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THE IMPACT OF FINANCIAL DEVELOPMENT ON RENEWABLE ENERGY CONSUMPTION IN MAURITIUS

Mercy T. Musakwa[1] and Nicholas M. Odhiambo

Abstract

This study examined the asymmetric impact of financial development on renewable energy for Mauritius using data from 1990 to 2022. The study was motivated by the growing call for countries to reduce their carbon footprint, which has been spearheaded by the United Nations. The study, therefore, aims to examine whether financial development in Mauritius plays any significant role in its renewable energy drive. The study used a financial institution index developed by the IMF to investigate the nature of the relationship among the two variables. Using the non-linear autoregressive distributed lag (NARDL) model, the study found positive shocks on financial development to be positively associated with renewable energy consumption in the short and long run. However, negative shocks on financial development were found to have no significant impact on renewable energy consumption. The study, therefore, recommends that Mauritius should continue to expand its financial sector in order to increase its renewable energy consumption and transform its renewable energy mix, as highlighted in its Renewable Energy Roadmap 2030.

Keywords: Renewable energy, Mauritius, NARDL, financial development; financial institution Index.

JEL: C2; G2; Q20

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1. Introduction

The continuous build-up of carbon emissions over the years associated with anthropogenic and natural causes has resulted in climate change, which threatens the achievement of the Sustainable Development Goals, among other national development aspirations. Climate change has increased the frequency and intensity of natural disasters like cyclones, heavy rains, heat waves, drought, coastal erosion, and rising sea levels, among other negative developments. The scale and severity of the disasters threaten economic growth and development, with governments being financially overwhelmed when trying to support the affected individuals and businesses. There has been a call from international organisations like the United Nations (UN) for each country to take steps to reduce its carbon footprint. The major contribution to carbon emission is associated with fossil fuels that are used to generate electricity. To reduce carbon emissions and take care of the climate, the United Nations, through the SDGs and the Paris Agreement, calls for a concerted effort to minimise the adverse effects of economic activities on the climate. Mauritius is among the signatories to the SDGs and the Paris Agreement. Thus, the country is expected to take intentional steps to reduce its carbon footprint. Mauritius has not disappointed in its drive to increase renewable energy use. The renewable energy drive is ingrained in the legislation, which clearly spells to Mauritius businesses and people that the government fully supports alternative energy sources.

It is against this background that the current study aims to examine whether financial development in Mauritius plays a significant role in its renewable energy drive. Several studies have been conducted on the linear relationship between financial development and renewable energy. These studies do not account for the asymmetric effects of financial development on energy consumption. There is a growing body of literature advocating for an asymmetric

relationship since negative and positive shocks on financial development might not affect renewable energy in the same way.

This study investigated the nature of the relationship between renewable energy and financial development using a non-linear ARDL (NARDL) approach. The NARLD approach shows how negative and positive shocks on financial development affect renewable energy. The results are important to policy makers in formulating the appropriate policy response to financial development shocks in Mauritius. Mauritius is an interesting country selected for this study because it is one of the advanced countries classified previously as an upper-income country before COVID-19 and has made great strides in creating an environment that supports a move to cleaner energy. The findings of this study will shed light on the nexus between financial development and renewable energy, especially in Africa, where many countries are still in the teething stage when it comes to the implementation of policies aimed at promoting renewable energy exploration.

The rest of the study is divided as follows: Section 2 covers a literature review, which is divided into country-based literature and empirical literature. Section 3 presents the methodology, while Section 4 covers empirical results. Section 5 concludes the study.

2. Literature review

2.1 Dynamics in financial development and renewable energy in Mauritius

The Bank of Mauritius was created in 1967 after the enactment of the Bank of Mauritius Act in 1966. Mauritius has established robust supervisory and regulatory flare, contributing to a sound financial sector (Mauritius Finance, 2024). The financial sector is supported by a strong

legal framework, such as the Financial Services Act 2007, Banking Act 2004 and several laws that cover several banking services – insurance, anti-money laundering, pensions and securities (Mauritius Finance, 2024; Mauritius International Financial Centre' MIFC,' 2024). Since 2005 Mauritius has streamlined the banking licensing to one licence for both local and cross-border banking services (MIFC, 2024). The Financial Services Commission was established in 2001 and supported by the Captive Insurance Act, Insurance Act, Private Pension Schemes Act, Securities Act, Offering Services Act and the Financial Services Act (Financial Services Commission, 2024). The Commission monitors, regulates, and licenses businesses in the sector covered by the Acts highlight. The Financial Services Commission aims to suppress crime and malpractice, promote transparency and efficiency of the financial market, and ensure stability and soundness of the financial system (Financial Services Commission, 2024). The banking sector provides several services, such as individual banking, corporate banking, private banking and wealth management, global business banking, and investment management (MIFC, 2024).

The Mauritius International Financial Centre (MIFC) provides a well-regulated and transparent platform for cross-border investment and finance (MIFC, 2024). This has attracted international banks, legal firms, investment funds, and corporate services to Mauritius. To date, there are 19 banks, and the sector is projected to contribute 13.1% to GDP, consisting of 972 funds, 176 management companies 176, and employs 9449 employees (MIFC, 2024). Along with its advancement in digital assets, Mauritius has built an ecosystem able to facilitate virtual assets. It has also built a Fintech Hub, which provides a safe environment for crowdfunding and peer-to-peer lending (MIFC, 2024). Mauritius's financial sector also embraces the use of mobile banking, which offers a plethora of services. Thus, like in other developing countries, this step has provided access to many people, even in areas where physical banks are not

available. The Bank of Mauritius launched a financial literacy strategy that focuses on protecting and educating customers about financial and banking sector services. Figure 1 reports the trends in financial development.

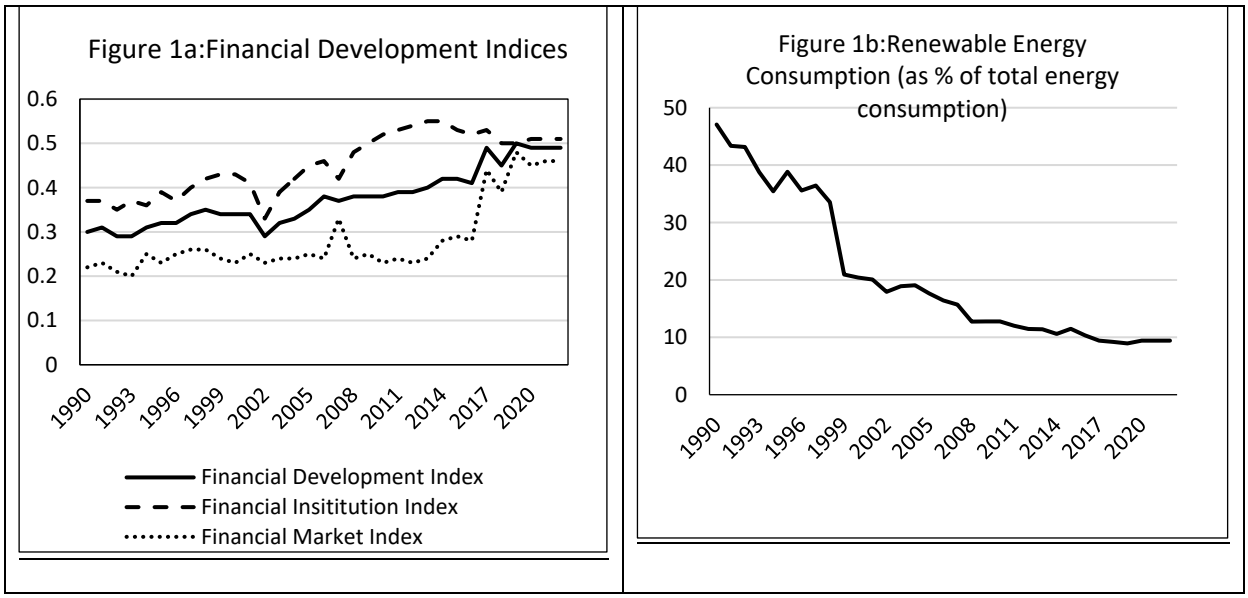


Figure 1: Financial development from 1990-2022

Source: World Bank (2024) and IMF (2024)

Figure 1a reports the dynamics in financial development in Mauritius captured by the Financial Development Index and broken down to bank-based and market-based measures captured by the Financial Institution Index and Financial Market Index, respectively. Mauritius has experienced a general improvement in financial development during the study period. The bank-based financial sector appears to be strong compared to market-based contribution. Although more studies in the literature identify financial development with an increase in renewable energy consumption, for Mauritius, energy consumption as a percentage of total final energy consumption, as reported in Figure 1b, has declined over the study period.

On the renewable energy front, Mauritius is a signatory to the Sustainable Development Goals (SDGs), the Paris Agreement, and the COP21 against climate change. This makes the reduction of carbon footprint important to the country on its journey to meet the SDG target and contribute to the battle to reduce climate change emanating from anthropogenic activities. Mauritius' renewable energy stance is advanced through investment in infrastructure, policy support, and public engagement.

On the policy front, the National Energy Policy launched in 2007 places emphasis on energy efficiency and renewable energy. To facilitate and promote innovation in renewable energy, the Mauritius Renewable Energy Agency was created through Act 11 of 2015 to promote and oversee the development of renewable energy in Mauritius. Some of the functions of the agency include, amongst others, outlining a renewable energy strategic plan every five years; encouraging and supporting studies and research on renewable energy; compiling data on renewable energy use and benefits; contributing to the funding strategy for renewable energy projects; sharing information and knowledge on technology on renewable energy; and assessing the requirements on skills aligned to renewable energy projects (Ministry of Energy and Public Utilities, 2024). The mandate of the agency is to promote and create a conducive environment for the development of renewable energy in Mauritius. The Ministry of Energy and Public Utilities plays a big role in shaping policies and promoting the transition to renewable energy in Mauritius (Ministry of Energy and Public Utilities, 2024). The Central Electricity Board (CEB), which falls under the Ministry of Energy and Public Utilities, is responsible for the distribution, transmission and sale of electricity in Mauritius (International Trade Administration, 2024). The CEB produces 37% of its energy requirement from thermal power, and part of the energy requirement is met by independent power producers, mainly

through the generation of biogas energy from sugar cane (International Trade Administration, 2024).

Mauritius has made strides to reduce carbon emissions and has moved towards cleaner energy sources. The Renewable Energy Roadmap 2030, which was launched in 2019, initially targeted a 35 percent renewable energy mix by 2025 with a scenario of up to 40 percent (UN, 2024). However, this was revised to 60 percent by 2030 (UN, 2024). The revision reveals the position and commitment the country has taken to reduce the carbon footprints and a shift from the use of fossils in electricity generation. Further, the government offers incentives to companies that invest in renewable energy (International Trade Administration, 2024). Some of the incentives include an annual allowance of 100 percent on the capital expenditure for the acquisition of green technology; tax exemption on interest to companies that invest in renewable energy through bonds and debentures; customs and duty exertion on any purchase of photovoltaic systems and chargers of electricity vehicles; and eight-year tax holiday for companies that invest in deep ocean water for air conditioning (International Trade Administration, 2024). Figure 1b reports the trends in renewable energy consumption in Mauritius. The trends in renewable energy consumption seem to conflict with the groundwork that has been made to support cleaner energy consumption, necessitating another study for Mauritius.

2.2 Empirical literature

Studies that investigated the impact of financial development on renewable energy are inconclusive, and most of them assume a linear relationship between the two. Some studies found a positive impact of financial development on renewable energy, others found no impact between the two, and yet some studies confirmed a negative relationship.

Belloumi and Aljazea (2024) analysed the impact of economic growth and financial development on renewable energy consumption for 13 major oil-exporting countries using data from 1990 to 2020. Financial development was found to positively impact renewable energy consumption in the long run. Ngcobo and De Wet (2024) fund the same results in a study on South Africa using data from 1990 to 2021 and an ARDL approach. The study found financial development to have a significant positive impact on renewable energy supply in the short run and the long run. In a study on 103 economics, Sue et al. (2023) found financial development to have a positive impact on renewable energy. All three aspects of financial development – depth, access and efficiency- had a positive impact on renewable energy consumption. In the same spirit, Elzaki (2023) studied the impact of financial development shocks on renewable energy for Saudi Arabia using data from 1990 to 2021 using the Basic Vector Autoregressive model (VAR) and forecasted-error variance decomposition (FEVD). The study found renewable energy consumption to have a positive response to shocks in financial development.

Mahmud (2023) found that Islamic countries with developed Islamic banking and Sukuk experience an increase in renewable energy production. Siswantoro and Mahmud (2023) also studied the impact of 10 Islamic finances on renewable energy production in Islamic countries using data from 2013 to 2021. The study found that Islamic countries with good development of Islamic banking have high renewable energy production. In the same spirit, Mukhtarov, Yuksel and Dincer (2022) found a positive relationship between financial development and renewable energy using data from 1980 to 2019 for Turkey. The study found a 1% increase in financial development to have a 0.21% increase in renewable energy consumption. Polat (2021) analysed the impact of financial development on renewable and non-renewable energy for 37 OECD countries using data from 2002-2015. Using the GMM, the study found consistent results like Belloumi and Aljazea (2024), Mahmud (2023) and Elzaki (2023). Assi,

Isiksal and Tursoy (2021, using the ARDL approach and data from 1998 to 2018 for ASEAN +3, found that financial development does not play a role in renewable energy consumption. Mukhtarov et al. (2020), in a study on renewable energy and financial development in Azerbaijan, found a positive relationship between financial development and renewable energy. Ji and Zhang (2019), in a study on China's energy revolution, found financial development to contribute 42.42 percent to variations in renewable energy growth. Capital markets and foreign investment were found to be important sources of renewable energy growth. Kutan et al. (2018), in a study on a panel of China, India, South Africa and Brazil, using data from 1990 to 2012, found stock market development to promote renewable energy consumption. Islam et al. (2013), in a study on Malaysia, using the Vector Error Correction Model (VECM), found a positive relationship between financial development and energy consumption.

Alsagr and van Hemmen (2021) explored the impact of financial development on renewable energy consumption in emerging markets using data from 1996 to 2015. Using GMM, the study found financial development to contribute positively to the transition to renewable energy consumption. Wang, Zhang and Zhan g (2021) used data from 1997 to 2017 and the ARDL-PMG model to explore the relationship between renewable, financial development and economic growth. The study found financial development to negatively influence renewable energy consumption in the long run and positively in the short run. Anton and Nucu (2020), in a panel of 28 countries in the European Union (EU) using data from 1990 to 2015, found financial development to have a positive on the share of renewable energy consumption. Capital market development was found to have no effect on renewable energy in the new EU Member States.

Apart from the above-mentioned studies, there are a few studies that used a nonlinear ARDL approach to examine the relationship between financial development and renewable energy consumption. For example, Amine et al. (2021) used nonlinear autoregressive distributed lags (NARDL) to investigate the impact of financial development on renewable energy consumption in the United States using quarterly data from 1975 to 2019. Using bank-based and stock-based financial development measures, the study found both positive and negative changes in financial development to influence renewable energy. The study found positive and negative changes in financial development to have a positive effect on renewable energy consumption. Negative changes were found to have a huge impact on renewable energy consumption.

3. Estimation Techniques

The non-linear autoregressive distributed lag (NARDL) approach is used to investigate the impact of financial development on renewable energy consumption. The advantage of the NARDL is that it captures the positive and negative shocks of financial development on renewable energy consumption. Thus, the approach, in comparison to a simple ARDL, relaxes the assumption of a linear impact of the independent variable on the dependent variable. Following Siswantoro and Mahmud (2023) and Lahiani et al. (2021) with a modification of some variables, the study uses economic growth, trade openness, CPI and carbon emission as control variables.

Data and definition of variable variables

The primary variables in this study are renewable energy consumption and financial development captured by the Financial Institution Index (FII). The control variables included in the model are Gross Domestic product per capita (GDPPC), trade and price levels captured by the consumer price index (CPI). The study used annual data from 1990 to 2022. The data were obtained from the World Bank and the IMF Financial Development Index Database.

Table 1 provides a summary of each variable.

Table 1: Variable definition

Variable	Description	Source	Expected Sign
REW	Renewable energy consumption as a percentage of total energy consumption	WDI	-
FII	Financial Institution Index – an index of bank-based financial development measures	IMF	FD^+ - +ve impact FD^- - -ve impact
TRADE	Trade openness - a sum of export and imports as a percentage of GDP	WDI	+ve
GDPPC	Gross Domestic Product per Capita	WDI	+ve
CPI	Price level expressed as Consumer Price Index	WDI	-ve

WDI = World Bank Development Indicators

IMF- IMF Financial Statistics Database

Model specification and data

The general model used in this study can be expressed as follows:

$$REW = f(\text{FII}, \text{TRADE}, \text{GDPPC}, \text{CPI}) \ldots\ldots\ldots\

Where:

FII=financial development

TRADE = Trade openness

GDPPC = Gross Domestic Product Per capita

CPI = inflation

The financial development variable in Equation 1 can be decomposed into positive and negative partial sums as follows:

$$FII_t = \rho_0 + FII_t^+ + FII_t^- \ldots\ldots\ldots\

$$\Delta REW_t = \pi_0 + \sum_{i=1}^{p} \pi_{1i} \Delta REW_{t-i} + \sum_{i=0}^{q1} \pi_{2i}^{+} \Delta FII_{t-i}^{+} + \sum_{i=0}^{q1} \pi_{3i}^{-} \Delta FII_{t-i}^{-} + \sum_{i=0}^{q3} \pi_{4i} \Delta TRADE_{t-i}$$

$$+ \sum_{i=0}^{q4} \pi_{5i} \Delta GDPPC_{t-i} + \sum_{i=0}^{q5} \pi_{6i} \Delta CPI_{t-i} + \rho_1 REW_{t-1} + \rho_2^{+} FII_{t-1}^{+}$$

$$+ \rho_3^{-} FII_{t-1}^{-} + \rho_4 TRADE_{t-1} + \rho_5 GDPPC_{t-1} + \rho_6 CPI_{t-1} + \mu_{1t} \ldots\ldots\ldots (5)$$

Where:

π_0 = constant; $\pi_1 - \pi_5$= short-run coefficients; $\rho_1 - \rho_5$ = long-run coefficients; and μ_{1t} = error term.

The NARDL error correction representation of Equation 5 is given in Equation 6.

$$\Delta REW_t = \pi_0 + \sum_{i=1}^{p} \pi_{1i} \Delta REW_{t-i} + \sum_{i=0}^{q1} \pi_{2i}^{+} \Delta FII_{t-i}^{+} + \sum_{i=0}^{q2} \pi_{3i}^{-} \Delta FII_{t-i}^{-} + \sum_{i=0}^{q3} \pi_{4i} \Delta TRADE_{t-i} +$$

$$+ \sum_{i=0}^{q4} \pi_{5i} \Delta GDPPC_{t-i} + \sum_{i=0}^{q5} \pi_{6i} \Delta CPI_{t-i} + \lambda ECM_{t-1}$$

$$+ \mu_{2t} \ldots\ldots\ldots\

4. Empirical results

4.1 Unit root test results

The Dickey-Fuller Generalised Least Squares (DF-GLS) and Phillips-Perron (PP) unit root tests were carried out on the variables in model to determine stationarity. The results of the stationarity tests are presented in Table 2.

Table 2: Unit Root Test

	Dickey-Fuller Generalised Least Square (DF-GLS)		**Phillips-Perron (PP)**	
Variable	Level	Δ	Level	Δ
REW	-0.569	-5.225***	-2.489	-5.625***
FII	-0.957	-6.244**	-1.162	-6.426***
GDPPC	-4.494***	-	-9.519***	-
TRADE	-1.755	-3.941***	-2.330	-3.165***
CPI	1.241	2.249**	0.583	-8.724***

*Note: *, ** and *** denote statistical significance at 10%, 5% and 1% levels, respectively*

Results reported in Table 2 confirmed that the variables included in the model are stationary in levels or first difference. Thus, the variables pass the requirement to use the autoregressive distributed lag approach. To proceed with the analysis, the bounds test for cointegration is conducted to establish whether a cointegration relationship exists among the variables included in the model. The results are reported in Table 3.

Table 3: Cointegration Results

F-Statistic		**Cointegration Status**
3.393*		Cointegrated
Asymptotic critical values for		
10%	5%	1%

I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
1.810	2.930	2.140	3.340	2.820	4.210

*Note: *, ** and *** denote statistical significance at 10%, 5% and 1% levels, respectively*

Results reported in Table 3 confirmed a long run relationship among the variable in the model. The F-statistic of 3.393 is compared to upper and lower bound critical values at 10%, 5% and 1%. The F-statistics is above the 5% upper bound, confirming the presence of cointegration.

The results of the long and short-run models are reported in Table 4.

Table 4: Empirical Results

Dependent Variable is URBGR		
Panel A: Long-Run Results		
Regressor	**Coefficient**	**T-ratio [p-value]**
$LFII^{+}$	3.054**	2.543[0.018]
$LFII^{-}$	0.963	0.937 [0.358]
$GDPPC$	2.031**	3.695[0.001]
$LTRADE$	0.465	1.092[0.285]
$LCPI$	-4.226***	-3.976 [0.000]
Panel B: Short-Run Results		
Regressor	**Coefficient**	**T-ratio [p-value]**
$\Delta LFII^{+}$	2.311**	3.158 [0.006]
$\Delta LFII^{+}(-1)$	1.906**	2.893 [0.010]
$\Delta LFII^{-}$	-0.890	-1.522 [0.145]
$\Delta LFII^{-}(-1)$	0.601	0.968[0.346]
$\Delta GDPPC$	-0.261	-0.489[0.631]
$\Delta GDPPC(-1)$	-1.277) *	-2.002[0.061]
$\Delta GDPPC(-2)$	-3.196**	-3.711[0.002]
$\Delta LTRADE$	-0.139	-0.393[0.699]
$ECM(-1)$	-0.624***	-5.101 [0.000]]
Panel C: Test statistics and diagnostics		
R- Squared R-Bar-Squared *F*-statistic [Prob]	0.609 0.507 5.976 [0.000]	

Panel D: Long- and short-run asymmetry results			
Test	**F-statistic**	**P-value**	
W_{LR}	8.000	0.011**	
W_{SR}	10.763	0.004***	

1) *, ** and *** denote statistical significance at 10%, 5% and 1% levels, respectively

2) W_{LR} = long-run asymmetric test

3) W_{LR} = short-run asymmetric test

4) *+ and - denotes positive and negative shocks.*

Results reported in Table 4 confirmed that positive shocks in financial development measured by the financial institution index have a positive impact on renewable energy consumption in both the short run and the long run. This is confirmed by the coefficient of $LFII^{+}$in the long run and $\Delta LFII^{+}$and $\Delta LFII^{+}(-1)$ that are statistically significant in the short run at the 5% level of significance. The result supports the notion that advancement in the bank-based financial sector leads to an increase in renewable energy consumption. This could be through green financing that opens opportunities for businesses and households to invest in renewable energy like solar. However, the negative shocks on financial sector_development have an insignificant impact on renewable energy consumption in Mauritius, irrespective of the time considered. The results in Figure 2 also confirm that positive shocks on financial development have a deeper impact on renewable energy than negative shocks. The findings are consistent with the drive to cleaner energy sources to mitigate climate change that is spearheaded by the United Nations and embedded in the National Development Plans of most countries. The results do not come as a surprise, given the radical steps that have been taken by Mauritius to develop the financial sector and advance clean energy in the country.

Other results presented in Table 4 confirm that gross domestic product per capita (GDPPC) has a positive impact on renewable energy consumption in the long run and a negative impact in the short run. Thus, the growth in GDP per capita contributes to an increase in renewable energy consumption as economic agents accumulate high income to spend in the long run but not in the short run. The results indicate the importance of_sustained economic growth to an uptake of renewable energy. The study also found price levels to have a negative impact on renewable

energy consumption in the long run. High price levels deter households from investing in renewable energy that is normally associated with high initial costs. Trade openness was found to have an insignificant impact on renewable energy consumption in Mauritius. The explanatory power of the model is 61%, with a rate of adjustment to the equilibrium when there is a disequilibrium in the economy of 62.4%. This is confirmed by a negative error correction term of 0.624, which is significant at 1%. Overall, the model was found to be generally stable, as confirmed by the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) (results not reported here for brevity). Figure 2 reports the cumulative dynamic multiplier.

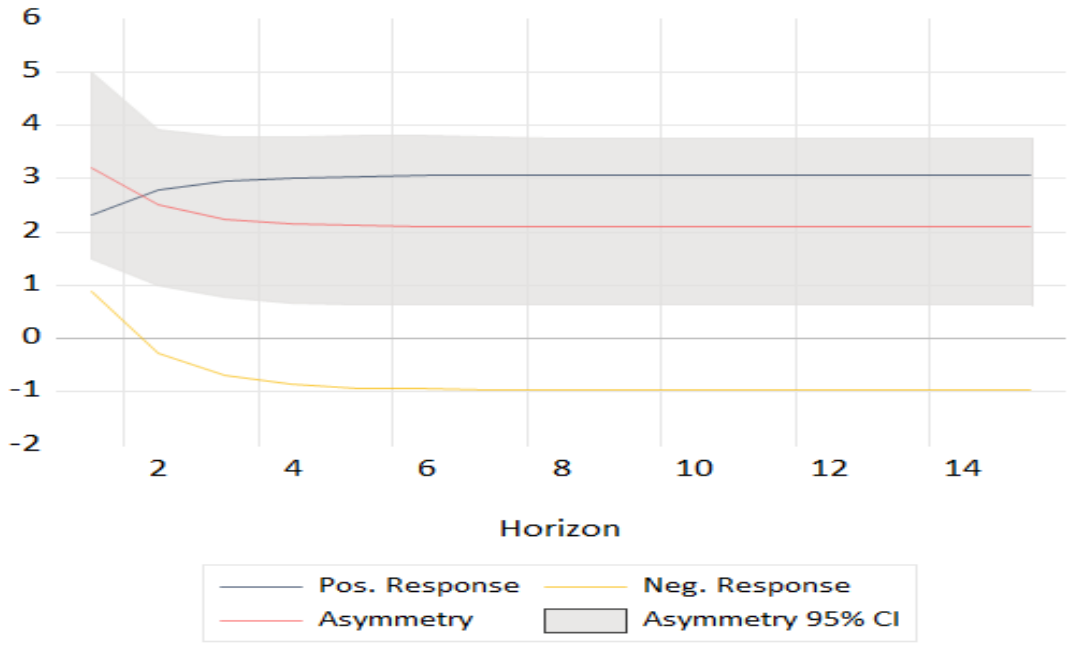


Figure 2: Cumulative Dynamic Multiplier

5. Conclusion

The asymmetric impact of financial development on renewable energy consumption was examined in this study for Mauritius, using data from 1990 to 2022. The growing call for countries to reduce their carbon footprint, which is spearheaded by the United Nations,

motivated this study to find out whether financial development in Mauritius plays any significant role in its renewable energy drive. The study used a financial institution index developed by the IMF to investigate the nature of the relationship among the two variables. Using the non-linear autoregressive distributed lag (NARDL), the study found positive shocks in financial development to be positively associated with renewable energy consumption in the short and long run. Thus, advancement in bank-based financial development was found to boost renewable energy consumption. However, negative shocks on financial development were found to have an insignificant impact on renewable energy consumption. The dynamic multiplier graph also confirmed the dominance of positive shocks on renewable energy consumption in Mauritius. Based on these findings, it can be concluded that bank-based financial development plays a positive role in influencing renewable energy consumption. It is recommended, therefore, that Mauritius continue supporting financial development in its journey to expand renewable energy consumption and reach a 60% renewable energy mix by 2030. Although scientific rigor was upheld in the analysis and reporting of this study, a few limitations were encountered. Although it would have been desirable to use a larger sample, the current study period was limited by the availability of reliable annual times series data that was available at the time of the study. Future studies may expand the study period when the data becomes available. Future studies may also benefit from market-based financial development measures and other renewable energy measures that have not been used in the current study. The use of disaggregated renewable energy data may also provide a different insight into the nature of the relationship between financial development and renewable energy consumption.

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