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Is Energy a Requirement for, or a Consequence of Economic Growth in Mauritius?

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Abstract

The non-reproducible nature of energy, coupled to its essentiality either as a direct or an intermediary input, makes it a crucial factor of production. We posit that it is, a complement to capital and labor and should be included in growth production models. Mauritius is a net energy importer, hence information about the nexus between energy consumption and economic growth is central to policy-making. This paper attempts to analyze this relationship for Mauritius within a multivariate framework over the period 1961 to 2019. The work adopts a dynamic time series framework (VECM approach) to account for dynamism, causality, endogeneity and omitted variables. Empirical results reveal long-run and short-run elasticities of energy consumption on economics growth of 0.33 and 0.17 respectively, thus giving credence to the thesis that energy is an important growth determinant in Mauritius. We also uncovered bi-directional causality between energy consumption and economic growth in both the long-run and the short-run. Therefore, unexpected and/ or voluntary contraction in either economic growth or energy consumption could result in a 'feedback effect' and dent either.

JEL: Q4, O1

1.0 Introduction

The development of the different theories of economic growth has generally focused on the primary land, labour and capital inputs, and has generally neglected the role that energy plays in the growth process. The non-reproducible nature of energy, climate change threats, and potential environmental impacts associated with energy production and consumption, and the lack of a direct substitute for hydrocarbons. The irreversible decrease in fuel reserves, coupled to the likely general future increase in energy prices would exacerbate the pressure on the demand for energy. This has re-centered the importance of energy in the economic growth debate. Given this reality, the nexus between energy consumption and economic growth has consequently been and still is widely analyzed and studied.

Stern (2004) reviewed the background theory of production and growth from different perspectives; firstly, from the viewpoint of economists and then natural scientists. He argued that it was crucial to understand of the role of energy in production, the increasing scale of production involved in economic growth, and the institutional ecosystem within which the energy consumption and economic growth nexus operates. From this standpoint, energy is an input to production. The quantum of that impact, in conjunction with other determining variables is of policy relevance as it would indicate how changes in energy consumption would likely impact on GDP in the short- and long-run. This nexus is also likely to result in a derived demand for energy, thus the level of output is one of the factors that can prospectively determine energy demand. Given this situation, there is therefore, the likelihood of a bi-directional causality between the two variables.

Despite supporting the above-mentioned thesis, Stern (2018) mentioned that empirical research on whether energy causes economic growth or vice versa is inconclusive. Kouton (2019) accounted for energy use in production and investigated the relationship between the two variables, but concluded that it depended on the phases of economic cycle in the different African countries. The literature is thus not prescriptive on the above-mentioned relationship; the energy-growth hypothesis can neither be imputed nor generalized for a particular country. Several explanations can be evoked, and they include: countries at various levels of development, methodologies used in such studies, time horizons covered by different studies and the varying the methodologies adopted. The nexus between energy and output therefore needs to be assessed on a specific country basis, considering intrinsic realities and context.

Mauritius is a middle-income small island development state with no oil, natural gas or coal reserves, and is therefore heavily reliant on imported petroleum products to meet most of its energy requirement. In Mauritius, research on establishing the role of energy consumption as a determinant of economic growth is scant. Given its reliance on imported sources of energy; any increase in energy prices or disruption in supply can potentially negatively impact economic growth in Mauritius. In this context, computing the economic output elasticity of energy is of direct policy relevance. Secondly it is also important to ascertain the direction of causality between energy and economic growth, so as to be better able to guide energy policy formulation. Mauritius is facing a dilemma, it wants to increasingly move towards a low carbon economy through energy-saving modes, but at the same time does not want to endanger its economic growth towards a high-income country. The determination of the direction of causality between economic growth and energy consumption is a key input in guiding the formulation of appropriate policies. The contribution of our paper is three-fold. Firstly, we posit that energy consumption plays an important role in economic development tin Mauritius, and aim at quantifying it. Our finding would supplement the existing literature given the specificities of, and realities faced by Mauritius as a net energy-importing small island state, with an aspiration to transit into a high-income economy bracket. Secondly, we make use of cointegration techniques, as key variables are likely to be non-stationary and stochastically trending; to determine the elasticity of energy on economic output in the short-run and long-run. Thirdly, we also investigate any causal relationship between energy consumption and economic growth in Mauritius, while conducting the analysis within a multivariate framework, thus controlling for theoretically-prescribed explanatory variables.

The remainder of this paper is structured as follows: Sect. 2.0 reviews the relevant extant literature, Sect. 3.0 delves into energy consumption and economic growth in Mauritius, Sect. 4.0 describes the methodological approach and the data, Sect. 5.0 presents and discusses the results and Sect. 7.0 finally concludes.

2.0 Related Literature

2.1 The role of energy in growth models

Physics suggests that energy is a contributor to economic production, as all economic processes must require energy, either as a primary input to convert materials in to desired products or as intermediary input in the production of other products or services. Using a biophysical economics approach, based on thermodynamics, Hall and Klitgaard (2012) stipulated that energy cannot be re-used, and as such a continuous supply of energy is necessary to maintain the current or support future economic activities. Ayres and Warr (2009) fully detailed the link between energy and production. Despite the undeniable role that energy plays in production, mainstream economic growth theories have largely ignored its central role, rather only focusing on capital investment, technological progress and human capital. In consequence the majority of macro-econometric models have mostly incorporated the classical factors of production, assuming in some cases that energy is an intermediate product of some combination of human labour and capital (see Wang et al., 2011; Voudouris et al., 2015). Ayres et al. (2013) highlighted that this disregard of the central role of energy, has also robbed economic growth theory from empirically assessing the impact of energy availability and prices on economic growth. As Stern (2018) highlighted, one underlying explanatory reason for the lack of recognition of the contribution of energy, may be because, historically energy scarcity may have hampered economic growth, but with the advent of modern energy sources, the importance of energy as a scarce growth determinant has diminished. Here it is important to point out that, given its non-reproducible nature, energy could in the long-run become scarce and limit economic growth. Ayres et al. (2013) provided a complementary explanation to the above, mentioning that given energy cost-shares account for a small proportion of total factor cost, economics theorists have disregarded energy as an unimportant source of productivity. Interestingly enough, Kuemmel et al. (2015), disputed classical assumptions that output elasticities should equal their cost shares for capital, labour and energy, and found that the output elasticity of energy is much larger than its cost share. Ayres and Warr (2009) also reported that the elasticity of petroleum was much greater than its small cost share. Therefore, dismissing energy as a determinant in growth models on the basis of small cost-shares may have been misguided. Ayres (2013) even extended the above reasoning and asserted that energy could be one of the main causes of economic growth, even downplaying the role of the classically-considered contributors. While acknowledging the above thesis, Stern (2018) does mention that empirical research on whether energy causes growth is inconclusive. Therefore, given the importance of energy in thermodynamic terms and the open debate on its quantitative significance as a growth determinant, it is important to empirically investigate this relationship within a growth modelling framework.

In the majority of economic growth models, labour and capital are assumed to be easily substitutable. But in an attempt to integrate energy into classical growth models, Stern and Kander (2012) added an energy input that has low substitutability with capital and labour, to extend Solow's (1956) growth model. The requisite of the elasticity of substitution between capital and energy being less than one, would allow the cost-share of energy to decrease over time, better reflecting energy intensity trends over time.

2.2 Causality between energy and economic growth

The literature presents two methods that have been extensively used to test for causality between energy and GDP, namely Granger causality tests and cointegration analysis. Hendry and Juselius (2000) extensively delved into these techniques, as applied to the link between energy and economic growth. There is a wide-ranging literature that has dealt with this relationship, yet no general consensus has emerged regarding the direction of causality between the two variables. Scanning studies, provides evidence to support four competing hypotheses characterizing the causal relationship. Firstly, there is the growth hypothesis which stipulates that there is a unidirectional causality running from electricity consumption to economic growth, implying that economic growth is dependent on energy consumption. Under this scenario, energy serves as a direct input in economic growth, as well as a complement to labour and capital inputs (Apergis and Payne 2009; Belke et al., 2011). In this particular scenario a shortfall in energy consumption could lead to a fall in economic growth. It is important to note that in certain cases, an increase in energy consumption can have a negative impact on GDP growth, in cases where energy is used in unproductive economic sectors (Squalli 2007). The second scenario is that causality runs in the opposite direction, that is from economic growth to energy consumption. This suggests that decreasing energy consumption would not necessarily have a bearing on economic growth. The third view is termed the 'feedback hypothesis' where there is a bi-directional causality between energy consumption and economic growth, meaning that there is interdependence between energy consumption and economic growth. The fourth strand that has emerged from the literature is the neutrality hypothesis which stipulates that there is no causality between energy consumption and economic growth. This absence of causality in either direction implies that implementing policies that affect energy consumption would not affect economic growth, and vice versa.

2.3 The empirics

2.3.1 Energy-related elasticities

Over the last decade or so, numerous studies have attempted to investigate and highlight the importance of energy in the production process by incorporating energy as an additional factor, at par with capital and labor in the production modelling framework. Eggoh et al. (2011) investigated the relationship between energy consumption and economic growth for 21 African countries over the period 1970 to 2006, and found positive energy output elasticities, energy exporters witnessing higher energy growth elasticities. Interestingly they also reported larger energy elasticities for energy as compared to labor for both the short- and long-run. Voudouris et al. (2015) applied the semi-parametric approach on data for 15 European countries covering 50 years. They found among other things that energy output elasticities are not equal to cost shares, implying an inclusion of energy in growth modelling. Giraud and Kahraman (2014) used an error correction model to estimate the long-run output elasticity of primary energy use in 50 countries over the period 1970 to 2011, and found that as opposed to mainstream macroeconomics where energy is nor generally included as a growth determinant, its elasticity lied between 0.6 and 0.7. Kuemmel et al. (2015), made use of an unconventional parametric production function, with energy as a third factor, and applied it to Germany, Japan and the US during the 20th century. They computed energy output elasticities of 0.4, 0.1 and 0.5 for USA, Japan and Germany respectively. Burke and Csereklyei (2016) used per capita data for 132 countries over 1960–2010 to estimate elasticities of sectoral energy use with respect to GDP. In general, they found a long-run energy-GDP elasticity of around 0.7. At the sectoral level, elasticities range from 0.25 for residential energy to 0.8 for transport and services. In general, computed energy growth elasticities, indicating that energy had an inelastic impact on GDP.

Another strand of studies has recently examined the causal link between renewable energy use and economic growth. Chen et al. (2020) employed a threshold model using a 103-country sample covering the period 1995 to 2015, and found that the relationship between renewable energy consumption and economic growth depends on the amount of renewable energy used. They demonstrated that the effect is positive and significant if and only if countries surpass a certain threshold of renewable energy consumption. Chang et al. (2015) also used the panel threshold regression method and found that countries characterized by high economic growth are able to respond to high energy prices with increases in renewable energy consumption. Such studies using threshold regression mostly concluded that no direct causal link was found between economic growth and renewable energy consumption for low-economic growth countries, generally indicating that perhaps the share of renewable energy in the total energy mix has been negligible.

The empirical investigation has also delved into the impact of growth in GDP on energy consumption. Csereklyei et al. (2016) used a panel data set of 99 countries, spanning the period 1971 to 2010 and an elasticity of 0.7. Van Benthem (2015) found a slightly higher elasticity of 0.97, after controlling for energy prices and time effects for a panel of middle-income countries. Apart from Joyeux and Ripple (2011) who estimated a long-run income elasticity of 1.08 for OECD countries, the general estimates varied from 0.7 to 0.97, meaning that an increase in GDP resulted in a proportionately lower increase in energy consumption.

2.3.2 Direction of causality

In his seminal study, Kraft and Kraft (1978) analyzed the relationship between energy consumption and GNP in the USA for the period between 1947 and 1974, and found a unidirectional causality relation from GNP to energy consumption. Subsequently Akarca and Long (1980) tested this relationship with the same data for the USA but could not could not find a relationship between the two variables. Since then, the literature has been enriched by numerous studies investigating this relationship under different contest, for different countries and covering different time spans, with some disaggregating energy into its sub-components. The econometric approaches adopted in the various studies revolved around Granger causality tests, error correction models, autoregressive distributed lag bounds testing and panel cointegration and error correction models. Payne (2008) surveyed the literature and provided an extensive review of the causality under different country context. He found that 29.2% of the results supported the neutrality hypothesis; 28.2% the feedback hypothesis; 23.1% the growth hypothesis; and 19.5% the conservation hypothesis. Even after accounting for differences in country GDP, he could not conclude on the various hypotheses. Other studies based on meta-analyses, literature reviews and systematic literature reviews, include Chen et al. (2012), Kalimeris et al. (2014), Omri (2014) and Stern (2018), they generally tend to concur with the mixed results reported by Payne (2008). Bruns et al. (2014) carried out a meta-analysis of Granger causality and cointegration studies carried out in 75 countries and reported that many seemingly statistically significant results in the literature are probably the result of statistical biases. They also highlighted that the impact of energy on economic growth could have been improved if energy prices would have been included among the explanatory variables in growth models.

A few studies have also covered African countries. Kouton (2019) endeavored to shed light on the heterogeneous relationship between energy use and economic growth in nineteen selected African countries from 1971 to 2014, by employing a nonlinear panel autoregressive distributed lag model. He concluded that the relationship between energy use and economic growth was asymmetric and depended on the phases of economic cycle in different countries. Jebli and Youssef (2017) analyzed the relationship in Tunisia from 1980–2011, using a VECM. Unidirectional causalities ran from non-renewable energy and economic growth to renewable energy. Among the few African evidences, features Jumbe (2004) who examined the relationship between electricity consumption and GDP for Malawi during the period between 1970 and 1999 and found a bidirectional causality relationship. Rufael (2006) also examined the relationship between electricity consumption and

GDP for 17 African countries for the period between 1971 and 2001 with limit test approach and found cointegration relationship in 9 countries and Granger causality relationship for 12 countries. While the direction of causality is from GDP to electricity consumption in 6 of these countries and from electricity consumption to GDP in 3 of them; bidirectional causality was found in 3 countries. Akinlo (2008) also found contradictory evidence for eleven African countries. Wolde-Rufael (2009) who re-examined the causal relationship between energy consumption and economic growth for seventeen African countries in a multivariate framework by including labor and capital as additional variables. Their results rejected the neutrality hypothesis for the energy–income relationship in fifteen out of the seventeen countries. Neeliah and Deenapanray (2012) attempted to unfold the causal relationship between electricity consumption and real economic growth in Mauritius. They used a cointegration model, covering the period 1961 to 2011. Their findings showed a short-term unidirectional causality running from electricity consumption towards economic growth, meaning that economic growth depended on electricity consumption. It is noteworthy to mention here that bivariate models do not allow for any substitution of energy with other variables, and hence they suffer from omitted variables bias. Studies covering African countries concurred with global findings that the direction of causality between energy and economic growth were inconclusive, depending on the varying contexts.

3.0 Energy Requirement And Consumption In Mauritius

In 2018, imported fossil fuels accounted for about 87.1% of total primary energy requirement (TPER), contrasting with 66% in 1993. TPER is the sum of imported fuels and locally available fuels less re-exports to bunkers after adjusting for stock changes; it amounted to 1586.3 Ktoe in 2018, having increased by 96% since 1993. Over the same period energy from local sources as a percentage of TPER decreased from 34–12.9%. In 2018, imported fossil fuels accounted for about 87.1% of TPER, coming from gasoline (12.1% of TPER), diesel oil (13.6%), kerosene (10.3%), fuel oil (17.6%), LPG (5.3%) and coal (28.2%). The remaining 12.9% came from local energy sources, namely bagasse, hydro, wind, landfill gas, photovoltaic and fuelwood. Bagasse accounted for 88.1% of local resources and the remaining sources accounted for the remaining 11.9%. total energy production from local renewable sources, decreased from 34% (274.2Ktoe) to 12.9% ((204 Ktoe) in 2018 (Statistics Mauritius, 2019).

The final energy consumption is defined as the total amount of energy required by end users as a final product, that is it does account for energy that is used for transformation into other forms of energy (Statistics Mauritius 2019). In 2018, final energy consumption was estimated at around 989 ktoe, having increased by 52% since 1993. Figure 1.0 illustrates the trends for final energy consumption and real GDP over the period 1961 t0 2019. “Transport” and “Manufacturing” were the two main energy-consuming sectors with 54.6% and 20.6% of final energy consumed in 2018. The remaining consumption was respectively by the household sector (14.0%), the commercial and distributive trade sector (10.2%) and the agricultural sector (0.4%).

Figure 1.0 shows that these two variables have been generally trending upwards since the early 1960s.

Energy consumption and real GDP have both been trending upwards, and both variables are related through the energy intensity index. It is a measure of the energy efficiency of a nation’s economy. It can be computed as the ratio of energy use to GDP, indicating how well an economy transforms energy into monetary value (Martinez et al., 2018). For our purpose, the metrics used for energy intensity are Ktoe per MRU million of real GDP. Generally speaking, total energy use has increased over time and over the same duration energy intensity has increased, then decreased. A lower energy intensity is the objective at the national level, as it can indicate an efficient allocation of energy to generating economic wealth. But the decreasing trend experienced in Mauritius, could also be that per capita energy use has increased over time, but it has increased at slower pace than GDP growth. Mauritius has successfully transformed from an overwhelmingly agricultural economic base to one which is now dominated by services which is less energy-intensive. Concomitantly, and as reported by Wang (2011) and Stern (2012) the decrease in energy intensity could also have been due to capital deepening in existing energy-reliant activities.

The gaps in the literature, from a contextual standpoint, coupled to the hypothesised importance of energy as a growth contributor in Mauritius, warrants a systematic study of the energy-economic growth relation, while accounting for the stationarity, dynamics, endogeneity and causality of the various timeseries variables intrinsic to the nexus.

4.0 Methodological Approach And Data

4.1 Econometric approach

We aim to investigate the relationship between growth and renewable energy. To construct the econometric model, we adopt a similar framework and specification as Wolde-Rufael and Menyah (2010), Wang et al. (2011), Chen et al. (2020) based on the conventional neo-classical one-sector aggregate production technology, where the production in the economy at time t, is given by the following production function:

$$GDP = f(PRIVT, ROADS, FDI, ENERGY, OPEN, EDU) \quad (1)$$

where *GDP* is total output of the country, *PRIVT* is the private physical capital of the country, *ROADS* is a measure of public capital (see Canning 1999), *FDI* is a measure of the foreign direct investment, ENERGY is the measure of energy consumption, OPEN proxies the degree of openness and *EDU* is the secondary enrolment ratio that accounts for the quality of labour. For the econometric analysis, Eq. (1) is expressed as a log-linear regression, where lowercase variables are the natural log of the respective uppercase variables:

$$gdp = \alpha + \beta_1 privt + \beta_2 roads + \beta_3 fdi + \beta_4 energy + \beta_5 open + \beta_6 edu + \mu \quad (2)$$

where μ is the error term.

4.2 Data description

The dependent variable output was proxied by the real Gross Domestic Product at constant price *(OUTPUT)*. The Gross Fixed Capital Formation by the private sector in percent of GDP was used to proxy Private investment (PRIVT). We used kilometers of paved road per square kilometer of area (*ROADS)* to proxy public capital (see Canning (1998), Canning and Bennethan, (2000)). Foreign direct investment (*FDI*) was measured using FDI inflows as a proportion of GDP. The proxy used for education (*EDU*) is the secondary enrolment ratios and that openness (*open*) is the total of export and import as a ratio of GDP. These are standard measures used in the literature (see Barro 1998, Sachs and Warner 1995 and Edwards 1998). The data series apart the one for 'road network' were retrieved from Statistics Mauritius and the Bank of Mauritius. As we have argued, energy is also an essential factor of production. Energy consumption is measured in Ktoe (*ENERGY*). The variables enter the equation in their logarithm, hence the estimated coefficients are the elasticities of output with respect to the respective growth determinants.

4.3 Unit Root Test

Before considering the appropriate estimation framework of the econometric model, it is important to investigate the univariate properties of all data series and to determine the degree to which they are integrated. Both the augmented Dickey-Fuller (ADF) (1979) and Phillips-Perron (PP) (1988) unit-roots tests have been employed for that purpose and the variables were found to be I(1). Subsequently a Johansen Cointegration test was carried out undertaken to establish the existence of any long-term relationship. Evidence from both the trace and maximal eigenvalue tests suggests that there is at most a single cointegrating vector or analogously 2 independent stochastic trends within the equation. At the 5% level, the trace value and maximum eigenvalue test both show that there is one cointegrating vector. So, we conclude that both the above specifications are cointegrated with one cointegrating vector.

4.4 The vector autoregresive model

Given the possibilities of dynamism, bi-causality and endogeneity in the growth model, it is believed that a VAR model would be best appropriate. It will allow us to also discuss the determinants of energy consumption through an 'energy consumption' equation. Aditiaonally the VAR framework would allow the investigation of any indirect effects that may be present between energy and GDP though the remaining growth explanatory variables.

5.0 Results

5.1 Estimates of long run elasticities

The estimated coefficients on the respective growth determinants, exhibit the theoretically-anticipated signs and are statistically significant (Table 1.0). Cointegration, coupled to the statistical significance of the estimated coefficients, indicate that economic growth has long term relationship with private investment (PRIVT), foreign direct investment (FDI), education (EDU), public investment (ROADS), degree of openness (OPEN) and energy consumption (ENERGY) in Mauritius over the time horizon 1961–2019.

Overall the outcomes of this study show that there is a strong long-run relationship between GDP, energy consumption and the remaining control variables. Positive effects are observed, albeit to different degrees for the private, public and foreign direct investment, as well as the openness and educational level on the GDP in Mauritius. Private investment, as expected, exhibits the highest output elasticity at 0.74). Our results are consistent with previous studies which have attempted to model the determinants of economic growth in Mauritius (see Khadaroo and Seetanah, 2008; Neeliah and Seetanah, 2016), thus providing some credence to our model and findings

Of prime relevance here, is the impact of energy consumption on GDP. The long-run parameter of energy is reported to be significantly and positively associated with the GDP of the country with an output elasticity of 0.33. This implies that a 1% increase in energy consumption

would lead to a 0.33% increase in GDP in Mauritius in the long-run. Our result is in line with those reported by Eggoh (2011) who reported a long-run elasticity of 0.369 for 21 African countries for the period 1970 to 2006. But on the other hand, our results are lower than those reported by Giraud and Kahraman (2014), who estimated long-run elasticities of primary energy use for 50 countries, using data over the period 1970 to 2011, in the range of 0.6 and 0.7 and also, lower that the average elasticity of 0.7 reported by Burke and Csereklyei (2016) for 132 countries over 1960–2010. The long-run elasticity elicited here is within the elasticity bracket of 0.12 and 0.39, as reported by Narayan and Smyth (2003) for G7 countries. Generally, the elasticity of energy consumption on GDP tends to decrease with increasing development of a country. Our results tend to tally with this observation as they are lower than the elasticity of 0.5 reported by Lee (2005) for a sample of 18 developing countries, and higher that the 0.25 elasticity reported by Lee and Chang (2008) for 22 OECD countries. It is interesting to note that our long-run energy elasticity is of a lower magnitude that the those computed for private investment, foreign direct investment, education, openness, showing that increases in energy consumption is less impactful on economic growth as compared to the afore-mentioned determinants in Mauritius. Our finding therefore does not support the thesis of Ayres et al. (2013) who asserted that energy could be more growth-impacting than capital and labour.

5.2 Estimates of short-run elasticities

The results are robust to various standard tests, and weak exogeneity tests enabled us to reject the null hypothesis of weak exogeneity at 5% significance level in all cases. We thus proceeded with an unchanged system of equation. Given that the variables are stationary only in first difference and cointegrated, we proceeded to estimate a VAR in an error correction model. The results are shown in table 3.0 below.

Table 3.0 is a composite one, where each column can be viewed and analyzed as an independent function. From Column 2, it can be reported that 1% increase in the growth rate of energy consumption leads to a 0.17% increase in the growth rate of output after one year. It confirms a positive and significant contribution of energy consumption to output in the short-run. This finding is an estimate of the direct effect of energy on output in the short-run, and indicates that it might take some time for energy to be fully absorptive and operative in an economy. This is confirmed by the corresponding long-run elasticity of 0.33. All variables apart form education, are significant and explain to different degrees the short-run variation in output in the short-run. The error correction term is statistically significant at the 1% level and denotes the speed of adjustment to the long-run equilibrium. 28% of the existing disequilibrium is corrected in the next period, implying a moderate speed of adjustment. Overall, the system of equation passed all tests, including serial correlation, functional form, normality and heteroscedasticity. Our results concur with those of Eggoh (2011), who also reported smaller but significant short-run parameters for energy consumption.

Column 6 from table 2.0 presents the growth rate of energy consumption as the dependant variable. Interestingly a 1% change in growth of GDP leads to a 0.63% growth in energy consumption. Al-Rabbaie and Hunt (2006) reported along-run output elasticity in the range of 0.5 to 1.5 for 17 OECD countries. Our finding falls in the lower end of that spectrum, but shows that growth in GDP has an inelastic impact on energy consumption in the short-run. This interpretation would tend to support the hypothesis that Mauritius tends to depend less on energy consumption as its GDP is growing. Further analysis of the results from the ‘energy equation’ also reveals that along with growth in GDP, growth in private investment also plays a determining role in the growth of energy consumption in Mauritius. The existence of a significant short-run growth elasticity of energy consumption entails a bi-causal relationship between energy consumption and economic growth in the short-run.

From column 3 above, interestingly it is also shown that energy has favourable impact on private capital accumulation thus indicating possible indirect effects via this channel. In fact, a 1% increase in the growth rate of energy consumption leads to a 0.19% increase in the growth rate of private capital after one year. We also reported that a 1% increase in the growth rate of private capital leads to a 0.32%increase in the growth rate of GDP after one year. These two elasticities can imply that a 1% increase in the growth rate of energy consumption can lead to a 0.072% (0.19 × 0.32) increase in the growth rate of output after two years. This is an estimate of the indirect effect of energy consumption on output in the short-run through the private capital channel. Adopting a similar approach, we also computed the indirect elasticities of energy consumption on economic growth, through the foreign direct investment and openness channels respectively as 0.027 and 0.035 respectively.

6.0 Conclusions

Mauritius has witnessed a decrease in energy intensity, imputing that over time, economic growth has started to decouple with economic growth. It is reported that in the case of developing countries, higher energy consumption leads to an increase in economic growth, whereas for developed countries, there is less evidence of dependence between energy consumption and economic growth (Waheed et al., 2019). Mauritius is an upper middle-income country and is aiming to transit into the high-income economies bracket. It finds itself in between the above two set of countries in terms of economic development. It is undeniable that the contribution of energy is crucial in the transition towards higher economic development, but it is also acknowledged that the energy efficiency is more pronounced at higher development level. Given this background, it is imperative for policymakers to comprehend the connection between energy consumption and economic growth in order to design effective energy and growth policies. Given the prospective threats that the country also faces as a small island development state, there is also the continual debate around global climate change, greenhouse gases emissions, and type of economic growth. Mauritius is

grappling with all these topical and complex development issues. The computed energy consumption elasticities and direction of causality, in fact, can assist policy makers in informing their decision-making process and governance of renewable energy deployment. A general review on the energy consumption economic growth nexus, brings to the fore that the published literature around the subject cannot be directly used to inform policy-making in Mauritius given its own intrinsic specificities and its development transition state, and therefore necessitates the derivation of specific elasticity measures.

We therefore used a production model where the energy consumption variable was used along with proxies of capital and labor amongst others, to investigate the energy-growth nexus for Mauritius, by adopting a time series framework to consider dynamism, endogeneity and causality that existed among the variable under study. We calculate the magnitude of short- and long-run energy consumption elasticities for economic growth as 0.17 and 0.33, while controlling for foreign direct investment, openness, private and public investment, and education. We first of all bring some confirmatory value and credence to the thesis that energy consumption is an important contributor in economic growth in Mauritius. A bi-directional relationship was also confirmed between energy consumption and economic growth, thus supporting the 'feedback hypothesis' for Mauritius over the period of study.

Given the bi-directional causality in both the short- and the long-run, policies that aim to limit energy consumption could dent economic growth from both a short- and long-run perspective, which would be contrary to the national policy of achieving a higher-income country status. Consequently, energy policy should emphasize supply side options, by aiming to alter the relationship between energy consumption and economic growth. One such option is to make significant and sustained improvement in energy efficiency, despite the recorded decreasing trend in energy intensity for Mauritius. Such a measure will not necessarily entail a detrimental impact on economic growth. Additionally, Mauritius relies heavily on imported fossil fuels for transportation, electricity generation and production; it is thus vulnerable to any fluctuation and disruption in supply and the supply chain. Any sustained disruption can have deleterious impact economic growth in both the short- and long-run. To contribute towards addressing this issue, energy policy must foster on increasing indigenous energy production using local renewable energy sources, in the total energy mix. This would facilitate an energy transition, while also reducing fossil fuels-related CO_2 emissions; pointing towards future research on the impact of renewable energy consumption on economic growth

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Tables

Table 1
The long run estimates

	Growth Equation	Energy Equation
GDP	**-**	**0.84*** **
PRIVT	*0.56****	*0. 64****
ROADS	*0.18***	*0.334***
FDI	*0.45**	*0.254**
ENERGY	*0.33****	
OPEN	*0.47****	*0.168*
EDU	*0.35***	*-0.095*
*significant at 10%, ** significant at 5%, ***significant at 1%		

Due to technical limitations, table 2 docx is only available as a download in the Supplemental Files section.

Figures

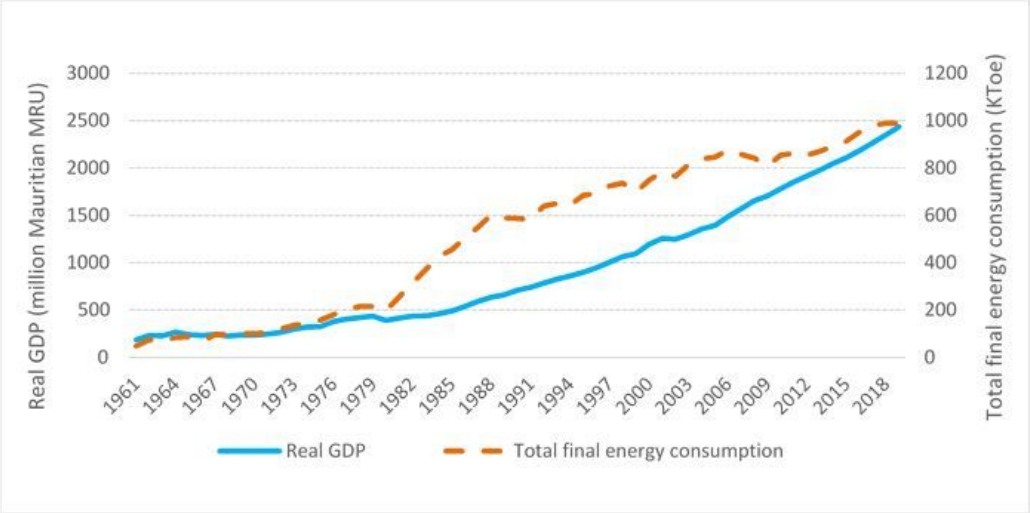


Figure 1

Real GDP and energy consumption for Mauritius (1961-2019)

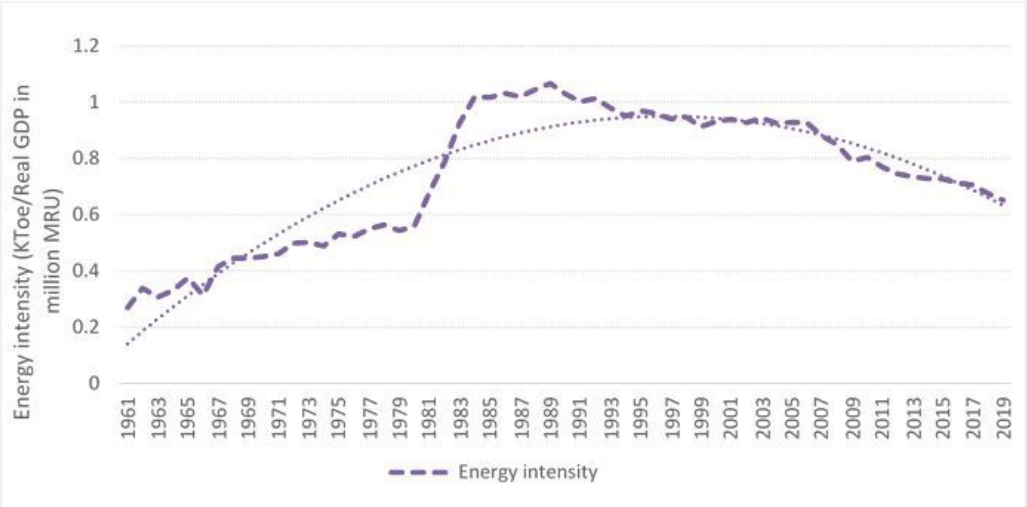


Figure 2

Energy intensity for Mauritius (1961-2019)

Supplementary Files

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- Table2.docx