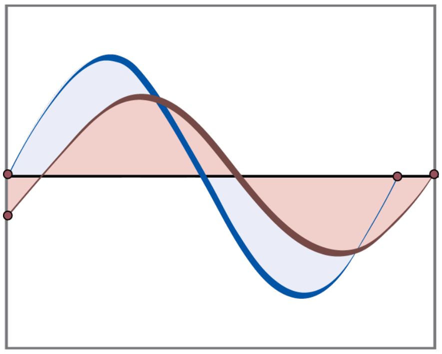
CENTRAL BANK OF TRINIDAD & TOBAGO

Working Papers

WP 01/2023 March 2023



Examining the Role of Fiscal and Monetary Policies in Climate Change in Trinidad and Tobago: The Effects of these Policies on Carbon Dioxide Emissions

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Climate change has become a real and pressing issue for all countries and urgent action is needed to avoid significant long-term economic and social consequences. Economic activity supported by fossil fuel combustion, that produces greenhouse gases such as carbon dioxide (CO_2), has been a key contributor to climate change. The last two decades have seen a growing body of literature considering fiscal and monetary policies as novel influencers of environmental emissions such as CO_2, given their influence on economic activity. This paper empirically examines the effects of these policies on climate change by investigating their impact on CO_2 emissions in Trinidad and Tobago. The analysis employs a Non-linear Autoregressive Distributed Lag (NARDL) model using data from 1970 to 2020. The paper also uses Principal Component Analysis (PCA) to develop fiscal and monetary policy indices. Fiscal policy significantly affects CO_2 emissions in the short and long run. However, monetary policy has negligible to no effects on CO_2 emissions. The findings suggest that these policies could benefit from reforms (green fiscal and monetary policies) to better contribute to climate change mitigation.

JEL Classification Number: E43, E63, E21, Q53, Q54, Q56, Q58, Q51

Keywords: Monetary policy, fiscal policy, CO2 emissions, NARDL methodology, cointegration, energy consumption.

EXAMINING THE ROLE OF FISCAL AND MONETARY POLICIES IN CLIMATE CHANGE IN TRINIDAD AND TOBAGO: THE EFFECTS OF THESE POLICIES ON CARBON DIOXIDE EMISSIONS

Avinash Ramlogan and Andell Nelson[1]

1. Introduction

Climate change is a real and pressing issue, requiring urgent actions to transform economies to low-carbon status. The Intergovernmental Panel on Climate Change (IPCC 2022) report warns that global warming is expected to reach 1.5°C between 2030 and 2050 and will continue upward if action is not taken to curb greenhouse gas (GHG) emissions. Economists and scientists strongly agree that global warming and climate change severely threaten economic development outcomes, livelihoods and human existence.

The role of macroeconomic (monetary and fiscal) policies, particularly in climate change mitigation, has recently gained researchers' attention. First, fiscal and monetary policies play vital roles as drivers of aggregate demand, economic growth, income levels, and inflation management, but their influence on environmental emissions is ambiguous. The rise in emissions in many countries has led researchers to increasingly probe the role of various contributing factors, such as macroeconomic policies, in the emissions-generating process. Second, climate change is also a challenge to sustainable growth and development. Decoupling fossil fuels from models of growth and development has become a requirement for competitiveness and sustainable economic growth for many economies globally. Exploring the influence of macroeconomic policies on environmental emissions may also reveal potential policy issues relating to achieving sustainable development.

Trinidad and Tobago is a small, open, hydrocarbon-based economy that exports crude oil, liquefied natural gas and petrochemicals. The country is also a key exporter of manufactured goods to the Caribbean. These activities translate to significant CO_2 emissions. Policy measures to curb CO_2 emissions are therefore crucial in the domestic context. On the one hand, fossil fuel resources drive domestic economic growth, which induces CO_2 emissions. However, on the other, the country needs to transition to low-carbon status to meet its commitments under international agreements. This makes it desirable to explore the links between macroeconomic policies and CO_2 emissions.

The primary purpose of this paper is to empirically estimate the effect of fiscal and monetary policy on CO_2 emissions in Trinidad and Tobago. The study offers a foundation for future research, such as investigating how the components of public spending affect CO_2 emissions and how green fiscal policy instruments (such as a carbon tax) can impact CO_2 emissions. These policies will also have implications for monetary policy as they can affect overall prices. The paper is structured as follows: Section 2 discusses the literature on the effects of fiscal and monetary policy actions on CO_2 emissions and their role in climate change mitigation. Section 3 discusses some stylised facts on Trinidad and Tobago's CO_2 emissions, energy consumption, and monetary and fiscal policy trends. Section 4 discusses the methodology used to assess the impact of macroeconomic policies on CO_2 emissions. Section 5 discusses the results, and Section 6 concludes with a few policy recommendations.

[1] The views expressed in this paper are those of the authors and do not necessarily represent those of the Central Bank of Trinidad and Tobago.

2. Literature Review

The economic literature on the role of fiscal and monetary policies in climate change is large and complex. High and rising CO_2 emissions require policy actions to engender a large-scale transition to a low-carbon economy. As a result, policy authorities are increasingly exploring the role of monetary and fiscal policies in reducing GHGs, such as CO_2 emissions. Thus, the literature review focuses on the role of fiscal and monetary policies in (i) influencing climate change through their impact on GHG emissions such as CO_2 and (ii) in climate change mitigation efforts.

2.1 Fiscal policy and GHG emissions

Conventional fiscal policy targets macroeconomic outcomes and can have unintended environmental spillover effects. Halkos and Paizanos (2012) indicated that the impact depends on the interaction of income-pollution and government spending-economic growth relations. The income-pollution part of this mechanism has been explored in the strand of literature that investigates the Environmental Kuznets Curve (EKC) hypothesis. The hypothesis postulates an inverted U-shaped relationship between environmental pollution and per capita income. That is, environmental pressure increases as income increases to a certain threshold; after that, it decreases (Grossman and Krueger 1995).

Regarding the government spending-growth relationship, the economic literature has described various channels through which fiscal policy may impact economic growth. These channels are subject to interferences by various factors, which could complicate the potential impacts of government spending on economic growth. Some studies found that public expenditure may reduce economic growth by crowding out the private sector, increasing government inefficiencies, distorting tax systems and incentives, and intervening in free markets. Others found that government spending may positively affect economic growth due to positive externalities, providing a socially optimal level of growth and offsetting market failures.

Prior studies have found mixed results in that fiscal policy can amplify or mitigate CO_2 emissions. **(Table 1)**. For instance, Yilanci and Pata (2021) investigated the G7 countries using data for 1875-2016 and found that public spending helped reduce emissions. Katircioglu and Katircioglu (2018) investigated the case of Turkey using data from 1960 to 2013 and found that increased public spending led to reduced emissions. On the other hand, in an earlier study, Bernauer and Koubi (2006) found that an increase in government spending is associated with more emissions, with the only exception being expenditure on public goods. Halkos and Paizanos (2012) found that government expenditure has a direct negative impact on Sulphur dioxide (SO_2) emissions but has an insignificant effect on CO_2 emissions. Their study further revealed an indirect negative relationship between government expenditure and SO_2 emissions in low-income countries, but the effect becomes positive as income increases. Yuelen et al. (2019) explored the impact of public revenue and spending in China from 1980 to 2016 and found that expansionary fiscal policy increases CO_2 emissions. However, the expansionary policy had a favourable short-term impact on emissions. Mahmood et al. (2022) found that government expenditure has a positive and scale effect on territory-based CO_2 and consumption-based CO_2 in Gulf Cooperation Council (GCC) economies through increasing CO_2 emissions.

Halkos and Paizanos (2016) examined the effects of fiscal policy on CO_2 emissions using quarterly data for the United States (US) from 1973 to 2013. The study found that the effects of fiscal policy depended on the pollution source, fiscal policy scenario, and the composition of government spending under consideration. Lopez et al. (2011) argued that reallocating government spending towards social and public goods reduces SO_2 emissions. The authors identified four channels through which fiscal spending could impact emissions: scale, composition, techniques and income effects. The scale effect refers to the pressures induced on the environment because of increasing economic growth. The composition effect refers to changes in the composition of economic activity and sectors that impact emissions differently. The technique effect refers to the influence of changes in labour efficiency and education on environmental quality. The income effect refers to the increasing need for a better quality environment due to the high-income status of the population. Their study utilised data from 38 countries over the period 1986 to 1999.

The economic literature has suggested using climate-related green fiscal policy as an alternative to avoid the potential adverse impacts of conventional fiscal policy on emissions. Green fiscal policy can fall into four broad categories: public spending and investment, public-private partnerships (PPPs), price policies (taxation and incentives), and public guarantees, which are targeted to reduce emissions such as CO_2.

Several studies have found that climate-related public spending and investment reduced CO_2 emissions. For instance, Ahmed et al. (2021) argued that government spending on clean energy infrastructure might reduce CO_2 emissions. The authors investigated the case of Japan using data from 1974-2017 and found that government investment in clean energy development projects and nuclear energy effectively reduced CO_2 emissions. Zhang et al. (2021) also argued that public spending on green energy technologies might promote green production innovation techniques and sustainable development. Further, Neves et al. (2020) noted that policies to promote renewable energy and foreign direct investment reduced emissions, boosting the emissions profile of several EU countries.

Similarly, PPPs can also be effective in reducing CO_2 emissions in countries. According to the World Bank (2020), approximately 70.0 per cent of global GHG emissions are generated by the construction and operation of physical infrastructure. Although this is part of the problem concerning climate change, it can be part of the solution to GHG mitigation. New opportunities for sustainable infrastructure are now available due to technological advances that have been reducing the costs of low-carbon alternatives such as renewable energy. If appropriately designed and implemented, PPPs can allow governments to improve infrastructure investment while reducing public spending (Arezki and Belhaj, 2019). However, PPP projects have been experiencing severe challenges in many countries due to weaknesses such as insufficient legal frameworks, project selection and costing capabilities (Innes, 2018).

According to economic theory, governments should use environmental taxes to discourage economic activities that generate negative externalities (Pigato, 2018). Several studies have sought to assess the effectiveness of a carbon tax on CO_2 emissions. A carbon tax is a tariff on fossil fuels and other products to reduce GHG emissions such as CO_2. Hashmi and Alam (2019) found that environmental taxes reduced CO_2 emissions in OECD countries using data from 1999 to 2014. Similarly, Solaymani (2017) investigated the role of taxes on emissions in Malaysia and found that carbon and energy taxes helped reduce emissions. Khan et al. (2021) reported that carbon taxes, renewable energy, and innovations helped reduce CO_2 emissions. Mardones and Flores (2018) reported that carbon taxes helped accelerate cleaner industrial use of energy in Chile and reduced emissions.

However, carbon pricing is sometimes ineffective in reducing emissions. Mardones and Flores (2018), which analysed the impact of variations on the carbon tax per ton of CO_2, found that taxes that are too low or too high would contribute to raising government revenue but not reducing CO_2 emissions. Fay et al. (2015) also pointed out that prices can be ineffective in reducing CO_2 emissions when low-carbon alternatives and long-term credibility are absent. Further, carbon taxes that only contain a revenue component are less likely to effectively reduce emissions. Therefore, successful carbon pricing regimes should contain revenue generation and expenditure components (Fay et al., 2015). Implementing a carbon tax of US$40.00 per ton of CO_2 on fossil fuels in the Latin American and Caribbean (LAC) region could generate an estimated US$69.0 billion per year (Coady et al. (2019) and Delgado, Eguino and Lopes (2021)).

Fiscal authorities can facilitate GHG reduction through incentives such as public guarantees. However, although public guarantees can reduce emissions, fiscal challenges in some countries may prohibit implementing this measure, requiring innovative financing methods through local capital markets (such as green bonds or financial instruments that support green initiatives (Delgado, Eguino and Lopes, 2021)). Mobilising public and private investment while developing capital markets are crucial in LAC countries since tremendous potential exists to innovate with financial instruments and simultaneously deepen local capital markets. Delgado, Eguino and Lopes

(2021) suggest that guarantees can either: (i) encourage commitments to pay a debt related to a climate change activity or (ii) serve as instruments to improve credit profiles when structuring sustainable infrastructure projects.

In addition to public guarantees, the regional literature conveys that eliminating or reforming energy subsidies can incentivise economies to reduce GHG emissions. Government subsidies have helped maintain artificially low fuel prices in the region. Governments in the LAC region spend approximately 1.0 per cent of GDP subsidising energy consumption. According to the IMF, eliminating energy subsidies, imposing taxes to address negative externalities, and a carbon tax could generate an estimated US$224.0 billion per year for the LAC region. These savings could amount to more than 2.0 per cent of GDP in 27 countries and more than 10.0 per cent in Guyana, the Bolivarian Republic of Venezuela, and Trinidad and Tobago (Delgado, Eguino and Lopes, 2021). Environmental taxes and reduced energy subsidies can potentially reduce informality, tax evasion, and corruption (Bento, Jacobsen and Liu, 2018).

2.2 Monetary policy and GHG emissions

Central banks have not traditionally been considered relevant for climate change mitigation efforts. The economic literature has established that monetary policy frameworks of central banks seek to stabilise output and inflation. In doing so, central banks attempt to influence the level of interest rates or money supply by adopting expansionary or contractionary monetary policy.

Monetary policy actions can transmit through complex but effective economic processes to impact environmental emissions. Interest rates or money supply changes can alter energy consumption patterns, aggregate demand, innovation activities and income per capita, impacting CO_2 emissions. For instance, monetary policy actions could exacerbate emissions in countries and undermine the efforts of other government policy measures, such as environmental and fiscal policies. Prior studies have led to mixed conclusions about the effects of monetary policy actions on emissions **(Table 1)**. For instance, Qingquan et al. (2020) found that expansionary monetary policy intensifies CO_2 emissions; but contractionary monetary policy appeared to contract emissions in 14 Asian economies. Isiksal et al. (2019) found a negative relationship between monetary policy (the real interest rate) and CO_2 emissions in Turkey. The paper further revealed that the impact of the monetary policy variable was supported by the energy consumption channel in Turkey. However, Muhafidin (2020) found a positive relationship in Indonesia. In Pradeep (2021), interest rates were similarly identified to possess a significant positive relationship with CO_2 emissions in India.

Further, Chishti et al. (2021) found that expansionary (contractionary) monetary policies ameliorate (deteriorate) CO_2 emissions in Brazil, Russia, India and China (BRIC). In the case of Pakistan, Ullah et al. (2021) found that a negative and positive shock to monetary policy instruments enhances CO_2 emissions in the short run. In contrast, a positive shock decreases CO_2 emissions in the long run. A regional study on the Association of Southeast Asian Nations (ASEAN) countries showed that contractionary monetary policy reduces CO_2 emissions, while expansionary monetary policy enhances CO_2 emissions in the long run (Mughal et al., 2021).

In light of the uncertainty involving the effects of conventional monetary policy on CO_2 emissions, the literature has suggested greening monetary policy. Recent studies suggest that central banks are actively contemplating developing and using climate-related green monetary policy measures to contribute to CO_2 mitigation. Some central banks have noted the urgency of climate change action and are already taking steps to implement green monetary policy. As countries decarbonise and central banks take on a more active role in climate change mitigation, climate-sensitive monetary policies should be considered without compromising the primary objective of price stability. Examples of green monetary policy include adapting central banks' collateral frameworks and using environmental, social and governance (ESG) criteria in their large-scale asset purchases (Coeure, 2018). These measures ensure that climate risks are adequately assessed and reflected on collateral frameworks and asset purchases. Central banks could also actively purchase green assets or eliminate high-carbon intensity assets in their portfolios or conduct green quantitative easing.

Central banks have also put forward proposals to provide financial resources for green economic activities. For instance, central banks could use their balance sheets to provide guarantees for loans to boost the financing of green investments to promote a structural shift in the economy to a low-carbon status (Dasgupta et al., 2019). Central banks could also utilise their balance sheets to ensure better access to funding schemes for commercial banks to invest in low-carbon projects or to provide loan financing to firms to invest in green projects (Aglietta et al., 2015). These policies, however, can be controversial, as conveyed by the IMF, and would require a rethinking of the role of central banks. **Table 2** summarises the key pros and cons of various climate-related fiscal and monetary policy measures.

Several studies have probed the possible links between macroeconomic policies and CO_2 emissions in developed and developing countries. Many of these studies have been conducted out of genuine concern that important links need to be understood as a basis for designing policies to assist in climate-change mitigation. The literature review also reveals that there is increasing recognition that macroeconomic policies, via their impacts on the level and structure of economic activities in a country, can significantly influence environmental emissions such as CO_2. The impact of macroeconomic policies on emissions differs among countries. Alternative policy options are available to policymakers to assist in climate-change mitigation. Fiscal policy options include carbon pricing, spending and investment, and public guarantees. Monetary policy can play a role, but some options can be controversial.

Table 1: Macroeconomic Policies and CO_2 Emissions

Author	Sample Period	Countries	Method	Results
(A) Monetary policy and CO_2				
Qingquan et al. (2020)	1990-2014	Selected Asian Economies	FMOLS and DOLS	EMP increases CO_2e CMP decreases CO_2e
Isiksal et al.(2019)	1980-2014	Turkey	ARDL	MP negative with CO_2e
Pradeep (2021)	1971-2014	India	ARDL	MP positive with CO_2e
(B) Fiscal policy and CO_2				
Fredrick and Lundstrom (2001)	1977-1996	77 countries	Panel Fixed and Random Effects	FP decreases CO_2e FP increases CO_2e in LICs
Bernauer and Koubi (2006)	1971-1996	42 countries	OLS	FP increases SO_2
Yuelan et al. (2019)	1980-2016	China	ARDL	FP increases CO_2 LR
Lopez et al. (2011)	1986-1999	38 countries	OLS	FP increases SO_2
Katircioglu and Katircioglu (2018)	1960-2013	Turkey	ARDL	FP decreases CO_2e
Halkos and Paizanos (2012)	1980-2000	77 countries	FE, DFE	FP insignificant effect on CO_2
Halkos and Paizanos (2016)	1973 - 2013	United States	VEC	EFP decreases CO_2
Ullah, Majeed and Chishti (2020)	1981-2018	10 Asian Economies	ARDL and NARDL	EFP increases CO_2e
Yilanci and Pata. (2021)	1875-2016	G7 countries	bootstrap causality	FP reduces CO_2e
(C) Monetary and fiscal policies and CO_2				
Muhafidin (2020)	1973-2018	Indonesia	ARDL	MP positive with CO_2e FP positive with Co_2e
Chishti, Ahmad, Rehman and Khan (2021)	1985-2014	BRICS economies	K&W, POLS, DOLS, FMOLS, PMG (ARDL)	EFP increases CO_2e CFP decreases CO_2e EMP increases CO2e CMP decreases CO_2e
Ullah et al. (2021)	1985-2019	Pakistan	NARDL	CMP decreases CO_2e EMP increases CO_2e EFP and CFP decrease CO_2e (LR)

Mughal et al. (2021)	1990-2019	ASEAN economies	NARDL	CMP decreases CO_2e (LR) EMP increases CO_2e (LR and SR) EFP decreases CO2e (LR) EFP increases CO2e (SR) CMP and CFP insignificant (SR)
Mahmood et al. (2022)	1990-2019	GCC region	PMG, FMOLS, DOLS	FP increases CO_2e LR FP increases CO_2e SR MP decreases CO_2e LR MP increases CO_2e SR

Source: Authors' compilation.
Abbreviations: ARDL, autoregressive distributed lag model; ASEAN, Association of Southeast Asian Nations; BRICS, Brazil, Russia, India, China, & South Africa; CFP, contractionary fiscal policy; CMP, contractionary monetary policy; DOLS, dynamic ordinary least squares; EFP, expansionary fiscal policy, EMP, expansionary monetary policy; FMOLS, fully-modified ordinary least squares; FP, fiscal policy; GMM, generalized method of moments; LR, long-run; MENA, Middle East and North Africa; MCT, Maki cointegration test; MP, monetary policy; NARDL, non-linear autoregressive distributed lag model; POLS, panel ordinary leased squares; PMG, pooled mean regression; SR, short-run; VECM, vector error correction model; LIC, Low-Income Countries; OLS, ordinary least squares.

Tables 2
Pros and Cons of Climate-related Fiscal and Monetary Policies

Example of Policy Tools	Pros	Cons
Public investment and spending	*Reduces fossil fuel energy consumption (e.g. electricity generation). * More climate-friendly public goods.	*Public finances may be challenged. * Transparency and accountability.
Public Private Partnerships	* Improves green infrastructure investment while reducing public spending. *Sharing of project risks (e.g. financial risks, timeframe). * Increases efficiency, technology and innovation expertise from the private sector.	*Requires proper PPP capacity such as appropriate legal framework which is not present in many countries. * Onus is on governments to create the appropriate enabling framework. * Can result in projects becoming more expensive compared to standard procurement practices due to the higher borrowing costs faced by the private sector compared to government rates.
Carbon Pricing	*Leverages the market mechanism to improve resource allocation. *Revenue generating. *Internalises the externalities.	* Market price set may not impact emissions. *Can be ineffective if political interference exists. * Firms may shift production to other countries. * Administrative cost of measuring firms' emissions. * Encourages tax evasion and methods to circumvent the policy by firms.
Public Guarantee	*Provides an upfront 'reward' for low-carbon options while maximising the efficiency of using public finances. *Calibrating the guarantees on the agreed social value of climate mitigation actions (SVMA) will ensure the economic efficiency of project selection.	* Public finances may be challenged.
Integrating climate-related risks analysis in central banks' collateral frameworks	Improves liquidity and reduces costs for financial institutions engaging in green projects.	* Requires reorienting central banks' objectives towards long-term sustainability rather than short-term liquidity. Only a limited number of central banks globally have an objective to promote or support sustainable economic growth.
Green QE	*Improves liquidity and cash flow of green investment projects.	
Climate Change Credit Scheme (Monetary Policy)	*Improves financial institutions' costs and access to funds for green	

	projects subject to an assessment of project risks. * Sectors declared as environmental priorities can be the target of direct credit policy instruments, such as subsidised loan rates.	*The emergence of trade-off relations between short-term monetary stability considerations and environmental sustainability. *Central bank's resources may already be stretched with monetary policy and financial stability issues.

Source: Authors' compilation based on the literature review section of the paper, including Krogstrup and Oman (2019).

2.3 Recent Developments in Climate Change modelling

In recent years, policymakers have leaned toward Integrated Assessment Models (IAMs) to guide climate-related policymaking. Climate-related events and risks are uncertain, requiring policymakers to develop plausible ranges and scenarios to assess the physical and transitional risks facing sectors and countries. Physical risk is damage to physical property and other productive assets that can impact economic output and inflation. Transition risk refers to actions by the economy to cut CO_2 emissions (McKibbin, et al. 2020). These models are being applied to provide insights on GHGs trajectory, climate impacts and options for future mitigation policies (such as carbon pricing, government regulations and green spending initiatives) to guide policymaking.

Central banks can also use IAMs to assess the long-term impact of climate change on the economy. For instance, the Network for Greening the Financing System (NGFS, 2022), which utilised IAMs, demonstrated that monetary policy regimes would likely face challenges because of climate change and its mitigation. In some NGFS (2022) IAM climate scenarios, implementing carbon prices in the transition leads to increases in energy prices. High energy prices feed into inflation and unemployment, creating a potential monetary policy trade-off problem. These models require a data-rich environment and a general understanding of the complex nature of the macroeconomy. The use of the IAMs is beyond the scope of this paper.

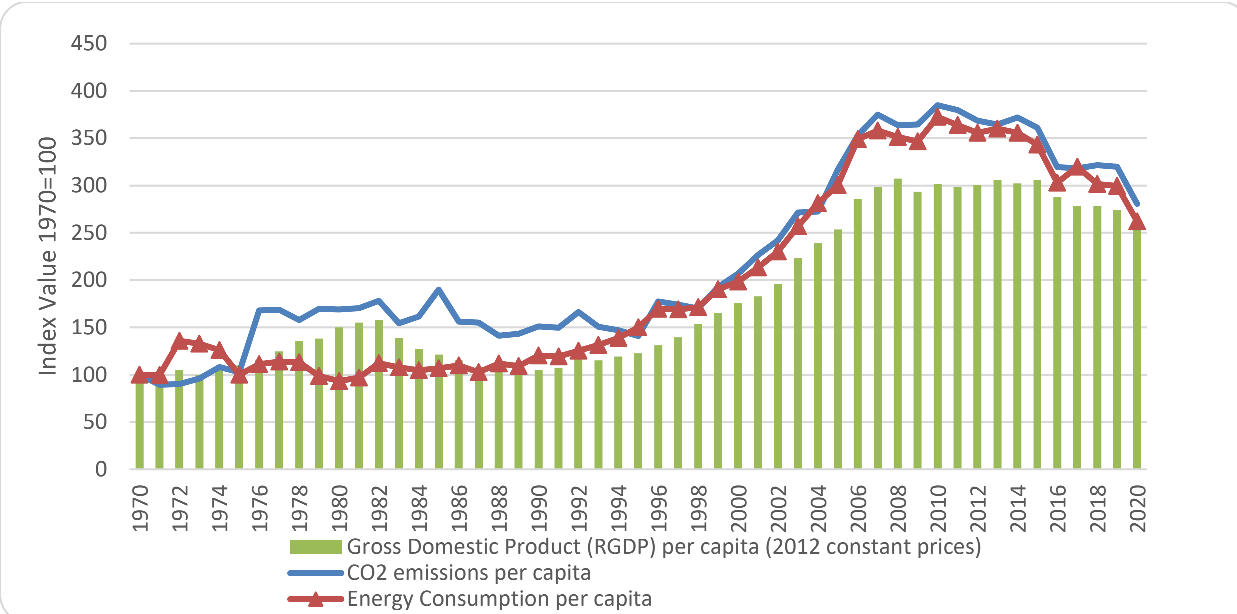
3. Stylised Facts

Although Trinidad and Tobago's contribution to global CO_2 emissions has been considered low in absolute terms, the country is a significant contributor to global emissions per capita. In 2018, Trinidad and Tobago ranked 2nd in the world in terms of CO_2 emissions per capita, and there is clear evidence of an ascent in emissions over time **(Chart 1)**[2]. Per capita emissions experienced an upsurge since the late 1990s and peaked in 2010. Even though there was a decline after 2010, emission levels remained elevated. The high level of per capita emissions stems from the industrialised hydrocarbon-based nature of the economy. The country's economic activity is dominated by the commercialisation of its natural gas and crude oil resources. The country also exports manufactured goods such as food and beverages and construction materials such as cement to the Caribbean. These activities make the economy a significant contributor to global CO_2 emissions.

[2] World Bank Global Carbon Project Report 2019.

From **Chart 1** there appears to be a direct association between CO_2 emissions per capita, energy consumption per capita and real GDP per capita. The decline in CO_2 emissions and energy consumption in 2009 and 2014 were primarily because of the financial crisis and the freefall in energy commodity prices[3], respectively. Additionally, the downward movement in CO_2 emissions and energy consumption from 2019 onwards was primarily a result of the COVID-19 pandemic, which affected economic activity. This pattern suggests that as per capita income increases in Trinidad and Tobago, so do the levels of CO_2 emissions, indicating that the country's economic development is not yet fully aligned with green technology.

Chart 1
Annual Carbon Dioxide (CO_2) Emissions, GDP and Energy Consumption



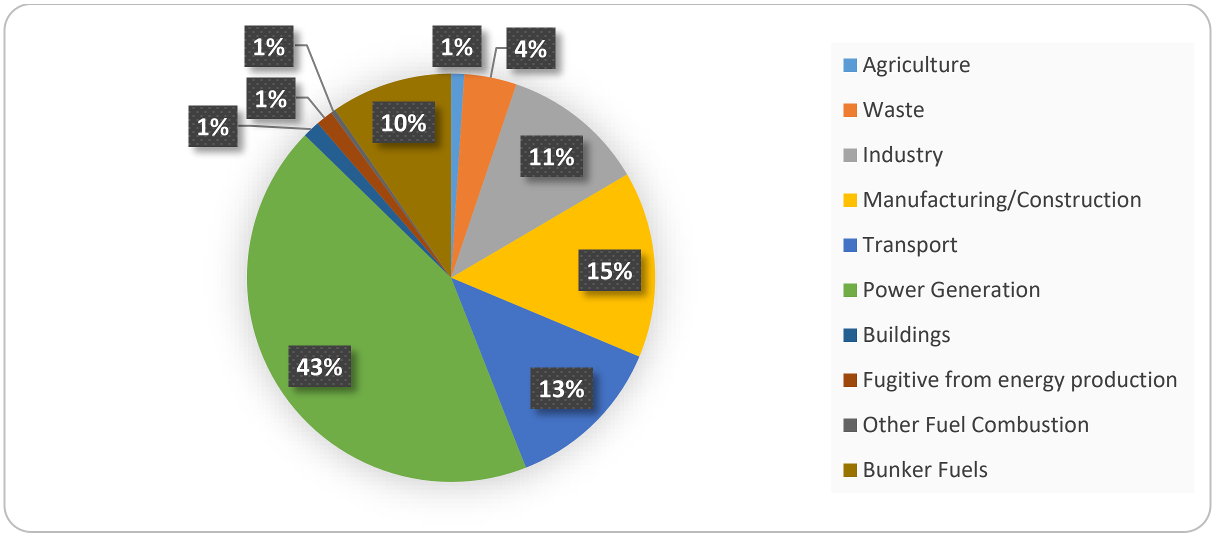
Sources: Global Carbon Project, Our World in Data and Central Statistical Office
Note: Carbon dioxide (CO_2) emissions from fossil fuels and industry. Land use change is not included. Data used refers to production-based CO_2 or territorial emissions. GDP per capita is in local currency adjusted for inflation. Data were converted into index values to aid comparison.

Chart 2 provides a sectoral decomposition of GHG emissions for Trinidad and Tobago for 2020, the majority of which is CO_2 emissions[4]. Power generation for use in energy production plants (such as liquefied natural gas and refined energy products) and industrial and manufacturing activities require burning fossil fuels, which contribute significantly to CO_2 emissions. The latest data show that power generation accounts for 43.0 per cent of GHG emissions. **Chart 3** also shows that manufacturing/construction (15.0 per cent), transportation (13.0 per cent), and industrial activity (11.0 per cent) are three sectors that are significant contributors. These emissions are generated either through burning fossil fuels or as a by-product of production activities.

[3] The freefall in energy commodity prices resulted in the Government's deliberate effort to consolidate aggregate expenditure. There was a 7.0 per cent cut in expenditure across government ministries.
[4] The authors were unable to obtain sectoral data for CO_2 emissions. However, Chart 3 shows GHG emissions for 2020 converted to carbon dioxide equivalent.

Chart 2

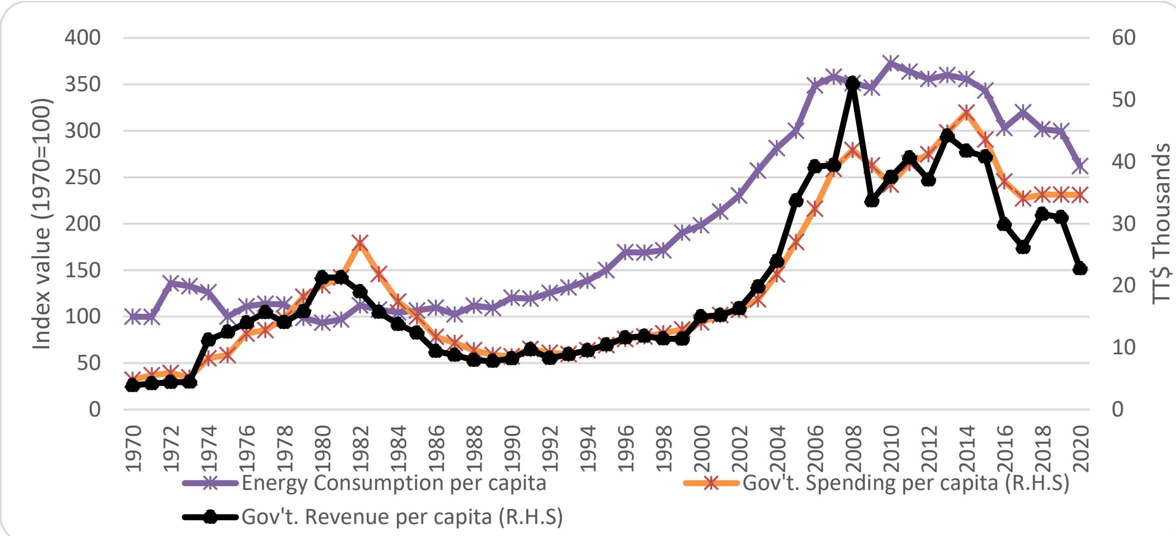
GHG ($MtCO_2e$) Emissions by Sector (2020) *



Sources: CAIT Climate Data Explorer via Climate Watch and Our World in Data CO_2 and Greenhouse Gas Emissions Database
Note: * Tonnes of Carbon Dioxide-Equivalents (CO_2e).

Chart 3 demonstrates the trends in government fiscal policy and CO_2 emissions in Trinidad and Tobago using data from 1970 to 2020. Increasing government expenditure per capita frequently coincided with enhanced revenue (revenue per capita) and vice versa, supporting the procyclical nature of fiscal policy (Cotton et al., 2013). CO_2 per capita also follows a similar trend increasing with government spending and falling with lower outlays. More recently, the downward movement in CO_2 emissions in 2020 also saw a reduction in government revenue due to the closure of activity in several economic sectors to address the COVID-19 pandemic. The overall trend suggests a strong link between government fiscal policy and CO_2 emissions. This link may result from the impact of government spending on generating economic activity and social spending (such as transfers and subsidies) on energy consumption and CO_2 emissions. It is also likely that government revenue is also emission-generating since the energy sector is a key revenue source. The chart suggests fiscal policy should carefully balance climate mitigation concerns while improving GDP per capita.

Chart 3
Trends in Government Expenditure and Revenue, CO_2 emissions and Energy Consumption

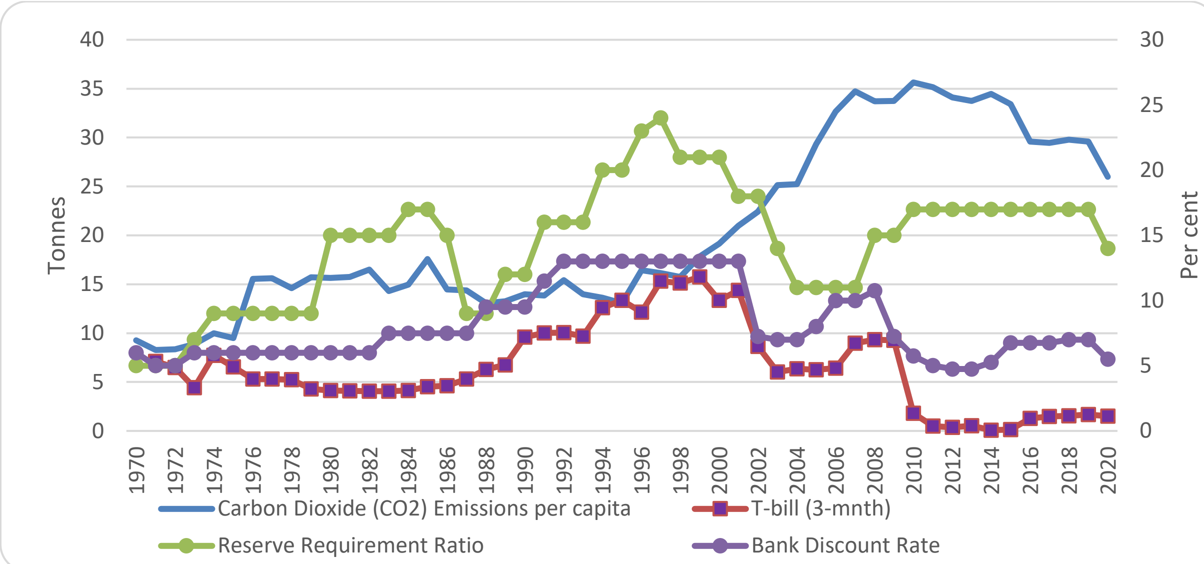


Sources: Our World in Data, Central Bank of Trinidad and Tobago (Handbook of Economic Statistics)

Chart 4 presents the trends in monetary policy and CO_2 emissions. The chart shows no clear association between monetary policy variables and CO_2 emissions for Trinidad and Tobago. It can be seen from the chart that among the monetary policy variables, the 3-month treasury bill rate and the bank discount rate[5] show a relatively high co-movement with each other. Also, there is a fair degree of co-movement between the reserve requirement ratio and the bank discount rate. However, there appears to be a low degree of co-movement between the reserve requirement ratio and the 3-month treasury bill rate. The chart suggests no clear relation between monetary policy and CO_2 emissions in Trinidad and Tobago. However, monetary policy in the Trinidad and Tobago context needs to be explored further to determine its impact on CO_2 emissions, as many studies have already concluded that interest rates can significantly influence credit, investment and consumption spending and aggregate demand channels and can result in changes in production-based CO_2 emissions.

[5] The bank discount rate was utilised instead of the repo rate due to the unavailability of data prior to 2002. The bank rate is set at 200 basis points above the repo rate.

Chart 4
Trends in the Bank Rate, Reserve Requirement, 3-Mth Treasury Bill Rate and CO_2 emissions



Sources: Our World in Data and Central Bank of Trinidad and Tobago

4. Methodology and Data

4.1 Econometric Methodology

Empirical studies have only recently begun exploring the impact of various macroeconomic policies on CO_2 emissions. Based on prior studies for other countries, we augment a Cobb-Douglas production-based pollution function. The empirical model is as follows:

$$LCO_2K_t = \delta_0 + \delta_1 LECK_t + \delta_2 LCIN_t + \delta_3 LFPI_t + \delta_4 MPI_t + \delta_5 LIMC_t + \epsilon_t \quad Eq[1]$$

where t represents the year and L logarithm. LCO_2K_t denotes CO_2 emissions per capita, $LECK_t$ is fossil fuel consumption per capita, $LCIN_t$ is carbon intensity[6], $LFPI_t$ is the fiscal policy index (a measure of fiscal policy), MPI_t is the money policy index (a measure of monetary policy), and $LIMC_t$ is a measure of import capacity[7]. Finally, ϵ_t is

[6] Carbon intensity is computed as the ratio of total energy consumption to gross domestic product multiplied by the ratio of total CO_2 emissions to gross domestic product.

[7] Recent studies infer that fiscal policy (FP) plays a vital role in polluting the environment. Fiscal policy includes the government changing its spending and taxation to increase or decrease aggregate economic activities. Fiscal policy can be either expansionary (EFP) or contractionary (CFP), depending on the different policy objectives. In the above equation, money plays an important role as a factor input in facilitating production as firms hold money balances to ensure they can purchase capital and meet daily expenses. From a theoretical standpoint, a central bank's monetary policy can significantly influence the money balances firms hold. Variations in monetary policy (money supply) can result in firms reducing or increasing their cash balances, thereby affecting production activities. Further, Qingquan et al. (2020) explain that the central bank's monetary policy can have a wide-ranging impact on the economy, including changes in aggregate production, consumption, foreign direct investment, financial development and economic growth. Expansionary (EMP) and contractionary monetary policy (CMP) changes can widely impact an economy

an error term. We divide the quantity variables by population to control for the effects of population growth on CO_2 emissions.

The next phase of the model is to incorporate short- and long-run effects into $Eq\ [1]$. To incorporate these effects, we follow Pesaran et al. (2001) ARDL approach to the error correction and cointegration framework as follows:

$$\begin{aligned}\Delta LCO_2K_t = \delta_0 &+ \sum_{i=1}^{n} \gamma_i \Delta LCO_2K_{t-i} + \sum_{i=1}^{n} \theta_{1i} \Delta LCIN_{t-i} + \\ &+ \sum_{i=0}^{n} \theta_{2i} \Delta LECK_{t-i} \\ &+ \sum_{i=0}^{n} \theta_{3i} \Delta LFPI_{t-i} \\ &+ \sum_{i=0}^{n} \theta_{4i} \Delta MPI_{t-i} + \sum_{i=1}^{n} \theta_{5i} \Delta LIMC_{t-i} + \delta_1 LCO_2K_{t-1} + \delta_2 LECK_{t-1} + \delta_3 LCIN_{t-1} \\ &+ \delta_4 LFPI_{t-1} + \delta_5 MPI_{t-1} + \delta_6 LIMC_{t-1} + \epsilon_{t-1} \quad Eq.[2]\end{aligned}$$

The short-run impacts are revealed as "first-differenced" variables, and long-run impacts are yielded by the estimates of $\delta_2 - \delta_6$ normalised on δ_1 in $Eq[2]$. Indeed, for long-run estimates to be valid, cointegration among the variables must be established. Narayan (2005) endorses using the F-statistics to find a joint significance of the linear model and has presented a different set of tabulated critical values that are valid for small samples. A key assumption of the ARDL is that model variables have different integrating properties, i.e., I (0) or I (1), and even a mixture of both. However, none of the variables should be I (2).

The fundamental hypothesis in $Eq\ [1]$ or $Eq\ [2]$ is that fiscal and monetary policy have symmetric/linear effects on the environment regarding CO_2 emissions. CO_2 emissions are assumed to have the same elasticity for positive and negative shocks to fiscal and monetary policy. However, the symmetry assumption can be counterfactual, especially in studies such as this one, which examine the impact of monetary and fiscal policy on CO_2 emissions. It is possible that CO_2 emissions may respond differently to monetary and fiscal policy expansions and contractions[8]. This insight will be necessary for analysing the impact of monetary and fiscal policies on CO_2 emissions. We modify $Eq\ [2]$ to detect possible asymmetric effects of monetary and fiscal policy on CO_2 emissions in the short and long run. Our specification follows the Shin et al. (2014) asymmetric error correction modelling approach. In this approach, we decompose fiscal policy $(LFPI_t)$ and monetary policy (MPI_t) fluctuations into twotime series variables, one

through various channels, influencing consumer spending and firms' investment decisions and leading to changes in CO_2 levels in a country.

[8]The symmetry assumption can lead to incorrect inferences and policy conclusions, leading to ineffective policy prescription.

signifying increases in fiscal and monetary policy and the other signifying decreases in monetary and fiscal policy[9]. We accomplish this using the partial sums approach as follows:

$$LFPI_t^{+} = \sum_{n=1}^{t} \Delta LFPI_t^{+} = \sum_{n=1}^{t} max(\Delta LFPI_t^{+}, 0) \qquad Eq\ [3]$$

$$LFPI_t^{-} = \sum_{n=1}^{t} \Delta LFPI_t^{-} = \sum_{n=1}^{t} min(\Delta LFPI_t^{-}, 0) \qquad Eq\ [4]$$

$$MPI_t^{+} = \sum_{n=1}^{t} \Delta MPI_t^{+} = \sum_{n=1}^{t} max(\Delta MPI_t^{+}, 0) \qquad Eq\ [5]$$

$$MPI_t^{-} = \sum_{n=1}^{t} \Delta MPI_t^{-} = \sum_{n=1}^{t} min(\Delta MPI_t^{-}, 0) \qquad Eq\ [6]$$

In $Eq\ [3]$ to $Eq[6]$, $LFPI_t^{+}$ and MPI_t^{-} are the time series variables which capture the partial sum expansionary fiscal and monetary policy. Similarly, $LFPI_t^{-}$ and MPI_t^{+} capture the partial sum of the contractionary fiscal and monetary policy. For the asymmetric or non-linear autoregressive distributed lag (NARDL) model, we replace the variables for fiscal and monetary policy in $Eq[2]$ with $LFPI_t^{+}/LFPI_t^{-}$ and MPI_t^{+}/MPI_t^{-} to obtain the following specification:

$$\begin{aligned}
&\Delta LCO_2K_t \\
&= \delta_0 + \sum_{i=1}^{n} \gamma_i \Delta LCO_2K_{t-i} + \sum_{i=0}^{n} \theta_{1i} \Delta LCIN_{t-i} \\
&+ \sum_{i=0}^{n} \theta_{2i} \Delta LECK_{t-i} \\
&+ \sum_{i=0}^{n} \theta_{3i} \Delta LFPI_{t-i}^{+} + \sum_{i=0}^{n} \theta_{4i} \Delta LFPI_{t-i}^{-} \\
&+ \sum_{i=0}^{n} \theta_{5i} \Delta MPI_{t-i}^{+} + \sum_{i=0}^{n} \theta_{6i} \Delta MPI_{t-i}^{-} + \sum_{i=0}^{n} \theta_{7i} \Delta LMC_{t-i} + \delta_1 LCO_2K_{t-1} + \delta_2 LCIN_{t-1} + \delta_3 LECK_{t-1} \\
&+ \delta_4 LFPI_{t-1}^{+} + \delta_5 LFPI_{t-1}^{-} + \delta_6 MPI_{t-1}^{+} + \delta_7 MPI_{t-1}^{-} + \delta_8 LIMC_{t-1} \\
&+ \epsilon_{t-1} \qquad Eq\ [7]
\end{aligned}$$

$Eq\ [7]$ permits asymmetric testing in several ways. For instance, different estimates and lag structures of $LFPI_t^{+}/LFPI_t^{-}$ and MPI_t^{+}/MPI_t^{-} can shed light on the short-term asymmetry of the CO_2 variable for the fiscal and monetary shocks. Also, the differences in the estimates of $LFPI_t^{+}/LFPI_t^{-}$ and MPI_t^{+}/MPI_t^{-} can notify us about the sign and size of the impact due to the partial sums. The Wald test can also be used to formally confirm the presence of short-run asymmetries by rejecting the null hypotheses $H_0: \sum_{i=0}^{q} \theta_{3i} = \sum_{i=0}^{q} \theta_{4i}$ and $H_0: \sum_{i=0}^{q} \theta_{5i} = \sum_{i=0}^{q} \theta_{6i}$. Finally, the long-run asymmetries of fiscal and monetary policies can be confirmed if the null hypotheses $H_0: \frac{\delta_4}{\delta_1} = \frac{\delta_5}{\delta_1}$ and $H_0: \frac{\delta_6}{\delta_1} = \frac{\delta_7}{\delta_1}$ are nullified in favour of a disparity.

[9] Granger et al. (2002) state that if two-time series positive and negative components are cointegrated, they have hidden cointegration and linear cointegration is a particular case of this hidden cointegration which is a simple case of nonlinear cointegration.

4.1.1 Dynamic Multipliers

Asymmetric dynamic multipliers can capture the impact of fiscal and monetary expansions and contractions on CO_2 emissions. We can use the following formulas to compute the asymmetric dynamic multipliers:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial LCO_2K_{t+j}}{\partial LFPI_t^+} \qquad m_h^+ = \sum_{j=0}^{h} \frac{\partial LCO_2K_{t+j}}{\partial MPI_t^+}$$

$$m_h^- = \sum_{j=0}^{h} \frac{\partial LCO_2K_{t+j}}{\partial LFPI_t^-} \qquad m_h^- = \sum_{j=0}^{h} \frac{\partial LCO_2K_{t+j}}{\partial MPI_t^-}$$

By construction, when $h \to \infty, m_h^+ \to L_{LFPI^+}$, $m_h^- \to L_{LFPI^-}, m_h^+ \to L_{MPI^+}$ and $m_h^- \to L_{MPI^-}$. These multipliers could capture the cumulative effects of expansionary and contractionary policy on CO_2 emissions from an initial equilibrium to the new equilibrium, as shown by Shin et al. (2014).

4.2 Data Description

The NARDL model is estimated by employing annual time series data from 1970 to 2020. The data was obtained from various sources.

The data on total CO_2 emissions, fossil fuel consumption, and carbon intensity of energy consumption[10] were sourced from Our World in Data (Global Carbon Project) [11]. CO_2 emissions per capita was obtained by dividing total CO_2 emissions by the total population. Similarly, we obtained fossil fuel energy consumption per capita by utilising annual population data. The data for the total population was obtained from the Central Statistical Office (CSO). Further, the definitions and the unit of measurement of CO_2 emissions and fossil fuel energy consumption can be obtained from Our World in Data. Import capacity (IMC), calculated by dividing total exports by total imports, was obtained from trade data from the Central Bank of Trinidad and Tobago. Government revenue and expenditure data were sourced from the Ministry of Finance and converted these into per capita terms by dividing them by the total population. Also, government revenue and expenditure data were converted into 2015 constant prices using the core inflation rate obtained from the CSO and the Central Bank of Trinidad and Tobago. All data were taken in their logarithmic form (except for the interest rates and reserve requirement).

Fiscal Policy Index

To capture the fiscal policy stance efficiently, a fiscal policy index was constructed using the method of Principal Component Analysis (PCA). The data for government revenue (GREVK) and government expenditure (GSK) were used to construct this index via the PCA method. Before applying the PCA to these variables, the degree of correlation between them needs to be determined. **Appendix Table 2** shows the correlation coefficients for these policy variables, which reveal a high degree of inter-correlation. Finally, the PCA weights were employed to construct a fiscal policy index.

[10] The carbon intensity of energy consumption is the ratio of CO_2 emissions to total fossil fuel energy consumption.
[11] See for further details: https://ourworldindata.org/co2-emissions.

The number of principal components (PCs) generated equals the number of variables used to construct the index, which means two PCs will be generated in this case. The first component accounts for the maximum variance, and the succeeding components account for smaller proportions. The variance accounted for a given component is expressed in eigenvalues. The sum of all the eigenvalues equals the number of variables or PCs generated. **Table 3** shows the PCs and their respective eigenvalues. Under the eigenvalue-one criterion (also known as the Kaiser Criterion), only PCs with an eigenvalue of more than one have to be retained and interpreted. **Table 3** also shows that only PC1 needs to be retained from the two PCs, which explains about 80.0 per cent of the total variance. The eigenvector or the weights of different variables in PC1 as shown in **Table 3** are multiplied by the time series of the respective variables[12]. These weighted data are then added to make a new time series. This variable is converted into an index by taking the first value of the series as the base value.

Table 3: Principal Components Analysis

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	1.608356	1.216712	0.8042	1.608356	0.8042
2	0.391644	---	0.1958	2.000000	1.0000
Eigenvectors					
Variable				**PC 1**	**PC 2**
GSK				0.707107	-0.707107
GREVK				0.707107	0.707107

Source: Eviews 9 output based on authors' calculation.

Monetary Policy Index

Similarly, to efficiently capture the monetary policy stance, we construct a monetary policy index via PCA. Data for the Bank Discount Rate, the 3-month Treasury bill rate, and the reserve requirement ratio are used to construct this index. **Appendix Table 2** shows the correlation coefficients for the three policy variables showing a reasonably high degree of inter-correlation, especially between the Treasury bill and the Bank Rate. However, these variables and the reserve requirement showed a relatively lower correlation. **Table 4** shows the PCA results, where each PC generated has a specific weighted composition for the three variables. **Table 4** shows that out of the three PCs, only PC1 needs to be retained, which explains about 72.0 per cent of the total variance. The eigenvector or the weights of different variables in PC1, as shown in **Table 4,** are multiplied by the time series of the respective variables[13]. These individually weighted data are then added to make a new time series index. The final variables used in our model are summarised in **Table 5**.

[12] The weights were derived by dividing each component (0.707 and 0.707) by the sum of the components.
[13] The same method was applied as in footnote 12.

Table 4: Principal Components Analysis

Number	Value	Difference	Proportion	Cumulative Value	Cumulative Proportion
1	2.153752	1.384598	0.7179	2.153752	0.7179
2	0.769154	0.692061	0.2564	2.922907	0.9743
3	0.077093	---	0.0257	3.000000	1.0000
Eigenvectors					
Variable			**PC 1**	**PC 2**	**PC 3**
RR			0.445234	0.859492	0.251079
BR			0.662564	-0.127618	-0.738053
TBILL			0.602308	-0.494962	0.626289

Source: Eviews 9 output based on authors' calculation.

Table 5: Variables Description

Variables	Abbreviation	Measurement	Sources	Expected Relationship with CO_2K
Carbon Dioxide Emissions per capita	CO_2K_t	Metric tons/total population	Our World in Data	
Fossil Fuel Energy Consumption per capita	ECK_t	Total Kilowatt-hour/Population	Our World in Data	+
Carbon Intensity of economic activity.	CIN_t	Total Fossil Energy Consumption (KWh)/Total GDP X Total CO_2 Emissions/Total Fossil Energy Consumption (KWh)	Our World in Data	+
Fiscal Policy Index	FPI_t	Gov't Spending per capita and Gov't Revenue per Capita PCA	Ministry of Finance	+ or -
Monetary Policy Index	MPI_t	Bank Discount Rate 3-Month Treasury Rate Primary Reserve Requirement PCA	Central Bank of Trinidad and Tobago	+ or -
Import capacity	IMC_t	Total Exports/Total Imports	Central Bank of Trinidad and Tobago	+

Source: Author's Construction

Note: [1] GDP is measured in 2017 international $ and PPP-adjusted. GDP data for 2019 and 2020 were estimated based on CSO data.

5. Discussion of Results

5.1 Short-run and long-run estimates

The results of the various diagnostic tests and the estimated short-run and long-run elasticity coefficients for the NARDL model are presented in **Table 6**. The diagnostic test results show that the error terms of the specification of the NARDL model are normally distributed, and the residuals are free from serial correlation and heteroscedasticity. Further, the speed of adjustment parameter (-0.61) is negative and statistically significant, indicating that the variables in the estimated NARDL model have a short-run dynamic and a long-run equilibrium impact.

The results show that the effect of fossil fuel energy consumption is positive and significant in the short run. In the long run, the coefficient of fossil fuel energy consumption is also positive and statistically significant at the 1.0 per cent level, indicating that an increase in fossil fuel energy consumption increases per capita CO_2 emissions. From the short-run coefficient, a 1.0 per cent increase in fossil fuel consumption increases CO_2 emissions by 0.36 per cent. From the long-run coefficients, a 1.0 per cent increase in energy consumption per capita increases CO_2 emissions per capita by 0.61 per cent. The results also show the short-run coefficient for carbon intensity (0.44) being positive and statistically significant. The long-run coefficient for carbon intensity (0.72) is positive, and comparatively much larger than its short-run counterpart, and statistically significant at the 1.0 per cent level, indicating that a 1.0 per cent increase in carbon intensity increases emissions by 0.72 per cent. Further, fossil fuel consumption due to expansion in domestic economic output combined with increased carbon intensity can lead to rapid growth in CO_2 emissions in Trinidad and Tobago.

The short-run coefficient of the import capacity ratio is positive and statistically significant (0.12) at the 1.0 per cent level, suggesting that a 1.0 per cent improvement in the country's import capacity increases CO_2 emissions by 0.12 per cent. Furthermore, the long-run coefficient (0.20) is also positive and statistically significant but at the 5.0 per cent level, indicating that a 1.0 per cent improvement in import capacity increases CO_2 emissions by 0.20 per cent in the long run.

The short-run estimates showed a positive value (0.27) for fiscal policy – a 1.0 per cent increase in fiscal spending and revenues (or fiscal expansion) increases CO_2 emissions by 0.27 per cent. This finding implies that expansionary fiscal policy increases CO_2 emissions. A possible explanation is that higher fiscal spending incentivises output through the aggregate demand channel, increasing CO_2 emissions. Additionally, different classes of expenditure, including spending on construction projects and capital imports, may impact CO_2 emissions differently, especially if they are not based on eco-friendly technologies. Further, spending on transfers and fuel subsidies can lead to more CO_2 emissions[14].

In contrast, the model shows the short-run coefficient (0.29) for negative fiscal policy (or fiscal contraction). The magnitude of the coefficients is confirmed to be statistically the same based on the results of the Wald test **(Table 7)**. The long-run estimates show a positive value (0.45) for the expansionary fiscal policy, which is significant at the 1.0 per cent level. The result suggests that an expansionary fiscal policy of 1.0 per cent would raise CO_2 emissions by 0.45 per cent. However, the long-run estimate for contractionary fiscal policy (0.48) is positive and statistically significant at the 1.0 per cent level, implying that a 1.0 per cent fiscal contraction would lead to a reduction in CO_2 emissions of 0.48 per cent over the long term. A possible explanation is that the reduction in spending reduces employment and economic

[14] The results are consistent with Yuelen et al. (2019).

activity, decreasing CO_2 levels. The overall finding is that fiscal policy is not oriented toward long-term climate mitigation.

In the case of monetary policy, the short-run estimate shows a negative value (0.01) which was significant at the 5.0 per cent level, suggesting that a monetary policy contraction of 1.0 per cent could adversely impact CO_2 emissions by 0.01 per cent. Also, the coefficient of the expansionary monetary policy is negative (0.0006) but statistically insignificant. The small size of these coefficients implies that monetary policy has negligible short-run effects on CO_2 emissions. Similarly, the long-run coefficient for contractionary monetary policy (-0.02) though significant at the 5.0 level (indicating that a contraction in monetary policy by 1.0 per cent reduces CO_2 emissions by 0.02 per cent), has a marginal impact on CO_2 emissions.

Table 6: Estimated NARDL Short-Term and Long-Term Coefficients

Variables	Short-run Coefficients		Std. Error	t-Statistic
D(LECK)	0.353	***	0.117	3.003
D(LECK(-1))	-0.259	*	0.135	-1.911
D(LCINT)	0.444	***	0.078	-5.687
D(LFPI_POS)	0.272	***	0.077	-0.519
D(LFPI_NEG)	0.293	***	0.067	4.378
D(MPI_POS)	-0.011	**	0.005	-2.171
D(MPI_NEG)	-0.0006		0.003	-0.159
D(LIMC)	0.122	***	0.047	2.566
ECT(-1)	-0.611	***	0.103	-5.884
Variables	**Long-run Coefficients**		**Std. Error**	**t-Statistic**
C	-3.729	***	1.149	-3.245
LECK	0.607	***	0.199	3.036
LCIN	0.726	***	0.180	4.037
LFPI_POS	0.445	***	0.076	5.833
LFPI_NEG	0.480	***	0.127	3.773
MPI_POS	-0.018	**	0.007	-2.284
MPI_NEG	-0.0009		0.0005	-0.158
LIMC	0.199	**	0.089	2.242
Model Diagnostics Tests				
R^2=0.767 Adj-R^2= 0.757	χ^2_{LM} = 1.99 [0.151]		χ^2_{BPG} = 1.98 [0.080]	
χ^2_{JB} = 1.232[0.540]	χ^2_{RS} = 0.431[0.668]		D.W = 2.17	

Note: *, ** and *** indicate a 10% level, 5% level and 1% level of significance, respectively. χ^2_{LM}, χ^2_{BPG}, χ^2_{JB} and χ^2_{RS} are parameters of the LM test for serial correlation, Brush–Pagan Godfrey test for heteroscedasticity, Jarque–Bera normality test, and Ramsey Reset test for model specification, respectively. Probability values in [].

Table 7: Wald Test Results

H_0	H_1	F-statistic	Decision
-C(5)/C(2)=-C(6)/C(2)	-C(5)/C(2)≠-C(6)/C(2)	0.039	Long-run symmetric relationship between expansionary and contractionary fiscal policy
-C(7)/C(2)=-C(8)/C(2)	-C(7)/C(2) ≠-C(8)/C(2)	1.97	Long-run symmetric relationship between expansionary and contractionary monetary policy

Note: *** depicts significance at 1% level

5.2 Fiscal and monetary policy dynamic multipliers

The asymmetric dynamic relationships between the policy variables and CO_2 emissions have been further analysed by plotting the multiplier effects **(Charts 5(a) and 5(b))**. The solid black line (dashed black lines) in **Chart 5(a)** describes the adjustment of CO_2 emissions to positive/expansionary (negative/contractionary) shocks to the fiscal policy index over 15 years. The asymmetry lines (red dashed lines) reflect the difference between the positive and negative impact multipliers over 15 years. **Chart 5(a)** shows that a positive shock to fiscal policy (or fiscal expansion) has a strong increasing effect on CO_2 emissions. In contrast, a negative shock (or fiscal contraction) decreases CO_2 emissions over the forecast horizon. It can also be seen that expansionary and contractionary fiscal policy display some symmetric behaviour, as the magnitude of the effect of a fiscal expansion on CO_2 emissions is almost the same as a fiscal contraction.

In the case of monetary policy, the solid black line (dashed black lines) in **Chart 5(b)** describes the adjustment of CO_2 emissions to positive/contractionary (negative/expansionary) shocks to the monetary policy index over 15 years. **Chart 5(b)** shows that a positive shock (or contractionary monetary policy) decreases CO_2 emissions over the 15-year forecast horizon. A negative monetary policy (or expansionary) shock has a small increasing effect on CO_2 emissions, but the magnitude of the effect is relatively much weaker when compared to a positive shock. **Chart 5(b)** also shows expansionary and contractionary monetary policy displaying symmetric behaviour. This finding implies that monetary policy shocks do not significantly impact CO_2 emissions.

Chart 5(a): Dynamic Multiplier (Fiscal Policy)

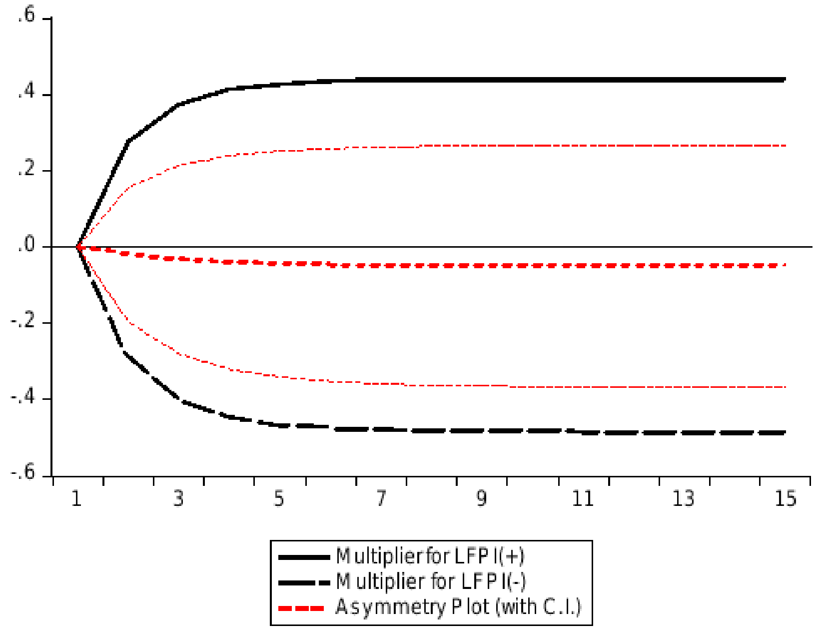
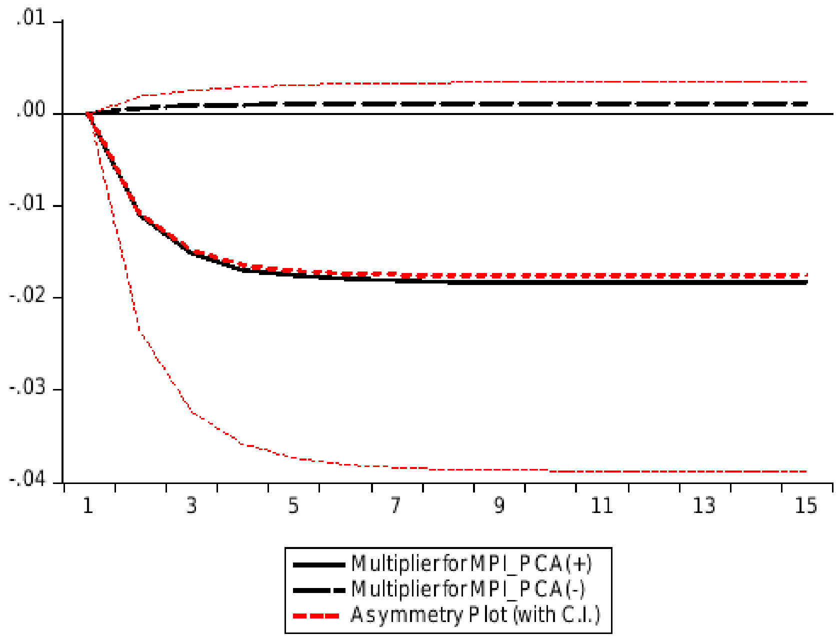


Chart 5(b) Dynamic Multiplier (Monetary Policy)



6. Conclusion and Recommendations

This paper's primary purpose was to examine the economic linkages between fiscal and monetary policy and CO_2 emissions, with the consort of some control variables (that is, fossil fuel energy consumption, carbon intensity of economic activity and import capacity) for Trinidad and Tobago. The application of the non-linear ARDL model confirms the existence of a long-run causal relationship among the variables. Further, the cointegrating parameter is negative and statistically significant, indicating that the variables in the estimated NARDL model have a short-run dynamic and a long-run equilibrium impact.

In examining the short-run and long-run dynamics, it is noteworthy that the impacts of fossil fuel energy consumption, carbon intensity and import capacity on CO_2 emissions are positive and statistically significant. A key feature is that their impact on CO_2 emissions is greater in the long run than in the short run. According to the NARDL model results, expansionary fiscal policy contributes significantly to increases in CO_2 emissions, while contractionary fiscal policy decreases CO_2 emissions. This implies that fiscal policy is not oriented toward reducing CO_2 emissions and some policy actions risk impacting domestic economic activity. On the other hand, monetary policy is found to have little to no impact on CO_2 emissions in the short and long run. The finding contributes to the mixed results found in the literature, reflecting the challenge of tracing monetary policy through rather complex channels to the real economy.

The paper's findings carry useful implications for governments, central banks, finance ministries, policymakers, and environment regulating agencies. Firstly, since higher fiscal spending leads to greater CO_2 emissions and is also a major requisite for improving growth and employment outcomes, there is a need for climate-sensitive policies to promote efficient use of fossil fuels and a scaling up of renewable energy to maximise output while keeping CO_2 emissions down, especially in major emitting sectors[15]. The industry, power generation, and transport sectors have been identified as the larger contributing sectors to CO_2 emissions in Trinidad and Tobago; therefore, tailoring policies to reduce or optimise fossil fuel consumption in these sectors can contribute to climate change mitigation. For example, prioritising public spending that promotes cleaner energy consumption in the transportation sector may reduce CO_2 emissions. In Trinidad and Tobago, using compressed natural gas (CNG) as an alternative and cost-effective fuel in public and private transportation is already being implemented[16]. In addition, there are incentives for efficient energy use and the production of renewable energy[17]. However, there is potential to increase industry usage of renewable energy within the energy mix. In the 2023 national budget statement, the Government stated its intention to develop a renewable energy policy and explore green hydrogen as a fuel.

[15] Trinidad and Tobago became a signatory to the Paris Agreement in 2018. Under this Multilateral Environmental Agreement (MEA), the country has agreed to cut GHG emissions in the power generation, transportation and industrial sectors. It has developed a Carbon Reduction Strategy to achieve the target. This commitment is known as our Nationally Determined Contribution (NDC), which has two parts: (i) a 15.0 per cent reduction in cumulative emissions from the major contributing sectors and (ii) an unconditional 30.0 per cent reduction in emissions from public transportation.

[16] The use of Compressed Natural Gas (CNG) as a transport fuel is widely used across the world. Although compressed natural gas is a fossil fuel, it is the cleanest burning fuel at the moment in terms of its emission of GHGs. See the United Nations Climate Change and Technology Network website for additional information: Compressed Natural Gas (CNG) as fuel | Climate Technology Centre & Network | 1184949 (ctc-n.org)

[17] Efficient energy use and reduction in GHG emissions is being encouraged through the provision of an increase in electricity rebates to households whose electricity bill is lower than $300.00, the removal of customs duties, motor vehicle tax and Value Added Tax (VAT) on batterypowered electric vehicles and several fiscal incentives through the CNG programme. Additionally, the Government is advancing its renewable energy goals with plans for the construction of two solar Photo Voltaic plants through build-own-operate schemes, feeding 92.2 megawatts and 20.0 megawatts of solar power onto the national grid at Couva and Trincity, respectively.

Apart from ensuring a greater composition of green public spending, the Government could also consider a mix of instruments such as an emissions trading system (ETS), a carbon tax and public guarantees to reduce CO_2 emissions. The Ministry of Finance is exploring carbon pricing approaches for Trinidad and Tobago, such as implementing a carbon tax and/or developing an ETS. Although there is widespread support for carbon taxes or ETSs as possible effective responses to climate change, these policies have their advantages and disadvantages which should be assessed in the Trinidad and Tobago context. Similarly, if implemented successfully, public guarantees can incentivise firms to invest in clean technologies. Energy subsidy reform, along with incentives such as the full removal of taxes on hybrid and electric motor vehicles, can reduce fossil fuel energy consumption and, by extension, CO_2 emissions.

Given the dual causation, that is, revenue and expenditure both contributing to CO_2 emissions[18], decoupling economic growth from fossil fuel consumption should be an imperative. Expenditure could be directed to building renewable energy capacity and transforming economic sectors to low-carbon status. Further, spending on strengthening the development, enforcement and effectiveness of environmental regulations can reduce CO_2 emissions and improve environmental quality through the environmental regulation channel.

This study also has implications for monetary policy to play a role in reducing CO_2 emissions despite little to no impact in the short and long run. Monetary policy can contribute to climate change adaptation and mitigation. Green monetary policy via a "central bank green interest rate" to indicate the funding costs available to commercial banks to finance private sector green investments[19] could be investigated. Some policymakers advance that green monetary policy instruments can convolute the role of central banking and, by extension, monetary policy objectives. However, some central banks recognise the urgency of climate change action and are taking steps to implement green monetary policy. Additionally, several central banks have started integrating climate-related shocks (physical and transition risks) into their financial risk frameworks. The NGFS)has been successful in scaling up green finance and helping central banks strengthen their analytical orientation to model the impact of climate change on the financial system. The Central Trinidad and Tobago, as a member of the NGFS, should continue to leverage the expertise available to build capacity in these areas.

[18] Since revenue increases are typically associated with higher fossil fuel consumption and public spending (given the procyclical nature of fiscal policy), which generates CO_2 emissions, directing expenditures towards renewable energy production can help transition the local economy away from fossil fuels to sustainable energy alternatives.

[19] The proposed central bank green interest rate is a policy rate set below the Bank's traditional policy rate, which can be utilised for short-term borrowing by commercial banks that re-lend for private sector green projects. Using a green policy interest rate could ensure that the financing cost of green investment is not adversely impacted by strong monetary policy contractions and will also facilitate low-cost liquidity flows to commercial banks wishing to commit funds for long-term green projects.

7. References

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8. Appendices

Appendix A: Descriptive Statistics

The descriptive statistics of the model variables are provided in **Appendix Table 1**. The table shows the mean, median, maximum, minimum, skewness and kurtosis, and Jarque-Bera test results for each data series. The Jarque-Bera test statistic is significant in some variables, meaning some variables are not normally distributed. Further, the correlation results **(Appendix Table 2)** indicate a strong positive correlation between the CO_2K and ECK, GDPK, FPI and IMC, but a weak negative correlation between CO_2K and bank rate and Treasury-bill rate and a weak positive correlation between the reserve requirement ratio.

Appendix Table 1: Results of the Descriptive Statistics

VARIABLES	CO_2K	CINT	ECK	GREVK	GSK	FPI	GDPK	BR	TBILL	RR	MPI	IMC
Mean	20.47	103.98	94470.74	19.84	20.75	466.30	20580.72	8.15	4.77	14.37	8.68	1.31
Median	16.13	110.69	70855.28	15.23	15.28	350.60	19183.46	7.00	4.52	15.00	7.71	1.24
Maximum	35.64	161.13	176079.8	52.66	47.91	1086.01	37359.01	13.00	11.81	24.00	15.40	2.16
Minimum	8.28	46.76	44127.77	3.906	4.79	100.00	10158.43	4.75	0.060	5.00	4.41	0.72
Std. Dev.	8.83	31.64	47810.97	12.68	12.89	290.55	7981.40	2.84	3.29	4.66	2.91	0.35
Skewness	0.48	-0.11	0.53	0.79	0.63	0.67	0.42	0.74	0.48	-0.23	0.96	0.52
Kurtosis	1.76	2.08	1.61	2.46	1.94	2.08	2.07	2.08	2.42	2.42	2.83	0.27
Jarque-Bera	5.25*	1.90	6.48**	5.98*	5.74*	5.64*	3.36	6.54**	2.74	1.193	8.02**	2.59
Probability	0.07	0.387	0.039	0.058	0.057	0.059	0.18	0.037	0.254	0.550	0.014	0.000
Observations	51	51	51	51	51	51	51	51	51	51	51	51

Note***, **, and * represents the values are significant at 1%, 5%, and 10%, respectively.

Appendix Table 2: Correlation Matrix

VARIABLES	CO_2K	ECK	CINT	GREVK	GSK	GDPK	FPI	BR	TBILL	RR	MPI	IMC
CO_2K	1.00	0.96	0.43	0.94	0.94	0.74	0.95	-0.18	-0.47	0.35	-0.10	0.75
ECK	0.96	1.00	0.45	0.89	0.88	0.67	0.90	-0.14	-0.39	0.32	-0.07	0.71
CINT	0.26	0.28	1.00	0.02	0.04	-0.25	0.03	0.68	0.45	0.71	0.74	0.13
GREVK	0.94	0.89	0.10	1.00	0.96	0.90	0.99	-0.27	-0.50	0.25	-0.19	0.77
GSK	0.94	0.88	0.10	0.96	1.00	0.91	0.99	-0.34	-0.62	0.29	-0.24	0.68
GDPK	0.97	0.94	-0.25	0.94	0.96	1.00	0.96	-0.23	-0.52	0.35	-0.14	0.75
FPI	0.95	0.90	0.11	0.99	0.99	0.91	1.00	-0.31	-0.57	0.28	-0.22	0.73
BR	-0.18	-0.14	0.68	-0.27	-0.34	-0.58	-0.31	1.00	0.87	0.54	0.95	-0.04
TBILL	-0.47	-0.39	0.45	-0.50	-0.62	-0.73	-0.57	0.87	1.00	0.26	0.83	-0.27
RR	0.35	0.32	0.71	0.25	0.29	-0.02	0.28	0.54	0.26	1.00	0.74	0.21
MPI	-0.10	-0.07	0.74	-0.19	-0.24	-0.51	-0.22	0.95	0.83	0.74	1.00	-0.03
IMC	0.75	0.71	0.19	0.77	0.68	0.63	0.73	-0.04	-0.27	0.21	-0.03	1.00

Appendix B: Unit root and non-linearity tests

Time series data analysis requires the investigation of the stationarity properties of the variables to decide the most appropriate method. We employ the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests to estimate stationarity. The results are recapped in **Appendix Table 3,** and the outcomes show that all variables are integrated of order one I(1) except for IMC, which shows evidence of stationarity. However, none of the variables are integrated of order I(2). However, it should be noted that the ADF and PP may give misleading results if the time series contain structural breaks.

Further, when a structural break is large, and the sample date is small, these tests have a lower ability to determine the stationarity property of the time series accurately. That is, it is more likely that the null hypothesis will not be rejected. Therefore, we estimate the extent of the non-stationary using the Augmented Dicky-Fuller (Structural Breakpoint) unit root test, designed to test unit root in the presence of a single break in the time series due to a change in the structure of the economy. The results for the variables in levels and first differences are presented in **Appendix Table 4**. Thus, even considering a structural break, the series displayed the same stationarity status compared to the standard unit root tests in almost all instances.

Appendix Table 3: ADF and PP Unit Root Test Results

Variables	Levels		First Difference	
	ADF	PP	ADF	PP
LCO_2k	-1.58	-1.65	-7.63***	-7.61***
LECK	-1.02	-1.17	-6.24***	-6.29***
LCIN	-2.09	-1.92	-8.27***	-8.46***
LFPI	-2.27	-1.94	-5.28***	-5.42***
MPI	-1.11	-1.32	-5.50***	-5.52***
LIMC	-3.64**	-3.57**	-6.29***	-12.99***

Note: *, ** and *** indicate significance at the 10%, 5% and 1%, respectively. For the ADF and PP, H_0 = Variable has a unit root and H_0= Variable is stationary for the KPSS test.
Critical values for the ADF and PP (level) tests are -4.15 (1%), -3.502 (5%), and -3.18 (10%).
Critical values for the ADF and PP (first difference) tests are -3.57 (1%), -2.92 (5%), and -2.59 (10%).

Appendix Table 4: Augmented Dicky-Fuller Unit Root Test with Structural Break

Notation	At Level			At First Difference			
	Break Date	T-Stat	P-value	Break Date	T-Stat	P-value	Result
LCO_2K	2002	-2.52	>0.98	1976	-9.08***	<0.01	I(1)
LECK	2015	-1.65	>0.99	1979	-6.42***	<0.01	I(1)
LCIN	2003	-4.31	0.33	1976	-8.81***	<0.01	I(1)
LFPI	1982	-2.89	0.97	1980	-5.89***	<0.01	I(1)
MPI	2001	-4.58	0.20	2002	-6.53***	<0.01	I(1)
LIMC	2004	-4.56	0.21	2006	-6.85***	<0.01	I(1)

Critical values (Level: Trend and Intercept) are -5.34 (1%), -4.85 (5%), -4.60 (10%) - If T-stat > critical value, reject H0: δ=0 (Has a Unit Root)
Critical values (1^{st} Diff: Intercept only) are -4.94 (1%), -4.44 (5%), and -4.19 (10%) - If T-stat > critical value, reject H0: δ=0 (Has a Unit Root)
Break Selection Criteria: Minimize Dicky-Fuller t-statistic, Automatic Selection based on F-statistic (max lag = 2, lagpval=0.10)

The presence of multiple structural breaks can indicate non-linearity in the data, and therefore the NARDL technique to analyse non-linear relationships among the variables. We confirm the non-linearity in the data by conducting BDS tests (Brock Dechert, Scheinkman and LeBaron,1996) of all the variables in the model. The test results in **Appendix Table 5** indicate non-linearity in all the variables used in the NARDL model.

Appendix Table 5: BDS Test Results for Non-Linearity

Variables	m=2	m=3	m=4	m=5	m=6
LCO_2K	0.17*	0.29*	0.37*	0.42*	0.46*
LECK	0.19*	0.32*	0.39*	0.45*	0.48*
LCINT	0.14*	0.23*	0.30*	0.34*	0.37*
LFPI	0.18*	0.29*	0.37*	0.41*	0.43*
MPI	0.15*	0.26*	0.32*	0.34*	0.34*
LIMC	0.06*	0.11*	0.14*	0.15*	0.14*

Note: * represents the 1% level of significance.

Appendix C: NARDL bounds test for cointegration

The results of the cointegration test based on the NARDL bound testing method are presented in **Appendix Table 6**. The critical bounds by Pesaran et al. (2001) are not considered appropriate for this analysis given that they are estimated from a large sample (Narayan 2005), while this study uses a relatively small sample of 51 observations (1970 to 2020). Therefore, the critical values for evaluating the null hypothesis are taken from Narayan (2005). Narayan (2005) computed two sets of critical values: lower bounds I(0)and upper bounds critical values I(1) from sample sizes ranging from 30 to 80. **Appendix Table 6** suggests that the F-statistic (11.371) is greater than the upper bound from Narayan (2005) at the 1.0 per cent significance level. The study, therefore, rejects the null hypothesis of no cointegration among the variables. This outcome suggests a long-run causal relationship between CO_2 emissions, fossil energy consumption, carbon intensity, fiscal policy, monetary policy, and import capacity.

Appendix Table 6: Results of Bounds Test

Specification	Optimal Lag		F-Statistic
(1) F[LCO_2K|LECK, LCIN, LFPI, MPI, LIMC]	ARDL(1, 2, 0,0,0,0,0,0)		11.371***
Critical value bounds	**1%**	**5%**	**10%**
/0 bound (k=7, n=50)	3.282	2.457	2.099
/1 bound (k=7, n=50)	4.73	3.650	3.181
/0 bound (k=7, n=45)	3.383	2.504	2.131
/1 bound (k=7, n=45)	4.832	3.723	3.223

Note: Optimal lag length for all NARDL models are based on Schwarz Information Criterion (SIC); unrestricted intercept and no trend; *, ** and *** indicate 1% level, 5% level and 1% level of significance, respectively.

Appendix D: Model test for multicollinearity

Appendix Table 7 shows the variance inflation factor for the chosen specification, which is less than 5, suggesting no multicollinearity problem in the model. Therefore, the estimated results can be used to understand macroeconomic policy effects on CO_2 emissions in Trinidad and Tobago.

Appendix Table 7
Variance Inflation Factor

Sample: 1970 2020			
Included observations: 51			
	Coefficient	Uncentered	Centered
Variable	Variance	VIF	VIF
LECK	0.001376	1860.753	3.545546
LCIN	0.003684	913.4332	2.934237
LFPI	0.000768	288.7931	3.410743
MPI	5.25E-06	24.53887	2.443097
LIMC	0.002628	682.6094	1.955945
C	0.017536	977.3537	NA

Source: Eviews 10 Output

Appendix E: Structural break adjusted CUSUM and CUSUMSQ plots

Appendix Figure 1 shows the structural break adjusted CUSUM and CUSUMSQ statistics. The figures are within the critical bounds for the 5.0 per cent significance level, indicating that the coefficients of the estimated NARDL model specifications are stable.

Appendix Figure 1
CUSUM and CUSUMSQ Plots for NARDL Model