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Estimating the Effects of Energy Price Shocks for Trinidad and Tobago

Nirvana Satnarine-Singh

Victor Gauto

Inter-American Development Bank

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Abstract

For Trinidad and Tobago, positive energy price shocks can have deep impacts on several important indicators such as government revenue, GDP and the external sector. In ascertaining the impact of these price shocks, a structural vector auto-regressive (S-VAR) model was used and positive shocks applied to real GDP, the debt ratio, government revenue and government expenditure. This exercise was undertaken for the period 1970-2024, with a structural break identified which takes into account the change in the production structure of the economy from oil refining to natural gas processing. The main insight of the results indicate that the energy sector of Trinidad and Tobago is now less poised than in previous years to benefit from positive price shocks. The model also shows that price shocks had the largest effect on government expenditure.

JEL Codes: C22, H11, H50, P22, P28, Q48

Keywords: energy prices, fiscal, GDP, structural change, Trinidad and Tobago

Introduction

The energy sector plays a pivotal role in the Trinidad & Tobago economy, and consequently large oil and natural gas price swings can have deep impacts in both the real economy and fiscal sector. Furthermore, pro-cyclical tendencies result in lasting effects on fiscal and debt indicators. This note analyzes the impact of energy price shocks pre and post the country's transition from being predominantly oil based towards natural gas processing. In doing so, structural break years are identified and utilized in estimating a structural vector auto-regressive (S-VAR) model. From this, positive price shocks were applied to real GDP, the debt ratio, government revenue and government expenditure. The latter part of the analysis puts into perspective the probability of these price shocks occurring and explores the possible ramification from a policy perspective. The main findings from the model indicate that positive energy price movements had deeper impacts on the economy prior to the transition to natural gas which is potentially related to T&T's maturing energy sector. Additionally, the model shows that prices shocks tend to have the largest impact on government expenditure which can exacerbate economic volatility.

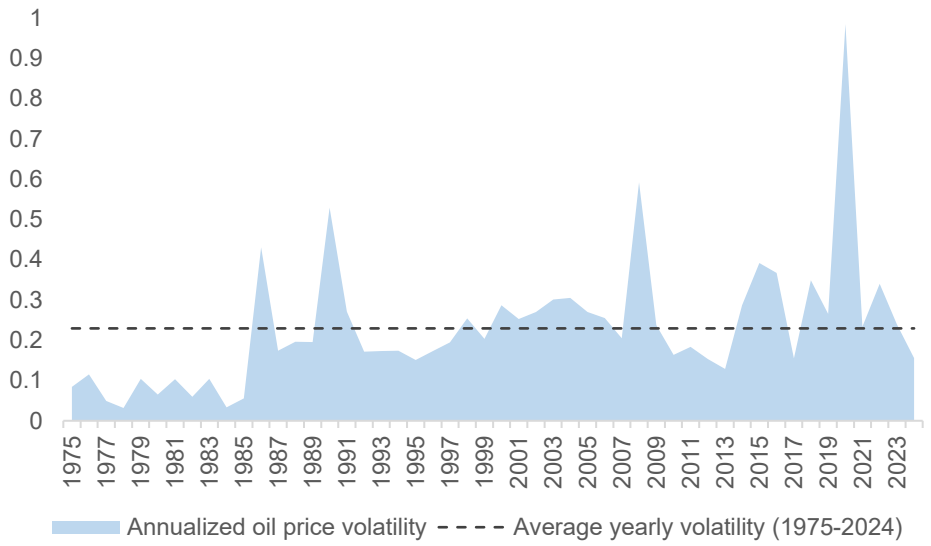
Ascertaining the importance of the hydrocarbon sector

Commodity price movements are inextricably linked to several economic indicators of resource exporting economies (Vandyck et al. 2018; Bova et al 2016; Hardri: 2012). For Trinidad and Tobago, positive energy price shocks can contribute to increases in government revenue and nominal GDP, which in turn reduces debt to GDP ratios[1]. The most recent example is in 2022, when natural gas prices increased by 64% and crude oil prices increased by 39% thereby influencing changes to key macroeconomic indicators. Specifically, in 2022 real GDP increased by 1.5% while the debt-to-GDP ratio declined from 79.6% in 2021 to 66.6%, mostly explained by a 22.6% increase in nominal GDP, demonstrating the possible impact of large positive energy price shocks. The current account balance and foreign currency reserves are also dependent on the possibility of external price shocks. From a fiscal perspective, the budgetary estimates

[1] Outstanding debt can increase less than proportionally to nominal GDP, resulting in a lower debt to GDP ratio. The optimal debt ratio or the debt burden which does not have a strong negative impact on growth varies across the literature, see (de Soyres 2022).

of the country and therefore financing needs are pegged to the authorities' projected crude oil and natural gas prices, with differences in projected and actual prices affecting deposits and sometimes withdrawals from the country's Heritage and Stabilization Fund[2]. While the HSF and accumulated international reserves contributed to absorbing some economic volatility, for decades exogenous price shocks has been an important cause of vulnerability, with energy price booms contributing to maintaining the economy's dependence on the energy sector, affecting further diversification towards the non-energy sector[3], especially as price volatility has been increasing in recent times (Figure 1).

Figure 1: Oil price volatility, Std. deviations of logarithmic changes in monthly average real prices at an annual rate



Source: EIA and Author's calculation

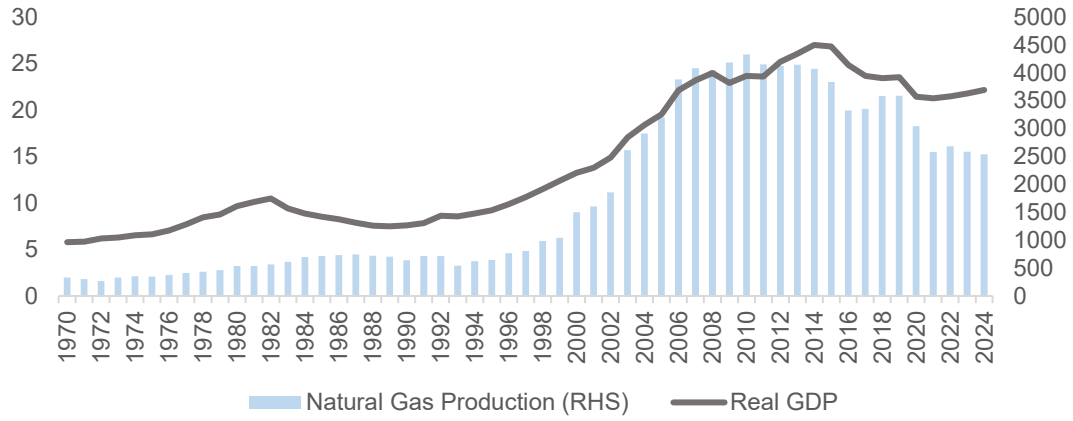
The resource endowments of Trinidad and Tobago historically tilted the production structure to incorporate its comparative advantage in the energy sector, firstly in terms of crude oil refining then towards downstream natural gas processing and liquefied natural gas production. Over the years, the economy therefore benefitted from an accumulation of both physical and human capital through industrialization and diversification of the energy sector, which resulted in a permanent shock to real GDP in the early 2000s (See Figure 2). With natural gas production essentially stagnating since 2019, as the sector reached a stage of maturity, the impact of positive energy price shocks is therefore envisaged to become less significant to the real economy.[4] This situation could be reversed if significant gas reserves were found.

[2] In FY2020, 40% of the government's fiscal deficit was financed through the HSF while in FY2021 49% of the deficit was financed with resources from the HSF. In 2022, with oil and gas prices surpassing budgeted estimates, US346.2 million was deposited into the HSF in September and December of 2022 Fiscal years run from October to September in T&T.

[3] Copious literature exists linking this to Dutch Disease, a term used to describe the crowding out effect caused by a boom in a traditional exportable sector which adversely affects the non-booming tradable sectors of the economy. An expanding non-tradeable sector can further cause an appreciation of the real effective exchange rate (REER) through the Balassa-Samuelson effect (see Corden and Neary 1982; Harding et al 2020).

[4] The non-energy sector drove economic recovery post-Covid. However, non-energy sector exports remain relatively low, growing average 0.7% for 2011-2024 according to CBTT data.

Figure 2: Real GDP (US billion) and Natural gas Production (mmcf/d)



Source: World Bank World Development Indicators and Ministry of Energy T&T.

Data

Data on real oil prices and real natural gas prices was collected from the US Energy Information Administration (EIA). Other commodity price data was collected from the IMF's commodity price database. The Central Bank of Trinidad and Tobago's Handbook of Key Economic Indicators provided data on government debt, government revenue and government expenditure. Lastly, data on GDP both nominal and real (constant 2015) terms was sourced from the World Bank World Development Indicators. The time frame of the analysis is 1970-2024 (annual data), with the summary statistics of each variable presented in Appendix A.

Methodology

The Impulse Response Function (IRF), derived from a Structural Vector Autoregressive (SVAR) model, is used in assessing the impacts of the respective price shocks on the main fiscal indicators of Trinidad and Tobago. The impulse response measures the impact of an energy price shock of one standard deviation on a series of economic indicators analyzed in this note.

The SVAR, which imposes restrictions on the contemporaneous relationship between the endogenous variables is denoted as:

$$B_0 y_t = B_1 y_{t-1} + \cdots + B_p y_{t-p} + u_t \quad (1)$$

Where: u_t is a K*1 vector of structural innovations, B_i is a K*K coefficient matrix which also accounts for the contemporaneous relationship between the variables, y_t is a K*1 vector of variables used in the model (Commodity prices[5], T&T GDP, T&T Debt/GDP, T&T Expenditure, T&T Revenue) and p is the lag length.

The reduced form model, is therefore:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t \quad (2)$$

Where $A_i = B_0^{-1} B_i$ and $\varepsilon_t = B_0^{-1} u_t$

For this model, the Cholesky decomposition was used to identify the model, hence the reduced form errors are orthogonalized, making them uncorrelated. Therefore, the model is recursive where the A matrix is lower-triangular (with K(K-1)/2 restrictions) based on the assumption of ordering by degree of exogeneity and B is a diagonal matrix.

In terms of the model diagnostics, the optimal lag length was selected based on reviewing four criteria including final prediction error (FPE), Akaike's information criterion (AIC), Schwarz's Bayesian information criterion (BIC), and the Hannan and Quinn information criterion (HQIC). The variables were tested for unit roots with and without structural breaks and the stability of the VAR was assessed[6].

Results

Based on a visual inspection of some of the key variables included in the model, there are clear signals of a significant change in the series trend or structural breaks. Identifying structural breaks in this exercise is important to avoid confounding the price shock with other factors, including policy or structural changes. Figures 3a-3c exhibit how the key economic indicators (real GDP, government expenditures and revenue) trended over time[7]. For all three variables, there are distinct trend changes in the early 1990s and in 2000. GDP fell significantly in 1986, mainly due to the collapse of oil prices, then began increasing again in 1990 as prices stabilized. Similar structural breaks are observable for government revenue and spending. Several studies undertaken for T&T using statistical and policy-based inferences also identify the presence of at least one structural break. Based on some recent literature, the break years identified are 1994 (Roopnarine et al. 2019[8]), 1983, 2000 and 2009 (Fuentes et al 2015; Khadan 2017[9]) and 2004 (Camba-Crespo et al 2022). However, the results of the LR test and the Wald test for structural breaks in this model, as well as the Zivot-Andrews unit root tests and the Clemente, Montañés, Reyes (CMR) tests for unit roots with structural breaks, identify two possible breaks, especially with regard to real GDP. These are 1992 and 2000, which are reasonable findings given the important policy and structural changes around these years. In 1992 the Petroleum Production Levy and Subsidy Act was amended to limit the value of the levy paid by oil producing companies to 3% of the companies' gross income, while prior there was no such limitation therefore the oil companies covered the full subsidy. After the amendments the government covered the excess cost to maintain the fuel subsidy which kept prices fixed to consumers. Stand-by arrangements with the IMF also ended between in 1991-1992 and in 1999 the commencement of LNG production saw the transition of the economy away from crude oil towards natural gas.

[5] The commodity prices in this case were crude oil, natural gas, ammonia and methanol prices. Separate models were used to test each price to ensure stability of the VAR.

[6] The optimal lag was two according to FPE and AIC and one according to HQIC and BIC. The model was tested under both lag lengths with no significant differences in the results of the Impulse Response Function (IRF) noted; the model with two lags is therefore presented below. All the variables were shown to by integrate of order one (I1) however, the VAR satisfied the stability conditions when estimated both in levels and in differenced forms. The model was also tested in levels and differenced form with similar trends in the IRF. The model in levels is presented for ease of economic interpretation.

[7] The natural log of the variables were used here and in the analysis to reduce variability of the data in the model.

[8] This paper assesses the impact of the external environment on five economic indicators of T&T, over the period 1970-2019. The break was identified through policy observation.

[9] Fuentes et al. 2015 used the Bai and Perron (1998, 2001) test for multiple structural breaks using GDP growth. Khadan 2017 used both the Zivot and Andrews (1992) and Clemente, Montañés, and Reyes (1998) tests for unit roots with structural breaks for 5 variables; structural breaks to real GDP are shown here.

Figure 3a: T&T real GDP

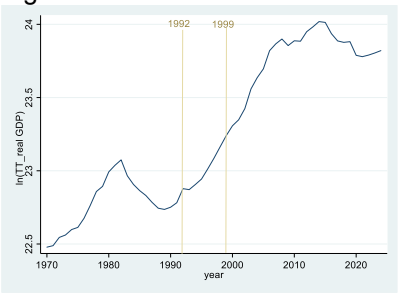


Figure 3b: T&T expenditure

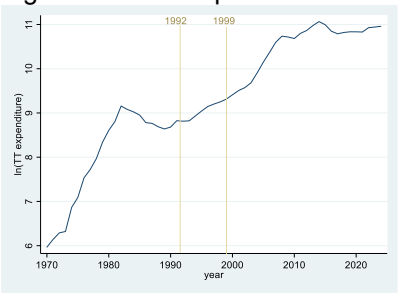
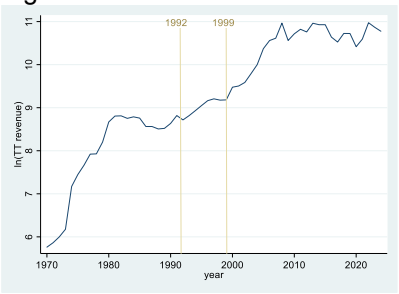


Figure 3c: T&T revenue*



* The natural log of real GDP and government expenditure and revenue are used.
Source: World Bank, Central Bank of Trinidad and Tobago.

The effect of the price shocks was therefore tested over two periods, taking into account the structural breaks as 1992 and 2000. In testing the SVAR, to ensure robustness of the results, the same model was tested under the same assumptions for both break years but in moving forward the results are presented using only 1992. Therefore, the first time period is prior to fiscal policy changes and the development of the natural gas processing industry ranging from 1970-1992. The second period captures the transitioning period where natural gas and petrochemical production were on the ascent, ranging from 1993-2024. The main findings from this exercise firstly show that the vulnerability of the economy to energy price shocks, was reduced with the transition from an oil exporting economy to a natural gas and petrochemical based economy. Specifically, the findings indicate that oil prices had a more pronounced and longer lasting effect on selected economic indicators in the period 1970-1992 relative to the period 1993-2024, mainly due to larger transmission effects, potentially related to the sector's maturity over the latter period energy resources have declined

Figure 4a: Response T&T real GDP to a (positive) oil price shock (1970-1992)

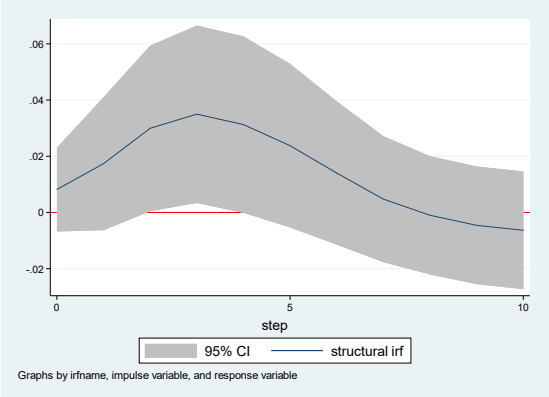
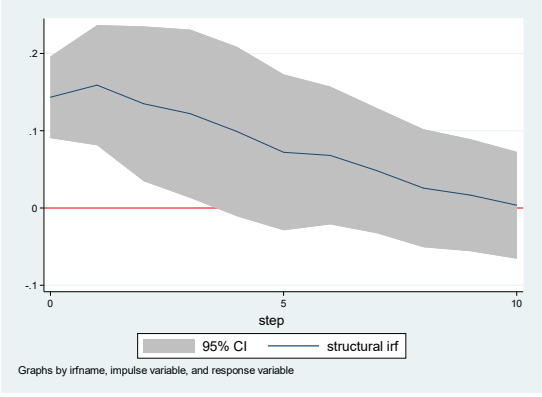


Figure 4b: Response of T&T Revenue to a (positive) oil price shock (1970-1992)



Note: The natural log of real GDP and government revenue is used, following the specification of the SVAR model.

For the period 1970-1992, oil production was robust reaching a high of 230,000 barrels of oil/day in 1978, therefore the impact of a price shock was fairly substantial. A positive oil price shock of one standard deviation is shown to positively affect real GDP up to the third year following the shock (though the impact is not statistically significant in years 1 and 2). Specifically, during this period of higher oil production, a one

standard deviation positive shock of oil prices, which is around a 49% increase in the average price, is estimated to increase GDP by 1.7% in year 1, 3.0% in year 2 and 3.5% in year 3 for a cumulative expansion of 8.2% between year 1 and year 3, before subsiding as observed in Figure 4a. The impact on government revenue is more pronounced with the one standard deviation shock lasting for 3 years before subsiding and causing a cumulative growth in revenue of 41.6% between year 1 and year 3. In year 1, following the shock, revenue was estimated to increase by 15.9% before beginning to taper off to13.4% in year 2 and 12.2% in year 3. (Figure 4b).

Figure 4c: Response of T&T expenditure to a (positive) oil price shock (1970-1992)

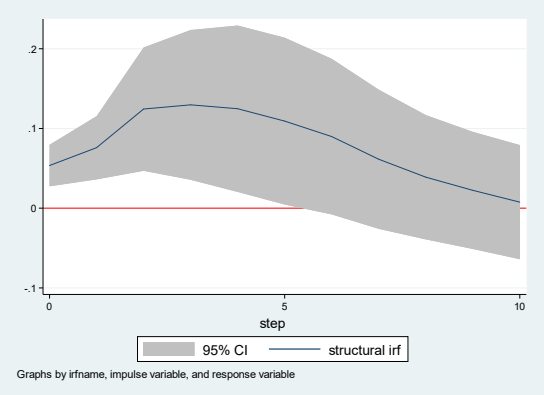
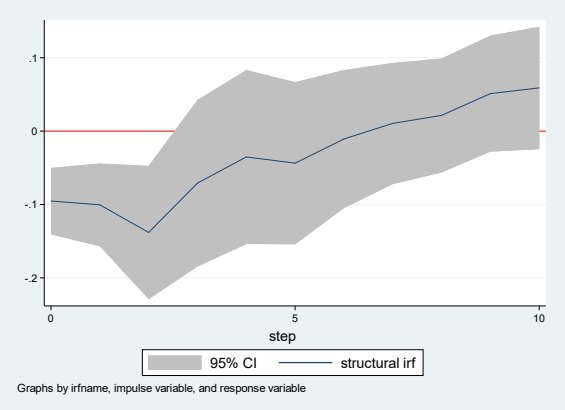


Figure 4d: Response of Debt/GDP to a (positive) oil price shock (1970-1992)



Note: The natural log of government expenditure and the debt/GDP ratio is used, following the specification of the SVAR model.

The shock had the longest lasting impact on expenditure, which lasts for 5 years before tapering off and becoming statistically insignificant. Government expenditure is estimated to have increased by 7.6% in year 1, 12.4% in year 2, 13% in year 3, 12.5% in year 4 and remained fairly high at 11% by year 5, for a cumulative increase in expenditures of 56.5% attributable to the positive energy price shock. The debt to GDP ratio is shown to be significantly affected for 2 years following the shock, with the debt ratio estimated to fall by 10% in the first year and up to 14% in the second year before beginning to revert to the mean (Figure 4d).

For 1993-2024, consideration is given to the gas industry as it developed while oil production gradually declined. However, the co-movement of oil and natural gas prices imply that shocks to both can fairly be captured in the model through a shock on oil prices alone (See Appendix A2). In the latter years of this timeframe, energy prices were exposed to both positive and negative shocks due to the Covid-19 pandemic, as well as the Ukraine War. Oil prices were shown to have a lower effect during this period, especially on real GDP[10]. The results indicate that a positive oil price shock of one standard deviation, which during this period is approximately a 50% increase in the average price, increased real GDP by 2.4% one year following the shock, 2.8% in year 2, and tapering off to 2.5% in year 3, for a cumulative impact of 5% for three years, lower than the 8.2% estimated before 1993. The effect on revenue lasts 2 years, increasing by 11.4% in the year following the shock before beginning to fall to 8.0% in year 2, then becoming statistically insignificant by year 3, for a cumulative effect of 19.4%. This figure is lower than 29.3% over two years which was estimated before 1993 (Figure 5b), suggesting the energy price shock had a greater impact when Trinidad and Tobago was predominantly an oil producer than after the gas industry developed.

[10] The Petroleum Company of Trinidad and Tobago (Petrotrin) was a state owned oil company and the sole oil refinery in T&T. During this timeframe period Petrotrin would have also been an important contributor to GDP. The refinery was closed in November 2018.

Figure 5a: Response of T&T real GDP to a (positive) oil price shock (1993-2024)

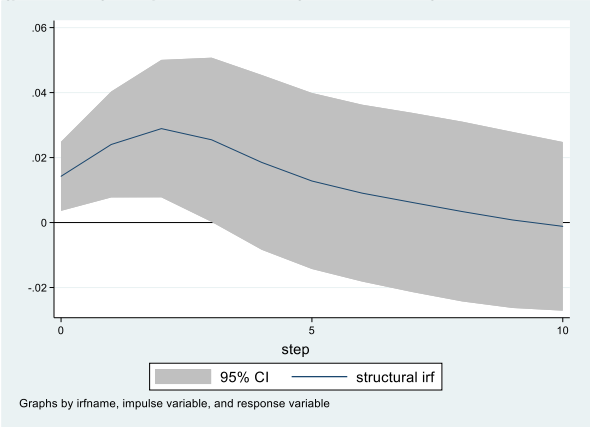
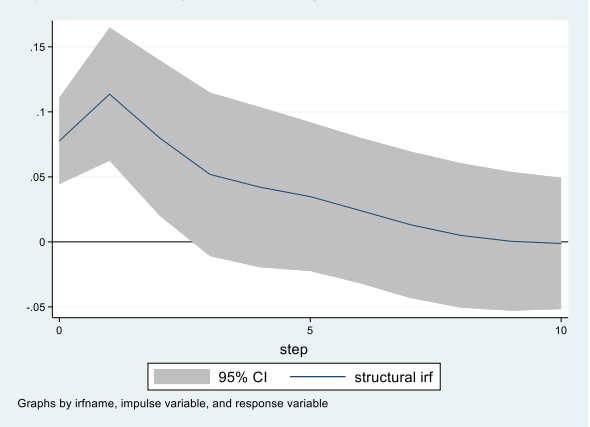


Figure 5b: Response of T&T Revenue to (positive) oil price shock (1993-2024)



Note: The natural log of real GDP and government revenue is used, following the specification of the SVAR model.

Similar to the above analysis, the impact of the shock had the longest lasting significant effect on expenditure, which lasted for 4 years before becoming statistically insignificant. Expenditure is estimated to have increased by 7.4% in year 1, 7.8% in the 2nd year before falling to 6.7% and 5.3% by year 3 and year 4 respectively for a cumulative impact of 27.2%. The debt to GDP ratio is shown to be significantly affected for 2 years following the shock, with the debt ratio estimated to fall by up to 7.8% in the 1st year and 6.0% in the 2nd year before beginning to revert to the mean. Once again, the impact of the positive price shock is lower in 1993-2024 compared to 1970-1992.

Figure 5c: Response of T&T Expenditure to (positive) oil price shock (1993-2024)

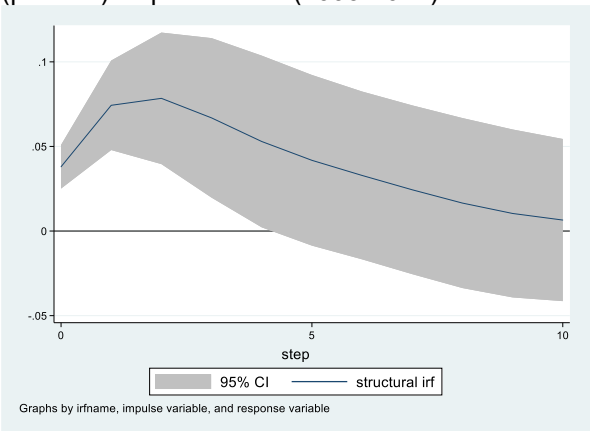
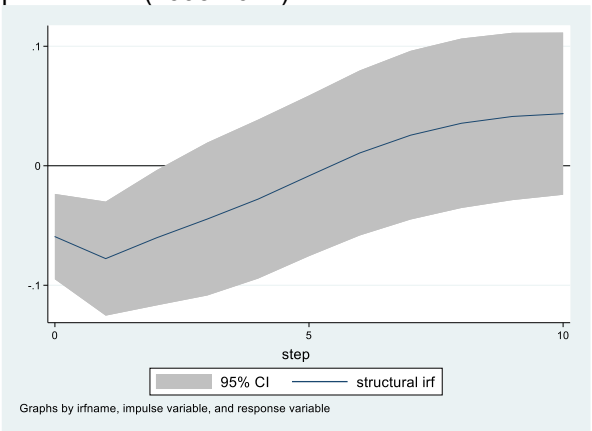


Figure 5d: Response of Debt/GDP to (positive) oil price shock (1993-2024)



Note: The natural log of government expenditure and the debt/GDP ratio is used, following the specification of the SVAR model.

Table 1: Summary of responses to positive oil price shocks of one standard deviation.

Variable	Cumulative significant impact 1970-1992	Cumulative impact 1993-2024
GDP	8.2% increase over 3 years	7.7% increase over 3 years
Government Revenue	41.6% increase over 3 years	24.6% increase over 3 years
Government Expenditure	56.5% increase over 5 years	31.4% increase over 5 years
Debt Ratio	24% decrease over 2 years	13.8% decrease over 2 years

Note: The impact in 1993-2024 was statistically significant for 3 year for GDP, 2 years for revenue, 4 years for expenditure and 2 year for debt ratio but the full impact is presented for comparison.

The impact of natural gas price[11] shocks were also assessed and presented in figures A1a-A1d in the appendix. A one standard deviation shock which is approximately a 49% increase in average prices had no significant impact on GDP in 1993-2024. Revenue increased by around 6% in the year following the shock before tapering off and becoming statistically insignificant. Expenditure was only significantly impacted in 1 year following the positive shock, increasing by 4% and the debt ratio fell by 8.5% 1 year following the shock before becoming insignificant. The declining trend in natural gas production due to the sector's maturity, could be affecting the model's results, as natural gas price increases cannot be leveraged into higher production levels

Further explanation of shock scenario

From the data on real oil prices for the period 1993-2024, a positive one standard deviation shock was calculated and translates into an increase in real oil prices by around US$36 per barrel or a year-over-year increase of 47% using 2024 data [12]. Actual annual price variations between 1993 and 2024 are much lower, such that the probability of having a positive energy price shock of one standard deviation is relatively low, further dampening their effect on GDP and other key indicators. Based on the available annual data, real oil prices never increased by more than US$36 per barrel year over year, while oil prices declined by more than US$36 twice over this 30-year period.

In an optimistic analysis the absolute price changes are considered to determine the effects of only a positive price shock, therefore the probability of prices either increasing or decreasing by more than US$36 is only 7%. Realistically, the probability of prices increasing by more than US$36 on a year to year basis is zero. The most likely scenario (70% chance) is an absolute yearly change ranging between US$0.00 and US$15.00 (Table 1), less than half a standard deviation. Therefore, a positive shock of this magnitude to oil prices, given the current economic structure, would result in a maximum GDP growth of around a 1% annually, tapering off by the second year following the shock, according to Figure 5a.

[11] Natural gas prices in measurement terms are much lower than oil prices so the effect of a standard deviation shock may not show up.
[12] In this sector the positive price shock is discussed. Khadan (2017) shows that the negative impact of energy price changes is less pronounce than the positive.

Table 2: Probability of price deviations

Absolute change (US$)	Number of price increases or decreases (1993-2024)	Probability
$0-$5	4	13%
$6-$10	8	27%
$11-$15	9	30%
$16-$20	2	7%
$21-$25	3	10%
$26-$30	1	3%
$31-$36	3	10%
>$36	2	7%

Source: Authors' calculations

In the booming period of the analysis (1993-2009) average GDP growth of Trinidad and Tobago was 6.7%, but in the subsequent period average growth fell to -0.5%. Although there were several positive energy price shocks after 2008, growth in TT remained moderate, which could be related to both oil and gas production are facing production challenges as extractive resources have become scarcer, which could be reversed if significant gas reserves were discovered

Figure 6: Average GDP growth of resource rich economies (1993-2008)

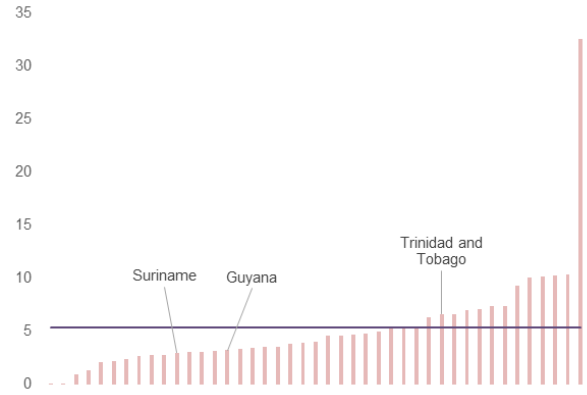
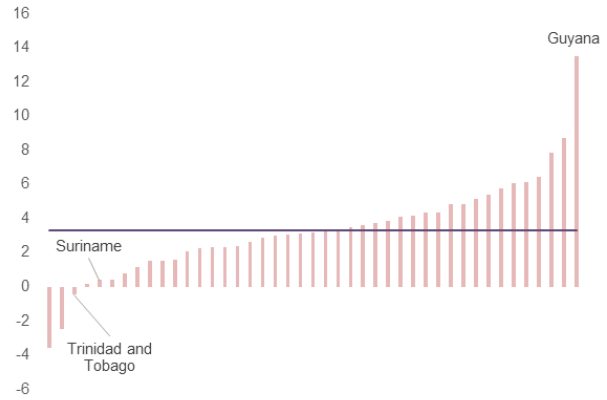


Figure 7: Average GDP growth of resource rich economies (2009-2023)



Note: CCB resource rich economies are highlighted green. These are Guyana, Suriname and Trinidad and Tobago. The selection of countries were based on economies which has a share of resource rents in GDP similar or above that of T&T. Equatorial Guinea had the highest growth rate in Fig. 6, driven by substantial oil discoveries in the 1990s.

Conclusion

The impact of energy price shocks varies across oil dependent economies depending on a multitude of factors including level of dependence, fiscal discipline and institutional quality therefore the experience of T&T is unique from other small energy exporters. The main insight of the results indicate that the energy sector of Trinidad and Tobago is less poised than in previous years to benefit from positive price shocks given the productive capacity of the sector and diminishing gas supply. Specifically, the lower impact can be attributable to diversification mainly within the gas sector which increases dependence on the maturing extractive industries and divides the limited resource among several products, including petrochemicals,

exports and electricity generation. The model also shows that price shocks had the largest effect on government expenditure, which can contribute to economic volatility as revenue flows vary.

The energy sector however remains fundamental to the country's openness and external position such that it accounted for 80% of exports in 2024 and average 81% between 2012 and 2023. Therefore, given the resource endowments, in terms of human capital and natural resources, logistics and the natural gas supply constraint to the installed industrial capacity, there is significant potential to leverage the gas industry infrastructure to diversify the energy sector away from traditional non-renewable sources of energy to renewable sources to become an energy hub in the region. Furthermore, reducing dependence on energy price shocks would also contribute to reducing fiscal volatility and support medium-term budget planning.

The IDB along with the National Energy Corporation of Trinidad and Tobago produced, 'A Roadmap for a Green Hydrogen Economy in Trinidad & Tobago', which discusses how renewable sources of energy along with the country's vast gas industry infrastructure and skills can be leveraged to develop a new energy sector. This could put the economy in a superlative position, support energy transition, and reduce the economy's exposure to energy prices shocks as reviewed in this document, by developing new sources of income consistent with global energy demands. The production structure, in terms of availability of physical capital, skilled labor and market gives the economy an edge relative to others in the region and therefore strengthens its comparative advantage in the energy sector while continuing to develop potential of the non-energy sector.

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Appendix

Table A1: Summary statistics

Variable	No. of obs.	Mean	Std. Dev.	Min	Max
Ln(Oil Price)	55	3.3	1	0.26	4.6
Ln (TT real GDP)	55	23.3	0.5	22.5	24.0
Ln (TT Debt/GDP)	55	3.3	0.6	2.3	4.2
Ln(TT expenditure)	55	9.3	1.4	6.0	11.1
Ln (TT Revenue)	55	9.3	1.4	5.8	11.0

Figure A1a: Response of T&T GDP to (positive) gas price shock (1993-2024)

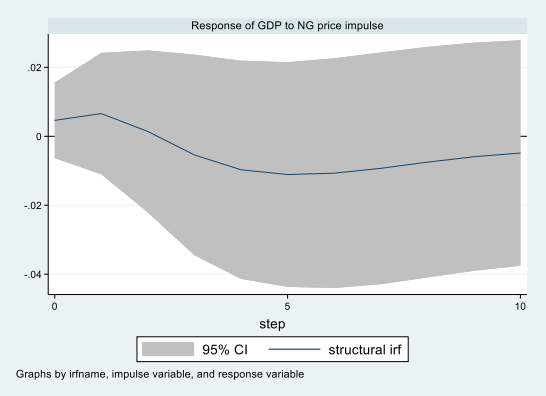


Figure A1b: Response of T&T Revenue to (positive) gas price shock (1993-2024)

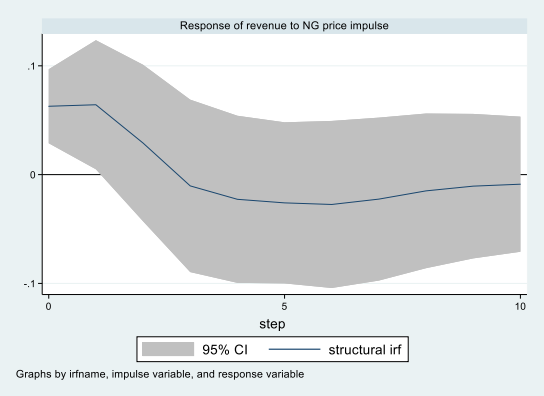


Figure A1c: Response of ln T&T Expenditure to (positive) gas price shock (1993-2024)

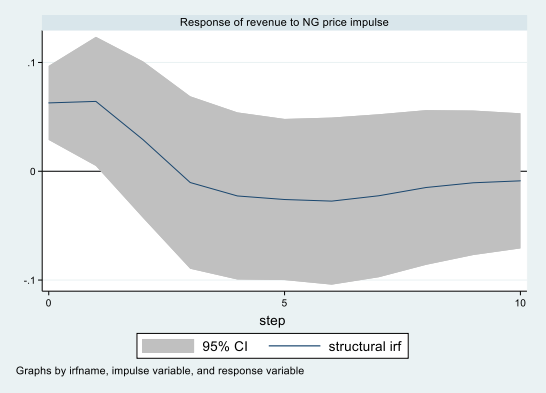


Figure A1d Response of Debt/GDP to (positive) gas price shock (1993-2024)

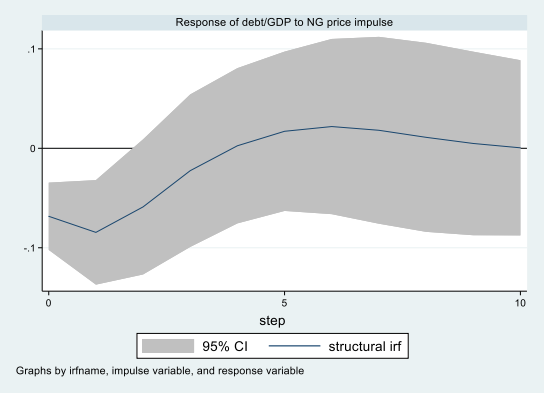
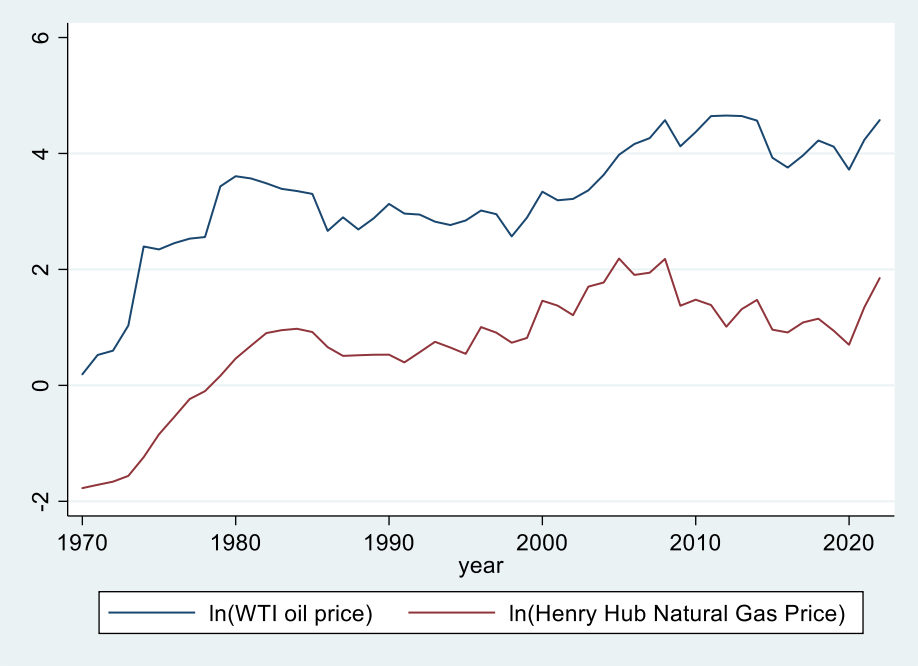


Figure A2: Movement of crude oil and natural gas prices



Source: IMF Commodity Price database