarters, driven mainly by a supply glut that has not had a sufficient increase in demand to compensate. As such, it is considered unlikely that the long term prices of hydrocarbons will reach levels seen in the late-2000's and early-2010's for any significant period in the foreseeable future (IMF WEO, 2017). The constrained scenario outlined in the model therefore becomes important in this context, and investigating the dynamics of the relationships between energy prices, the financial sector and the real economy in this scenario can provide a framework for developing an appropriate policy response.

The operations of a central bank impact the financial sector. Specifically, a bank intervenes in the market for foreign currency with the aim of maintaining an orderly market, and the main policy tool of the bank i.e., the Repo rate operates through the traditional monetary transmission channels, including the credit channel (Boodoo and Cheong, 2006). The ratio of total to public supply of foreign currency (INT) and the ratio of deposits to loans (D_L) become relevant to the analysis in the sense that while they are not modeled as policy tools, they are variables the operations of a central bank can affect.

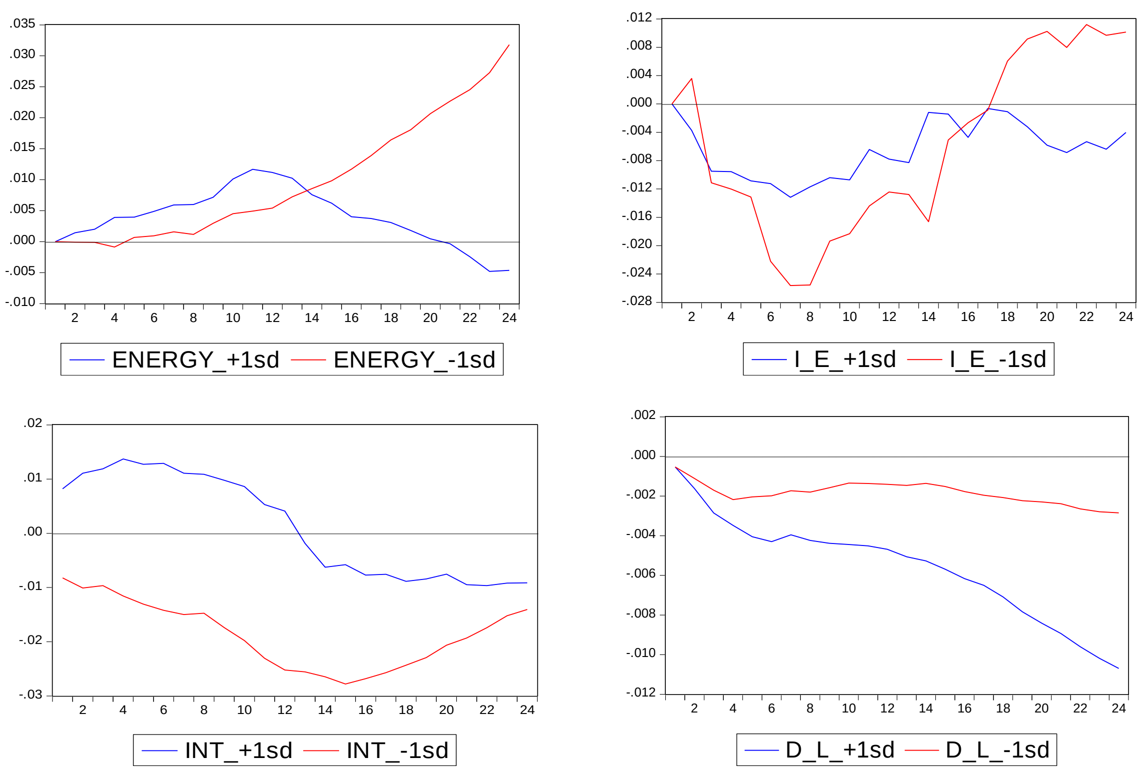
Fiscal conditions are not considered as an operating target of policy in this case for the reason that fiscal targets are the purview of a central government and not a central bank. Additionally, imposing a shock in this model that increases fiscal expenditure through a decline in the I_E ratio in the context of effectively lower oil prices raises the question about how this expenditure would be funded, which is beyond the scope of this paper. Nevertheless the effects on fiscal conditions of the changes in foreign currency interventions and the deposits to loans ratio are agnostically assessed. Additionally, the responses of the manufacturing and distribution sector activity, which both become negative over the reference period in the constrained scenario, are also assessed in the context of shocks from the financial sector variables. The aim of policy in the constrained scenario is taken to be the management of the financial sector conditions to find some optimal balance of economic activity and fiscal conditions. Reverting to the Cholesky decomposition, the ε_t vector is modified as follows and applied to the model:

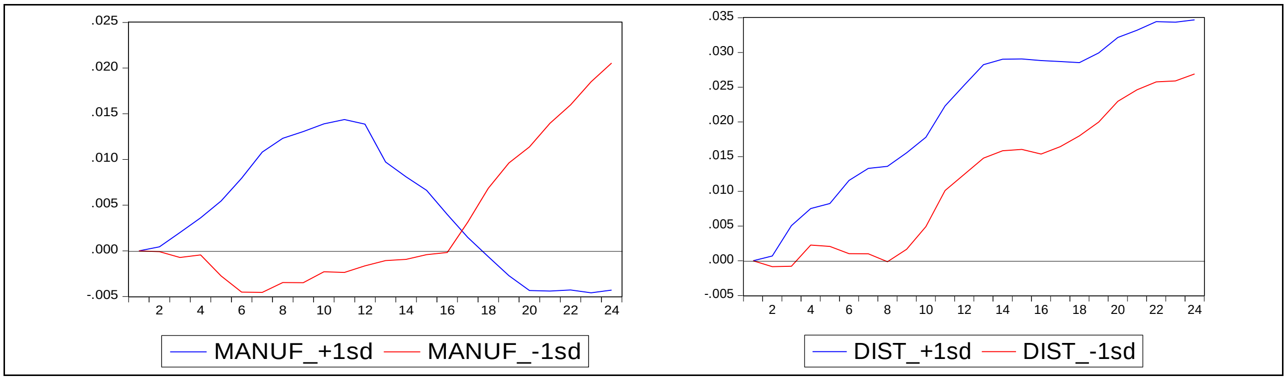
$$\varepsilon_t = \begin{bmatrix} E\_IB_t \\ 0 \\ 0 \\ INTERV_t \\ D\_L_t \\ 0 \\ 0 \end{bmatrix} \qquad \text{eq.4}$$

It is important to note that the source of shocks in the model remains the E_IB variable. The adjustments to the vector ε_t mean the first round effects of the restricted elements are removed, meaning that the IRF's of the restricted variables represent the summation of responses to the shocks originating from the unrestricted variables i.e., the first round shocks from the restricted variables are not considered. Under evaluation therefore, is the combined response required by the INT and D_L variables in order to return the IRF's of the fiscal and output variables to a favourable position. A negative two standard deviation shock is delivered to the E_IB variable and the resulting impulse response functions are shown in Figure 4 below:

Figure 4

Policy Response Scenarios Under Constrained Energy Prices





Source: Authors Calculations.

Two main scenarios were evaluated with respect to optimizing fiscal and output conditions. The first scenario applied to the D_L ratio. A small negative shock of approximately one sixth of a standard deviation was applied with respect to the D_L variable. This was found to ensure credit creation in both scenarios and to be consistent with more favourable fiscal and output conditions. This shock was applied in both scenarios. This reflected the idea that even in constrained price conditions, increases in loans relative to deposits well within an essentially 'normal' magnitude seem to facilitate positive macroeconomic results. The model's implication therefore is that under constrained energy price conditions, Bank policy should aim toward credit creation to bolster output.

Secondly, two alternate scenarios concerning the INT variable were tested. The first was defined by delivering a positive one standard deviation shock to foreign exchange interventions (+1SD), and the second was defined by delivering a negative one standard deviation shock to interventions (-1SD). Given its role as a proxy to an operational target, it is worth considering how the Bank intervenes in the foreign exchange market. It should be noted that the Bank occasionally intervenes in the foreign currency market to cover the net sales gap. This gap is the difference between sales to the public and purchases from the public by authorized dealers. As the Bank's forex operations aim to maintain an orderly market by maintaining a functional level of liquidity, foreign exchange interventions and the sales gap roughly equate. The implication however is that changes to the sales gap would be matched by interventions.

In the constrained scenario, purchases from the public are expected to decline. This development is likely what drives the increase of the 'INT_IB' impulse response function in Figure 3, as 'P' declines in the identity (I+P/P). Even if demand for foreign exchange remains constant, interventions would increase to match a growing difference between sales to the public and purchases from the public of foreign currency by authorized dealers. This decline of 'P' is likely what is reflected in the early periods of the INT_+1SD scenario in Figure 4. The INT_-1SD scenario however, imposes a negative shock on the (I+P/P) ratio. It is unlikely that purchases increase in the constrained scenario, thus it is interpreted as a rolling back of the extent to which the Bank intervenes to cover the net sales gap.

Considering the alternate scenarios for interventions, it is noted that the IRF's for energy sector activity respond positively to the scenario of negative shocks to interventions over the reference period. The IRF of the fiscal conditions variable (I_E) declines deeply in the early periods of both scenarios, reflecting the expected response of fiscal policy to energy price shocks outlined in Bruce and Girvan (1972). Fiscal conditions however become much more accommodative in the long run in response to lowered foreign currency interventions, recovering dramatically to settle in positive territory after the initial shock to revenue decreases it. The implication is that there may be some relation between monetary conditions and fiscal space that is not directly modeled, perhaps as lowered interventions increase the potential for growth in the monetary base, increasing the likelihood of raising revenue through debt and seigniorage.

Manufacturing sector activity reports differing long term responses to changes in the shocks from the INT variable scenarios. Manufacturing activity (MANUF_+1SD) increases in the short run but falls steeply to a negative cumulative position by the end of the reference period, in response to increased interventions. Conversely, after a slight initial decline, manufacturing activity (MANUF_-1SD) increases significantly in response to a lowering of the INT variable by one standard deviation.

If increased foreign currency interventions are interpreted as an induction of de facto nominal appreciation pressure to facilitate stability in the foreign currency market, lowered interventions thus amount to de facto nominal exchange rate depreciation. Theoretically, increased output is the expected result of an exchange rate depreciation, particularly if it can be interpreted as a result of an unanticipated monetary disturbance (Obstfeld and Rogoff, 1995). A change in interventions alters the ratio of foreign to domestic currency, with lowered interventions meaning that the ratio of foreign to domestic currency available in the financial system declines. From a purely monetary standpoint, an increase in the supply of domestic currency versus foreign currency can be considered a de-facto depreciation.

The mechanism by which this occurs in a small open economy may be different to what is purported by the main theoretical framework, which relies on an increase in domestic consumption to drive increased output. Small open economies are however, generally more trade intensive, and the implication is that trade would be the channel through which foreign exchange conditions affect manufacturing. A 'derived demand' effect was postulated for the economy of Belarus (Mazol, 2015) in response to a devaluation, which implies that even nominal increases in domestic prices of export goods can induce manufacturers to increase exports. The increase in the direct costs of imported intermediate goods may also stimulate manufacturers to increase exports in order to maintain some level of autonomous transactionary liquidity in foreign currency, unrelated to interventions in order to facilitate their operations. Increased exchange rate volatility was found to have this effect in Zambia (Rankin and Simumba, 2016), where episodic volatility in foreign exchange conditions was found to increase export variety as well as increase entry into the export market.

In any event, increased manufacturing activity in response to lowered interventions is consistent with the idea that inflexible foreign exchange market conditions are associated with higher output volatility and slower output growth (Levy-Yeyati & Sturzenneger, 2003). The conclusions of Koh (2015) also suggest that inflexible foreign exchange regimes are associated with higher output volatility. These results also reconcile with the work of Rodrik (2008), which argued that a systemic devaluation of the currency speeds up the structural economic change in a manner that promotes growth. Therefore, the de facto depreciation of the nominal exchange rate via reduced interventions affects economic activity through the structural changes it creates via inducing an environment of competitiveness. The model thus suggests that in the case of a managed market for foreign currency as exists in Trinidad and Tobago, there seems to be merit in allowing flexibility in the market for foreign currency under conditions of constrained energy prices.

Retail and distribution activity are highly dependent on imports. This is reflected in their consistently high demand for foreign currency (CBTT, 2016). An increase in interventions relaxes the hard-currency constraint on international transactions faced by households and firms, amounting to a de facto appreciation of the domestic currency. Funding interventions from official reserves in this way increases import based distribution sector activity, as it decouples current availability of foreign currency from current price conditions. The increase in distribution sector growth under conditions of increased foreign currency interventions (DIST_+1SD) is thus interpreted as a service-demand (retail and distribution) driven impetus to growth. This demand is facilitated by increased foreign currency interventions i.e., a de facto exchange rate appreciation, similar to the fashion described by Corden and Neary (1982). A decrease in interventions would however amount to a de facto depreciation of local currency. This would have the effect of curtailing excess demand for foreign currency denominated goods and services, but the effect on distribution sector activity is not prolonged, as reflected by the rapid rate of increase of the DIST_-1SD impulse response function by the end of the reference period after being temporarily stymied at the beginning of the reference period. This reflects that distribution sector activity is not significantly affected by foreign exchange market conditions, raising questions about how the liability it imposes on the balance of payments can be managed going forward.

The choice that presents itself to the policymaker in response to constrained energy prices is therefore the direction of foreign exchange interventions. It should be noted firstly that fiscal conditions are more favourable in the long run in response to a scenario of a one standard deviation decrease in interventions. The long run response of manufacturing activity is also more favourable in the context of a one standard deviation decrease in foreign currency interventions, and is interpreted to result from positive productivity changes originating from a de facto depreciation of the currency.

While there is a larger magnitude response in distribution sector growth to increased forex interventions, these net gains to growth are interpreted to originate from imposing outflows on the country's balance of payments. These outflows emerge via decreasing official reserves by conducting interventions and weakening the current account through higher imports. They may represent an imbalanced and unsustainable position and are similar to the results found in Buetzer, Habib and Stracca, (2012), who predict oil exporters will draw down foreign reserves to defend a currency peg in response to low energy prices. The summary information in the model can therefore be said to suggest that managing forex market conditions to allow at least a de facto exchange rate depreciation via lowered foreign currency interventions, while fostering credit growth well within the bounds of normality, are appropriate responses to energy prices constrained in the model's fashion.

VI. Conclusion and Recommendations

Our analysis has highlighted that the Trinidad and Tobago economy has benefitted from high energy prices. However, under the imposition of a scenario of constrained energy prices the benefits disappear. The results of the model show that fiscal, financial and real sector conditions all deteriorate if energy prices do not exceed one standard deviation of its 12-period moving average. Such behavior is symptomatic of an economy that has remained dependent on its energy sector over the period under analysis. Further, it emphasizes the country's position as a price-taker thus placing it in a precarious position in the absence of high commodity prices. Analysis of the real sector underscores this notion as it showcases the restricted movement of output under the condition of prices remaining below one standard deviation of the mean. This behavior of non-energy output highlights a reliance on strong energy commodity prices to drive the overall economy. The model also points to symptoms of Dutch Disease and an inability to move toward a more diversified economy.

Further, from a monetary policy perspective, the model suggests that monetary tools can act as mechanisms through which growth can be facilitated under constrained energy price conditions. Through the imposition of foreign exchange interventions via both positive and negative one standard deviation shocks, as well as an imposition of a small impetus toward credit expansion, the model investigated the respective outcomes in both the fiscal and real sector variables. Fiscal conditions as well as conditions for manufacturing sector and energy sector output, all responded favourably in the long run to a scenario interpreted to be characterized by decreased foreign exchange interventions.

Comparison of the alternative intervention scenarios appears to suggest a tradeoff between short term and long term economic sustainability. Under the scenario characterized by constrained energy prices, increased foreign exchange interventions appear to bolster non-energy sector activity based on the import dependent nature of both the manufacturing and distribution sector. Such a stance by a monetary authority inherently acts as a buffer to the non-energy sector that allows them to, in the first instance, ramp up their levels of economic activity. The cost of this buffer however comes in the form of a depletion of official reserves. Further the positive results that found in the long term which arise in the reduced intervention scenario seem to reflect a more sustainable long run economic position.

The scenario of reduced interventions facilitates a more sustainable economic trajectory for Trinidad and Tobago. Under constrained energy price conditions, governments of small, open, petroleum price-taking economies will likely try to immediately stimulate economic activity through fiscal and monetary policy. This approach can often be costly, resulting in accumulated rapid, long term deterioration in fiscal conditions and depletion of official reserves through defending a currency peg. This model however points to a framework that delivers growth over the longer term through lowered foreign exchange interventions and manageable credit expansion. Improved fiscal conditions seem to derive from the prescribed framework and can provide a greater long term developmental impetus. Additionally this scenario results in superior long run energy sector expansion which has historically boosted the country's reserves position. The alternate scenario of increased interventions will likely place downward pressures on Trinidad and Tobago's reserves thereby adding to the external vulnerabilities already faced by being a price-taker.

In conclusion this paper has highlighted the challenges of an energy exporting economy in times of an adverse price shock. Simultaneously it has facilitated an analysis of the interaction of fiscal, monetary and real sector variables and their response under such conditions. We argue that an appropriate policy response to an adverse price shock would be to allow lowered interventions in the foreign exchange market. This implies a more flexible approach to the currency market, as well as an expansion of loans well within the bounds of statistical normality. In so doing a more stable and sustainable macroeconomic position is offered.

VII. References

Baffes, John, M. Ayhan Kose, Franziska Ohnsorge and Marc Stocker (2015). *The Great Plunge in Oil Prices: Cause, Consequences and Policy Responses.* Koc University- Tusiad Economic Research Forum Working Paper Series.

Baum, Anja, et al (2017). *Can they do it all? Fiscal Space in Low Income Countries.* IMF Working Paper.

Boodoo, E., and Cheong, D., (2010). *The Monetary Transmission Mechanism: A Closer Look at the Interest Rate Channel in Trinidad and Tobago*. Research Review Seminar.

Bruce, C.J. and Cherita Girvan (1972). *"The Open Petroleum Economy: A Comparison of Keynesian and Alternative Formulations".* Social and Economic Studies, Vol 21, No.2 , pp 125-152; Sir Arthur Lewis Institute of Social and Economic Studies, University of the West Indies.

Bruno, Michael and Jeffrey Sachs (1982). *"Energy and Resource Allocation: A Dynamic Model of "Dutch Disease".* Review of Economic Studies, Vol. 49, Iss.5, pp.679-705.

Buetzer, Sascha, Maurizio Habib and Livio Stracca (2012). *Global Exchange Rate Configurations: Do Oil Shocks Matter?* ECB, Working Paper Series, No. 1442, June 2012

Central Bank of Trinidad and Tobago, Monetary Policy Report, Volume XVI, Number 2, November 2016, ISBN 1817-1959.

Corden, Max and J. Peter Neary. *"Booming Sector and De-Industrialisation in a Small Open Economy."* The Economic Journal, Vol. 92, No. 368 (Dec., 1982), pp. 825-848

Glynn, John, Nelson Perera and Reetu Verma. *"Unit Root Tests and Structural Breaks: A Survey with Applications."* Revista De M´Etodos Cuantitativos Para, La Econom´Ia Y La Empresa. Pages 63–79. June 2007. ISSN: 1886-516X. D.L: SE-2927-06.

Hult, Mikaela (2015). *"The effect of Exchange Rate Appreciation on Growth: the Case of Switzerland."* Lund University.

Hunter, Munroe and Yi Wu. *Trinidad and Tobago: Selected Issues.* IMF Country Report No. 11/74, 2011

Husain, Aasim M., and an IMF Staff Team (2015). *Global Implications of Lower Oil Prices.* IMF Staff Discussion Note.

International Monetary Fund. 2017. *World Economic Outlook: Gaining Momentum?* Washington, April

Koh, Wee Chian (2015). *Oil Price Shocks and Macroeconomic Adjustments in Oil Exporting Countries.* Centre for Applied Macroeconomic Analysis (CAMA), Crawford School of Public Policy, College of Asia and the Pacific.

Koitsiwe, Kegomoditswe and Tsuyoshi Adachi (2015). *Australia mining boom and Dutch Disease: analysis using VAR method.* 3rd Economics and Finance Conference, Rome, Italy.

Levy-Yeyati, Eduardo and Federico Sturzenegger (2003). *To Float or to Fix: Evidence on the Impact of Exchange Rate Regimes on Growth.* American Economic Review, pp. 1173-1193.

Lutkehpohl, Helmut. *A New Introduction to Multiple Time Series Analysis*. Springer-Verlag Berlin Heidelberg, 2005. ISBN 3-540-40172-5.

Lutkehpohl, Helmut and Markku Lanne (2006). *Identifying Monetary Policy Shocks via Changes in Volatility*. CESIFO Working Paper No. 1744.

Mazol, Aleh. *Exchange Rate, Imports of Intermediate and Capital Goods and GDP Growth in Belarus.* BEROC Working Paper No. 32, November 2015.

Merza, Ebrahim, Mohammed Alawin and Ala' Bashayreh (2012). *The Relationship between Current Account and Government Budget Balance: The Case of Kuwait.* International Journal of Humanities and Social Science, Vol. 2 No. 7 pp 168-177.

Mohhades, Kamiar and M. Hashem Pesaran (2016). *Oil Prices and the Global Economy: Is It Different This Time Around?* Working Paper, International Monetary Fund.

Obstfeld, Maurice and Kenneth Rogoff (1995). *Exchange Rate Dynamics Redux*. Journal of Political Economy, 103, pp 624-660.

Perron, Pierre, and Timothy J. Vogelsang (1991). *Nonstationarity and Level Shifts with an Application to Purchasing Power Parity*. Econometric Research Programme, Research Memorandum No. 359.

Rankin, Neil and Joseph Simumba (2016). *Exports, imported intermediate input, and exchange rate volatility in Zambia*. IGC Working Paper F-89214-ZMB-1.

Rigobon, Roberto (2002). *Identification through Heteroskedasticity.* Sloan School of Management, MIT.

Rodrik, Dani (2008). *The Real Effective Exchange Rate and Growth.* Brookings Papers on Economic Activity.

Seers, Dudley (1964). *The Mechanism of an Open Petroleum Economy.* Social and Economic Studies, Vol 13, No. 2, pp 233-242; Sir Arthur Lewis Institute of Social and Economic Studies, University of the West Indies.

Walsh, Carl (2010). *Monetary Theory and Policy: Third Edition*. The MIT Press, Cambridge, Massachusetts.

Weeks, John (2008). *The Reduction of Fiscal Space in Zambia- Dutch Disease and Tight Money Conditionalities.* International Poverty Centre, Country Study No. 14.

Yanagisawa, Akira (2008). *Decomposition Analysis of the Soaring Crude Oil Prices- Analyzing the Effects of Fundamentals and Premium.* International Energy Economics Journal, Vol. 3, No. 2, pp. 30-47.

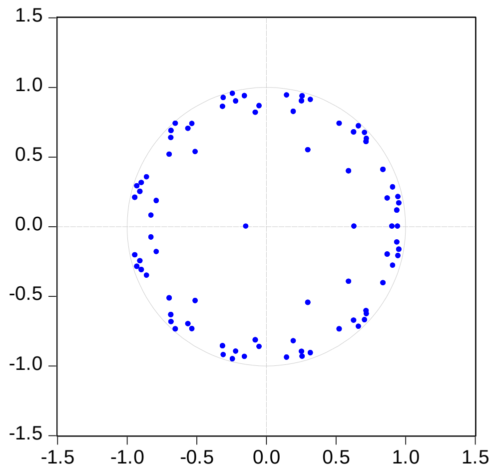
Appendix A

I. Adequacy Checks

i. Unconstrained Scenario:

a) Stationarity

Inverse Roots of AR Characteristic Polynomial



b) Serial Correlation

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 09/27/17 Time: 15:43
Sample: 2001M02 2017M05
Included observations: 184

Lags	LM-Stat	Prob
1	75.44731	0.0090
2	70.39453	0.0242
3	52.99707	0.3227
4	61.39080	0.1102
5	47.55141	0.5320
6	53.87770	0.2932
7	45.23215	0.6266
8	70.80816	0.0224
9	52.70339	0.3328
10	66.43934	0.0491
11	69.38439	0.0292
12	51.15141	0.3892

Probs from chi-square with 49 df.

c) Heteroscedasticity

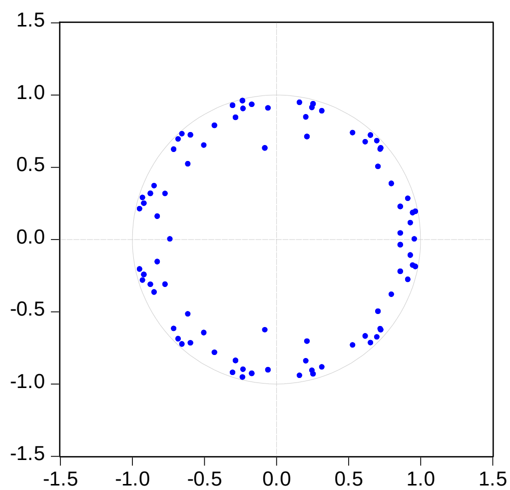
Joint test:

Chi-sq	df	Prob.
4636.233	4704	0.7565

ii. Constrained Scenario:

a) Stationarity

Inverse Roots of AR Characteristic Polynomial



b) Serial Correlation

VAR Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 09/27/17 Time: 15:45
Sample: 2001M02 2017M05
Included observations: 184

Lags	LM-Stat	Prob
1	94.03502	0.0001
2	60.84527	0.1194

3	71.31498	0.0204
4	50.82038	0.4017
5	73.85205	0.0124
6	44.15610	0.6695
7	53.53328	0.3045
8	66.41391	0.0494
9	47.21040	0.5459
10	71.29822	0.0204
11	41.24985	0.7764
12	57.83011	0.1814

Probs from chi-square with 49 df.

c) Heteroscedasticity

Joint test:

Chi-sq	df	Prob.
4681.340	4704	0.5898

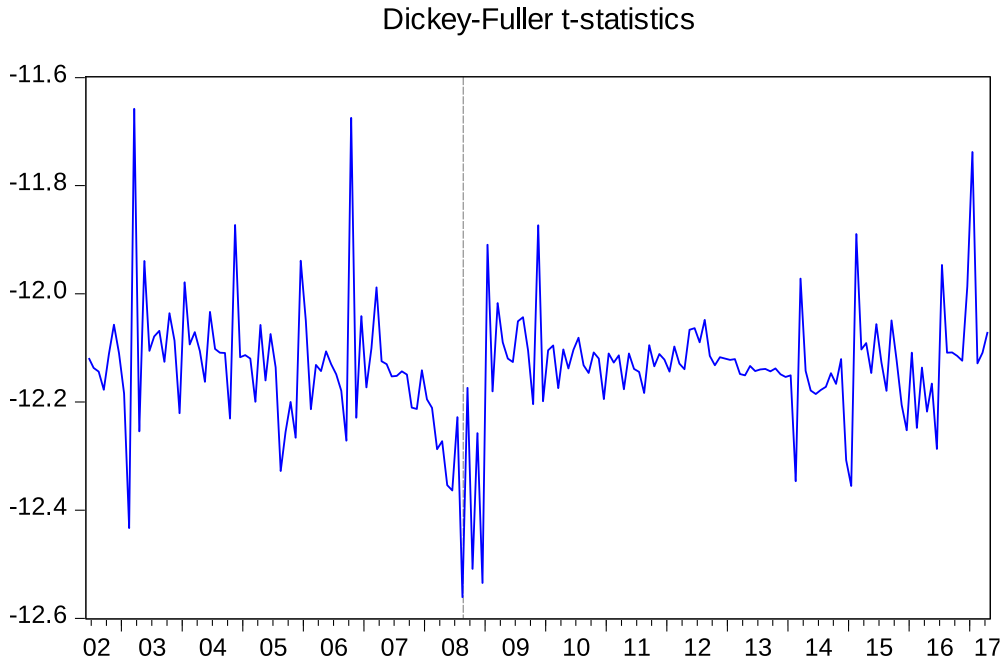
II. Breakpoint Test

Null Hypothesis: E_IN has a unit root
Trend Specification: Intercept only
Break Specification: Intercept only
Break Type: Innovational outlier

Break Date: 2008M08
Break Selection: Minimize Dickey-Fuller t-statistic
Lag Length: 0 (Automatic - based on Schwarz information criterion, maxlag=14)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-12.56088	< 0.01
Test critical values:	1% level	-4.949133	
	5% level	-4.443649	
	10% level	-4.193627	

*Vogelsang (1993) asymptotic one-sided p-values.


Dickey-Fuller t-statistics
-11.6
-11.8
-12.0
-12.2
-12.4
-12.6
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
17