“Increasing the productivity of manufacturing firms in Cameroon in a sustainable way: Renewable or non-renewable energy?”

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INCREASING THE PRODUCTIVITY OF MANUFACTURING FIRMS IN CAMEROON IN A SUSTAINABLE WAY: RENEWABLE OR NON-RENEWABLE ENERGY?

Abstract

The question of what energy form should guarantee firm productivity in the future is becoming increasingly important, considering the risk that the gradual depletion of the world's non-renewable energy reserves poses to the continuity of productivity. This study aims to assess the effect of individual energy forms on productivity growth of manufacturing firms in Cameroon. This paper uses a two-stage stochastic frontier method to determine the energy form that is most likely to ensure the continuity of the productivity of manufacturing firms in Cameroon in the next few years. The data for the study came from the Annual Enterprise Surveys (EAE) conducted by the National Institute of Statistics of Cameroon (NIS) from 2012 to 2019. The analysis data constitute a panel of 288 representative firms. Factors that primarily explain firm productivity were value-added, renewable and non-renewable energy, capital, labor, and raw materials. The study analyzed the entire manufacturing industry, agri-food sector, and other manufacturing industries. Despite being a group estimate, individual firms are taken into account. Across the manufacturing industry in Cameroon, the results indicate that renewable energy is the most advantageous form. Indeed, this form would cause a 9.27% increase in productivity for a one percentage point increase. However, as the impact coefficients are insignificant, it is difficult to assess the contribution of non-renewable energy to firm productivity.

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Keywords form of energy, energy consumption, manufacturing industry, agri-food, capital, labor, raw materials

JEL Classification Q32, Q40, Q42, Q47

INTRODUCTION

The importance of energy in industrial production has been known since the origins of industrial production activities. In fact, well before the industrial revolution, energy was already used in agropastoral economic activities. Thus, the challenges that confront energy issues also represent significant difficulties for industrial production. According to Güney (2019), the continuity of industrial production in the world inevitably depends on the sustainable management of energy resources. In turn, the risk of depletion of non-renewable energy reserves leads progressively to a possible risk of a halt in industrial production and, thus, a sharp drop in productivity growth.

Historically, the question of what form of energy guarantees the continuity of industrial production has often been raised. The economic literature has therefore identified the theorists of controlled exploitation of energy reserves, who assert that non-renewable energy is the form of energy that allows rapid productivity growth (Hotelling, 1931; Stiglitz, 1974; Solow, 1974). On the other hand, there were advocates of industry development through the exclusive use of renewable energy resources (Bhattacharya et al., 2016; Filippini et al., 2020; King, 2020).

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This question is still being asked today, mainly because of the historical opposition that seems to exist between renewable energy consumption and productivity growth. On the other hand, there is an apparent positive relationship between renewable energy and this same economic performance criterion. In the face of these challenges, what form of energy will guarantee productivity growth for manufacturing firms in developing countries like Cameroon in the coming years?

1. LITERATURE REVIEW

In terms of identifying the factors of production that determine firm productivity, marginalist economic theory is constantly evolving. For example, alongside the group that listed capital and labor as the main inputs, another group has emerged since the early 1930s that identifies natural resources, specifically energy, as a critical source of productivity growth (Bhattacharya et al., 2016; Filippini et al., 2020; King, 2020).

Further, there is a heated debate between proponents of non-renewable and renewable energy on the most recommendable form for determining this same criterion of firm economic performance. For example, Bi et al. (2014) make the regulation of the exploitation of energy reserves the only determinant of sustainable productivity growth. In contrast, King (2020) and Omri and Belaïd (2021) make renewable energy the factor designed to guarantee sustainable productivity of firms.

Even empirical literature has emphasized energy, either as a whole or in its individual forms. However, very few studies have focused on the comparative effects of these two forms of energy on firm productivity.

For example, Filippini et al. (2020), Montalbano and Nenci (2019), Arlet (2017), Allcot et al. (2016), and Mensah (2016) studied the energy-productivity relationship in China, Latin America, 80 economies worldwide, India, and Sub-Saharan Africa, respectively, using a combination of ordinary least squares (OLS) and decomposition techniques. The results reveal a positive relationship between these two variables in each case. However, they fail to shed light on the individual contributions of the energy forms.

Similarly, to verify the existence of a relationship between energy and firm productivity in China, Tao et al. (2017) and Wang and Feng (2015) used the data envelopment analysis (DEA) method coupled with the Malmquist decomposition. Their results indicated a positive relationship between energy and productivity, mainly due to technology. Finally, Shui et al. (2015) used a two-stage stochastic frontier model to investigate the effect of energy efficiency on productivity in China's automobile industry. The results demonstrate the strong influence of energy efficiency on the productivity of these firms. However, analysis of the energy factor remains unclear, mainly due to the lack of distinction in the forms of energy.

Melnyk et al. (2020) concluded that "the development of the service economy contributes to the dematerialization of economic systems, and stimulates energy use reduction and energy efficiency growth through the renewable energy development." Nycz-Wróbel (2021) and Yevdokimov et al. (2018) stated that the goal of shifting to alternative energy sources (e.g., liquid gas, natural gas, or renewable energy sources – wind energy, photovoltaic energy, solar energy, biomass, geothermal energy (utility vehicles), hydroelectric power (paper)) is to reduce emissions of pollutants into the air.

Despite the relative scarcity of studies seeking to make a comparative assessment of the short- and long-term effects of different forms of energy on productivity, to identify the form of energy that can guarantee productivity growth in the future, there is a heated methodological debate among researchers in the empirical literature. Three main stages have marked the evolution of this debate.

First, Filippini et al. (2020), Montalbano and Nenci (2018), Arlet (2017), Allcot et al. (2016), and Mensah (2016) studied the effect of energies on productivity using ordinary regression methods. These methods are then criticized by proponents of frontier methods as experimental and unsuitable for studying performance criterion. In the second punctuation, frontier methods address the effect of energies on productivity. This is the case of the DEA method (Data Envelopment Analysis method), which unfortunately has the limitation of assuming the full efficiency of production units. The concern to overcome this limitation led researchers to adopt the SFA (stochastic frontier analysis) method. This third punctuation mark in the methodological debate has two advantages: it makes it possible to study a causal relationship and evaluate performance within the same methodological framework; it is more realistic because it considers the potential inefficiencies of firms. Recent studies analyzed firm productivity using parametric methods. To do so, they start with a KLEM (KLEM production function is a relation that uses capital K, Labour L, Energy E, and Raw material M as inputs) functional form (Kumbhakar et al., 2015; Shui et al., 2015; Haoran et al., 2021). In most cases, as in this study, the choice of the stochastic frontier method is justified by the implicit assumption of inefficient production units. This assumption has the advantage of being close to the reality of production plants.

The objective of this study is to demonstrate that renewable energy is the form of energy that manufacturing firms in Cameroon should use if they are looking for a high level of productivity growth in the long run. The contribution of this study lies in assessing the effect of individual energy forms on productivity growth. Therefore, the study will follow the methodology that Shui et al. (2015) exposed.

The novelty of this study is threefold. First, the paper approaches the analysis of the energy-productivity relationship from an angle not yet considered. Indeed, different studies so far have never addressed the energy-productivity link in determining the most advantageous form of energy for firms' future productivity. Second, compared to most of the essentially macroeconomic works identified to date, it considers the energy-productivity link from an individual angle. Third, this study determines the form of energy to turn to when faced with the need to significantly improve firms' productivity in the context of an energy deficit.

2. METHODOLOGY

The methodology used to measure the contribution of renewable and non-renewable energy to productivity was developed in two steps. Firstly, total factor productivity is estimated from a stochastic frontier function. Secondly, the specific role of energy is determined through another step in which energy is regressed on productivity growth.

The econometric estimates leading to this decomposition start with the following Cobb-Douglas production technology:

$$y_{it} = f\left(x_{it};t\right)\exp\left(-u_{it}\right). \quad (1)$$

The production function in Equation (1) follows a semi-normal distribution with

$$N\left(\frac{\sigma\sqrt{2}}{\sqrt{\pi}},\sigma^2\left(1-\frac{2}{\pi}\right)\right), \quad (2)$$

as parameters. Productivity growth is given by the following equations:

$$TFP = \dot{y} - \sum_j S_j^a \dot{x}_j, \quad (3)$$

$$\dot{TFP} = TC - \frac{\partial u}{\partial t} + \sum\left\{\frac{f_j x_j}{f} - S_j^a\right\}\dot{x}_j = \\ = \dot{TFP} = TC - \frac{\partial u}{\partial t} + \sum_j\left\{\varepsilon_j - S_j^a\right\}\dot{x}_j. \quad (4)$$

Under the assumption of constant returns to scale, as formulated by Nishimizu and Page (1982), the study has:

$$TC = \frac{\partial \ln f(.)}{\partial t}, \quad TEC = -\frac{\partial u}{\partial t}, \quad (5)$$

$$RTS = \sum_j \frac{\partial \ln y}{\partial \ln x_j} = \sum_j \frac{\partial \ln f(.)}{\partial \ln x_j} = \\ = \sum_j f_j(.)x_j / f(.) \equiv \sum_j \varepsilon_j, \quad (6)$$

which are the different components of productivity related to technology, the efficiency of the production process, and input allocation. Here, the study considers the input-oriented frontier of Färe and Primont (1995), who studied the maximization of productivity by considering the number of inputs used to produce. The respective values of this model lead this study to the original mod-

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els of Aigner et al. (1977) and Meeusen and Van den Broeck (1977). The analysis of productivity, in this case, consists of observing the rate of change in productivity and determining to what extent a particular production input influence it.

Considering a single output (manufactured goods) enables this paper to capture the heterogeneity of firms in the sample. Moreover, a recent study that analyzed productivity via stochastic frontier analysis (Kumbhakar et al., 2020) has solved the endogeneity problems. Similarly, the choice of the two-stage estimation procedure allows for obtaining consistent estimators (Musau et al., 2021). Finally, the choice of the maximum likelihood technique was justified by the need to match the estimated parameters with those of a semi-normal distribution (Kumbhakar et al., 2015).

3. RESULTS AND DISCUSSION

3.1. Overall trends in firm productivity and energy consumption in Cameroon

An examination of the available figures on the performance of manufacturing firms in Cameroon reveals that the performance of these production units is weak. According to the NIS (2020), over the period 2012–2019, the average annual turnover of manufacturing firms was 4,962.41 USD, and these same firms created an average of 1,690.63 USD in value-added. On average, the turnover grew by 11.34% in the period, while the growth in value-added was 10.7% but has fallen overall since 2006 (Figure 1).

Similarly, recent trends in the energy consumption of manufacturing firms are surprising. According to NIS (2020), from 2012 to 2019, 74.17% of the energy used in Cameroonian manufacturing firms was renewable, while only 25.83% of the energy was of non-renewable origin. This is illustrated in Figure 2.

Energy is a critical factor in manufacturing, accounting for 4.38% of the total intermediate consumption, that is, 3.25% for renewable energy and 1.13% for non-renewable energy.

For example, according to estimates based on NIS (2019b) data, the average growth in turnover for the agri-food industry is 20%, and the average value-added is 1,731.73 USD. This exceeds the value-added by the manufacturing industry as a whole. At the same time, the average turnover of the agri-food sector, 1,715.62 USD, is well below the average for the manufacturing industry. Furthermore, only 41% of the energy consumed by Cameroon's agri-food firms is from non-renewable sources (5.52% of intermediate consumption), while 59% of energy is of renewable origin (7.98% of intermediate consumption). According to the same source, energy represents 13.51% of the intermediate consumption by agri-food firms.

In the textile industry, energy represents only 0.7% of intermediate consumption (0.45%: renewable, 0.31%: non-renewable). Therefore, non-renewable energy represents 44.19% of the total energy consumed, compared to 64.74% of the total renewable energy consumption. The textile industry achieved an average turnover of 965,373 CFA francs against the average value-added of 118,839.3 CFA francs

Source: Compiled by the authors based on data from NIS (2019b).

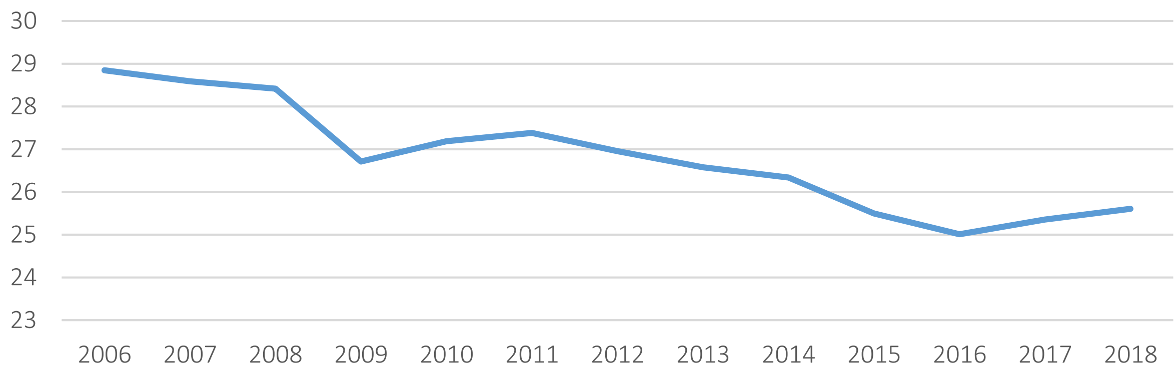

Figure 1. Evolution of industrial value-added (% GDP)

Source: Compiled by the authors based on data from NIS (2020).

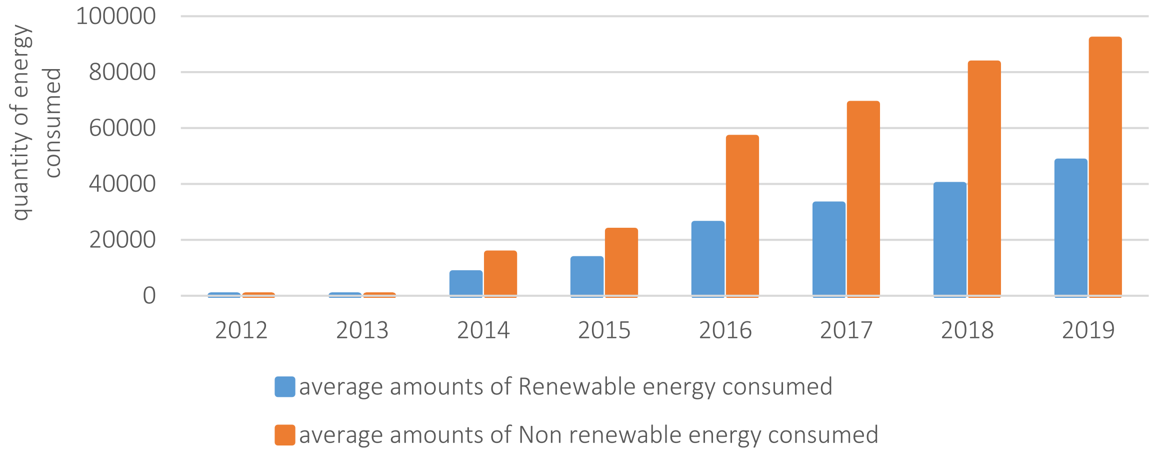

Figure 2. Evolution of manufacturing firms' average energy consumption in Cameroon (2012 and 2019)

without the possibility of isolating the respective contributions of each form of energy. This is practically the same for all industrial branches. The consumption of non-renewable energy is lower than that of renewable energy, and it is impossible to distinguish the effect of a particular form of energy on productivity.

As can be seen, in Cameroon, manufacturing firms abuse renewable energy, yet the performance of manufacturing firms remains chronically low. On the other hand, non-renewable energies, which have proven their effectiveness throughout the economic history of the world, are now facing a problem of depletion. This gradual depletion leads to the designation of renewable energy as an alternative energy source. In addition, the lack of information on the individual contributions of each form of energy presents decision-makers in firms with the dilemma of adopting the best form of energy in an energy deficit context. Information on the level of the economic viability of any energy form would undoubtedly provide insight into the most desirable direction that firms can take. Therefore, determining the contribution of each form of energy to firm performance is of great importance. Moreover, it would inform firms about the choices they should make regarding the energy factor.

Today, more than in the past, the issue is coming back to the fore with the rise of environmental concerns. Specifically, in African countries that are still less industrialized, what form of energy should be used to sustainably increase the productivity of manufacturing firms? This is on the understanding that the main form of energy used in various sectors of activity in these countries is renewable.

3.2. Data and data description

The analysis and measurement of Cameroonian firms' productivity are based on data from the Annual Enterprise Surveys conducted by the NIS from 2012 to 2019. The data contain economic information on firms' activities. This includes information on manufacturing value-added (output variable), firms' expenditure on renewable and non-renewable energy, and the cost of other factors such as capital, labor, and raw materials (input variables). This choice of other factors is part of the concern when considering the multiple factors that primarily explain a firm's productivity. Thus, data constitute a panel of 288 representative firms in the Cameroonian manufacturing sector. The problem of the representativeness of this sample is linked to the constraint of data availability.

The descriptive statistics of the study variables are presented in Table 1. Among other things, it should be noted that renewable and non-renewable energy expenditures contribute to value-added without the possibility of distinguishing their different proportions in such value.

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Table 1. Descriptive statistics of explanatory variables of the productivity growth of manufacturing firms in Cameroon

Source: Compiled by the authors.

Variable	Average	Standard deviation	Min	Max	Observations
Value-added	8.60802	3.83311	0	18.37642	N = 962
Capital	1.10204	3.697647	2.302585	20.72327	N = 962
Labor	9.950108	4.620021	0	20.72327	N = 962
Renewable energy	7.595842	4.326346	0	14.78601	N = 962
Non-renewable energy	7.719718	4.477329	0	15.95048	N = 962
Raw materials	9.231191	4.58931	0	20.67197	N = 962

Table 2 summarizes the correlation between study variables and sheds light on those that could explain the firm's productivity via manufacturing value-added.

Table 2. Summary of correlations between the study variables

Source: Compiled by the authors.

Variable	Value-added
Value-added	1.0000
Capital	0.6469*
Labor	0.3383*
Renewable energy	0.5913*
Non-renewable energy	0.5468*
Raw materials	0.5291*

Note: * – significance at the 10% level.

The effect of each form of energy on the productivity growth of Cameroonian manufacturing firms is shown in Table 3.

Despite being a group estimate, individual firms are taken into account. In addition to these overall results, the study presents some estimation results for certain sectors, such as agri-food and other industries, that have a sufficient number of observations to lend themselves to the stochastic frontier method.

These estimates are globally significant; the statistics obtained for the likelihood ratio are higher than the values of the theoretical chi-square statistics obtained (significance at the 1%, 5%, and 10% thresholds).

The estimation results show that renewable energy explains 9.27% of the productivity growth of manufacturing firms in Cameroon. Thus, a 1% increase in the amount of renewable energy consumed leads to a 9.27% increase in productivity. This is true for all manufacturing firms as well as the selected sectors of activity.

In the food industry, the explanatory power is 7.26%, and in other manufacturing industries, it is 7.34%. This result is in line with Filippini et al. (2020), who estimated that energy increases productivity by 3.1% in some regions of China. Similarly, Allcot et al. (2016) found that the productivity growth points gained from industrial energy use in some economies around the world were between 5% and 10%. Ultimately, this result supports the assumption that renewable energy is a driver of productivity growth and reinforces the dominant theoretical view on the factor explaining productivity.

The results also indicate that non-renewable energy negatively affects the overall productivity of the manufacturing sector in Cameroon; this effect is quantified at –3.73195%. That is, a 1% increase in the consumption of non-renewable energy leads to a 3.73% decrease in productivity. However, this result should not be considered at face value because the coefficient is insignificant. However, this trend is found in the two selected subsectors of activity where non-renewable energy affects productivity by 7%.

This reinforces the importance of energy in production processes. This finding underlines the conclusion of the economic theory on the contribution of production sectors to productivity. The overall results confirm the assumption that renewable energy is more critical than non-renewable energy for the productivity of manufacturing firms in Cameroon.

This result supports the biophysical economics hypothesis on the importance of energy in production. More fundamentally, this result reinforces the

Table 3. Estimates of the effect of the form of energy on the productivity of manufacturing firms in Cameroon

Source: Compiled by the authors.

Sectors	Variables	Coefficients	Standard deviation
Entire manufacturing industry	Capital	0.2355179***	0.0084337
	Labor	0.0424194***	0.0069647
	Renewable energy	0.0927754***	0.0162284
	Non-renewable energy	–0.0373195	0.13186
	Raw materials	–0.0402724	0.0084808
	Year	–0.3021735	0.0292379
	_cons	606.5164	58.84348
Agri-food	Capital	0.32238***	0.0218124
	Labor	0.0014504	0.0172382
	Renewable energy	0.0726742**	0.034849
	Non-renewable energy	0.0706362**	0.0293354
	Raw materials	–0.0629656	0.0269911
	Year	–0.4561555	0.0642295
	_cons	916.8285	129.3511
Other manufacturing industries	Capital	0.2321223***	0.0218279
	Labor	0.0008793	0.017251
	Renewable energy	0.0734262**	0.0348595
	Non-renewable energy	0.0707708**	0.0293527
	Raw materials	–0.06282	0.0270022
	Year	–0.4564151	0.0636006
	_cons	917.346	128.0741

No. of obs. overall = 792; Agri-food = 150; Other manuf. industries = 150
No. of groups overall = 164; Agri-food = 33; Other manuf. industries = 33
Wald χ^2 (6) overall = 904.26; Agri-food = 232.70; Other manuf. industries = 233.29
Loglikelihood overall = –855.9921; Agri-food = –168.8540; Other manuf. industries = –168.9587

Note: ***, **, * – significance at the 1%, 5%, and 10% levels, respectively.

increasingly dominant thinking on the importance of renewable energy for production compared to the contribution of non-renewable energy. Above all, environmentalists consider the issues of environmental preservation and the sustainability of development. The argument regarding the lack of sustainability of fossil fuels again demonstrates the relevance of the option chosen by Cameroon in promoting renewable energy.

Apart from energy in the two dimensions considered herein, other factors can help explain productivity growth in manufacturing firms in Cameroon. These include capital, labor, raw materials consumed in the production process, technology represented in the model by time, and a constant scale factor.

In the entire sample, the capital factor positively affected productivity growth; this effect was estimated at 23.55179%. This statistic can be observed in agri-food and other industries in which capital positively affects productivity growth. Looking at the overall impact, the positive effect outweighs the negative effects in the oil and textile sectors. Moreover, there is nothing fundamentally abnormal in the sign of the coefficient that measures the effect of capital on Cameroonian manufacturing firms' productivity.

Similarly, the sign of the labor factor is also positive, which is in line with significant theoretical findings. As in the case of the capital factor, agri-food and other industries have significant and positive impact coefficients.

The results of the overall and sectoral estimates reveal a negative coefficient, which is not significant for raw materials and technology, as represented in this case by time. The constant term, which expresses the scale factor, is also of minor importance because the coefficients obtained are all non-significant.

The results have at least two implications for economic policy. First, Cameroonian public authorities, whose intervention is necessary for good energy management, should invest more in creating a renewable energy infrastructure (Ostrom, 1990). However,

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using forms of renewable energy other than hydroelectricity would solve the energy deficit (Harris & Roach, 2018). This will also be an important factor in productivity enhancement in the next few years. Second, the Cameroonian government could implement various measures to facilitate renewable energy production, including regulatory reforms or fiscal and customs measures. Such measures would facilitate the import of materials useful for the production of renewable energy, which is essential for firm productivity. In addition, this measure should be extended to households to achieve energy savings.

CONCLUSION

The purpose of this study is to determine which of the energy forms used by manufacturing firms in Cameroon should guarantee the productivity growth of these firms in the future. To achieve this objective, a two-stage stochastic frontier method was used. The first stage of implementation of this method allowed the paper to estimate the productivity levels of sample firms. The second step allowed obtaining the impact coefficients of the energies on productivity growth. This was implemented on the statistical data provided by the NIS, relating to the Annual Enterprise Surveys between 2012 and 2019. The results obtained show that despite the great importance of non-renewable energy in the industrial world production systems, the sustainability of manufacturing production in Cameroon will need more renewable than non-renewable energy.

Indeed, renewable energy has an impact on productivity growth of 9.27% for every 1% increase in the quantity of this form of energy. This coefficient is far higher than that of non-renewable energy, which impact coefficient shows a negative effect (–3.73%) on long-term productivity growth. However, manufacturing firms often face difficulties, that as technology lag. The capital factor positively affected productivity growth; this effect was estimated at 23.55%. Similarly, the sign of the labor factor is also positive, which is in line with major theoretical findings. On the other hand, the results of the overall and sectoral estimates reveal a negative coefficient, which is insignificant for raw materials and technology.

As demonstrated by the findings of this study, Cameroonian public authorities should invest more in creating renewable energy infrastructure and implement a range of measures to facilitate renewable energy production.

AUTHOR CONTRIBUTIONS

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Formal analysis: Nguenda Anya Saturnin Bertrand.
Investigation: Koumou Landry Etienne.
Methodology: Nguenda Anya Saturnin Bertrand.
Project administration: Nguenda Anya Saturnin Bertrand.
Software: Koumou Landry Etienne.
Supervision: Nguenda Anya Saturnin Bertrand.
Validation: Nguenda Anya Saturnin Bertrand.
Writing – original draft: Nguenda Anya Saturnin Bertrand, Koumou Landry Etienne.
Writing – review & editing: Nguenda Anya Saturnin Bertrand, Koumou Landry Etienne.

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