THE EFFECT OF FINANCIAL DEVELOPMENT ON RENEWABLE ENERGY CONSUMPTION IN CAMEROON

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Abstract

The improvement of the energy structure and the development of the renewable energy sector play an important and strategic role in Cameroon's responsibilities against climate change. So, the authorities and policy makers have made great efforts to achieve this. But one of the main constraints of Cameroon's energy transition lies in financial issues, which are inevitably linked to the country's financial development. At the heart of this reflection therefore arises the question of knowing: What could be the impact of financial development on the consumption of renewable energies in Cameroon? This study therefore aims to examine the impact of financial development on the consumption of renewable energies in Cameroon over the period from 2000 to 2022. Our research is based on a Vector Autoregressive (VAR) model; seven variables of financial development have been used to explain the consumption of renewable energies in Cameroon. The results of the empirical analysis show that foreign direct investments, the evolution of bond markets and energy prices represented by the consumer price have a negative effect on the consumption of renewable energies. On the other hand, domestic credit provided by the financial sector, banking availability, economic development, and income have a positive impact on renewable energy consumption. Our empirical results provide valuable insights into the best ways to deploy capital in the renewable energy sector, in order to provide customers with cost-competitive options, and to facilitate the implementation of policies that contribute to environmental sustainability and energy security.

Keywords: financial development, renewable energies, VAR model, Cameroon.

JEL: C22; Q01; Q20; Q43.

1. Introduction

Energy is a critical component if countries are to achieve sustainable development. The ongoing demand for energy has intensified in previous decades and continues to grow now. Population expansion, improved lifestyles, increased output, and economic competitiveness all contribute to the growing demand for energy. As a result, worldwide energy consumption rose by 44% between 1971 and 2018 (World Bank, 2017a, 2017b). Furthermore, figures show that fossil fuels account for roughly 78.4% of the total energy consumption (REN21, 2017). Excessive combustion of fossil fuels emits excessive amounts of carbon dioxide (CO_2) into the atmosphere, causing negative environmental effects such as global warming. Consumption of renewable energy contributes not only to a cleaner environment (by reducing greenhouse gas emissions), but also to independence from fossil fuel markets (e.g. oil and gas) and energy security. In Cameroon, increased consumption of renewable energies is one of the main energy policy objectives. "Cameroon has significant renewable energy potential as well as limited oil and gas reserves. There is a strong governmental commitment to developing the energy sector, thanks in large part to international donor support. However, universal access to energy is still far from being reached. The development of renewable energies other than hydroelectricity is embryonic, and load shedding is regular." (IFDD, 2022).

Renewable energy has the potential to diversify the energy mix. Less reliance on fossil fuels results in increased resilience to energy market shocks. Furthermore, green energy production has the potential to avoid additional environmental harm. However, transitioning from fossil fuels to renewable energies can be difficult, and one of the most significant challenges is cost. There are several financial

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challenges to overcome when compared to fossil fuel-based energy projects, including greater infrastructure, start-up, and operating expenses. In this environment, a strong financial system is required to ensure effective price discovery and financing, as well as market liquidity. Additionally, financial markets increase capital allocation. A highly developed financial system encourages investment in growth areas, whereas an underdeveloped financial system discourages investment in declining industries (Wurgler, 2000).

Recent studies have focused on the relationship between energy consumption and economic growth, and have expanded to include a third dimension: financial development. The need to introduce financial development to explain this relationship is supported by several reasons: firstly, financial development attracts foreign direct investment (FDI), and hence high-level R&D investment, which amplifies economic growth and affects the dynamics of environmental performance. Secondly, financial development provides opportunities for developing countries to exploit new technologies, known as "green" technologies, and thus help them to improve the environment and sustainable development. Finally, financial development can also lead to increased pollution and environmental degradation. Investment costs are one of the most significant hurdles in deploying renewable energy. Indeed, renewable energies have a somewhat high initial investment cost when compared to traditional energy sources. Furthermore, renewable energy projects have long payback periods and require a large amount of capital. Financial development could thus play an essential role in increasing renewable energy use. Financial infrastructure can boost economic growth and influence energy demand (Sadorsky, 2010). Indeed, a high level of financial development promotes the growth of financial markets, banks, and stock exchanges, resulting in more cash available for investment (Sadorsky, 2010). According to Shahbaz and Lean (2012), financial development should have a favorable impact on economic growth and, consequently, energy consumption. They highlighted the key factors that explain how financial market improvements are linked to increased investment and economic growth. The initial mechanism is the level effect. This translates into matured financial markets raising capital for high-return initiatives. The second process is known as the efficiency effect. It indicates that financial development improves asset liquidity and diversity while also channeling financial resources to relevant enterprises.

According to Sadorsky (2011), financial development enhances an access to financial resources, resulting in increased demand for expensive goods and energy. According to Sadorsky (2011), financial development influences energy use in three ways: directly, through commerce, and indirectly through wealth. The direct effect is linked to stronger financial development, which allows consumers to borrow more easily and at lower costs so as to purchase consumer durables, resulting in increased energy consumption. The commercial effect arises when financial development enables enterprises to obtain financial resources more simply and affordably (Caporale *et al*. 2009). The wealth effect happens as economic confidence rises, expanding the economy and driving up demand for energy. Improved financial development makes it easier to save, borrow, and invest. With cheap financing costs, customers are more likely to buy consumer durables, thus increasing energy demand. However, Islam *et al*. (2013) suggest that financial prosperity encourages the purchasing of energy-efficient appliances, hence lowering energy usage. According to Chiu and Lee (2020), financial institutions play a significant role in countries with a stable financial climate because they provide industries with an easy access to finance through the stock market and banking sector. As a result, businesses would have more resources to invest in modern, energy-efficient equipment and technologies, resulting in lower energy usage.

In an environment where renewable energy investment is heavily promoted, financial development can play an important role. In the energy literature, there is an increasing interest in examining the factors that govern the use of renewable energy. As many empirical studies have focused on the interactions between the use of renewable energy and financial development, Habiba and Xinbang (2023) used the "Moment Quantile Regression" (MMQR) method to study the impact of different aspects of financial development on renewable energy consumption using panel data from seven emerging economies (E7) from 1991 to 2018. It is confirmed that the influence of independent variables varies across quantiles of renewable energy. Overall, they discovered that all three aspects of financial growth—financial development in general, financial market-related development, and financial institution-related development—have a beneficial impact on renewable energy usage. Regean and Bulime (2024) investigated the impact of financial development on the clean energy transition in 20 low- and middle-income nations in Sub-Saharan Africa. The study used two-stage, fixed effects, instrumental variable least squares models to investigate the impact of financial development on the shift to renewable energy. Their findings suggest that financial development has a positive effect on the shift to renewable energy. However, financial development has a considerable impact on financial institutions rather than financial markets.

According to a 2016 analysis on Cameroon's energy condition, the country has a high potential for renewable energy as well as minor oil and gas reserves. There is a strong governmental commitment to developing the energy sector, thanks in large part to international donor support. However, universal access to energy remains a distant goal, the development of renewable energies other than hydroelectricity is in its early stages, and load shedding is common. This is primarily due to the presence of financial constraints and the ongoing search for financing sources and methodologies tailored to energy management projects (MINEE, 2016). The complexity of procedures for obtaining international financing in Cameroon is impedes the growth of renewable energy. The access to the local financial industry is likewise difficult. The local banking industry has yet to properly comprehend the significance and necessity of improving access to credit for the renewable energy sector. (IFDD, 2022). Our research consequently focuses on the following question: What impact might the financial development of renewable energy consumption have in Cameroon?

This study examines how financial development affects renewable energy consumption. It contributes the following to the existing literature: first, while our research contributes to a substantial body of literature attempting to explain the relationship between financial development and energy consumption, we focus on renewable energy use, which is understudied in the existing literature. Second, this paper is one of the first to quantitatively examine the impact of financial development on renewable energy consumption in Cameroon, and third, we have added a new variable, bank availability, which represents the number of commercial banks and measures the accessibility of bank credit for adults.

Our article is organized as follows: section 2 provides a review of the literature on the subject, section 3 the methodology, section 4 presents the results and discussion, and finally we will have the conclusion.

2. Literature Review

2.1 *Theoretical review*

Financial development, which is defined as improving the efficiency and stability of the financial system, includes decisions to encourage foreign direct investment, banking system expansion, and stock and bond market activity (Sarkody, 2010). Financial development entails reduced financial risk, increased transparency, lower borrowing costs, and an improved access to finance (Sadorsky, 2010), all of which have a beneficial impact on the cost of renewable energy, which is a primary driver of renewable energy usage. The banking industry, as a critical component of the financial system, provides resources and encourages investment in renewable energy goods and technology. The expansion of the capital market raises the attractiveness of enterprises, allowing them to get extra resources to support investments in the energy sector, and also boosts confidence in the financial system, increasing demand for energy (Sadorsky, 2010).

Financial development stimulates a number of changes within a country, including reduced financial risk and improved quality of life, lower borrowing costs, greater transparency between lenders and borrowers, access to greater financial capital and investment flows, and access to the latest energy-efficient products and advanced technologies, all of which can affect energy demand by increasing consumption and fixed investment by firms. (Levine 1997; Xu 2000; and Fung 2009). Financial development can affect energy demand in several ways. One of the most direct ways that financial development can affect energy demand is by making it easier and cheaper for consumers to borrow to purchase high-value goods such as automobiles, homes, refrigerators, air conditioners, and washing machines (Mankiw & Scarth 2008). These consumer goods are typically energy intensive, which can negatively impact energy demand. Businesses also benefit from improved financial development, as it is easier for them to obtain and spend funds. The access to financial capital that can be used to expand existing businesses (purchase or construction of factories, buildings, etc.), to expand existing businesses, or to create new the ones. The development of stock markets is particularly attractive to businesses because it allows them to access an additional source of financing, equity financing, which can be used to expand the business in addition to capital investment. Increased stock market activity can increase risks for both consumers and businesses, which is an important component of wealth creation in an economy. Increased stock market activity also creates a wealth effect, which in turn affects consumer and business confidence (Mankiw & Scarth, 2008). The stock market is often considered a leading economic indicator, and increased stock market activity can be seen as a sign of economic growth and improved competitiveness which in turn creates increased economic confidence and increased economic activity and demand for energy.

According to Sadorsky (2010), financial development can affect energy use in two ways:

Positive influence:

This occurs through three channels: the direct influence, the business effect, and the wealth effect. Customers benefit directly from effective financial intermediation since they can quickly find resources and hence buy sustainable products, thus increasing demand for energy. The commercial impact is attributable to an increasing trend toward financial development, which improves enterprises' access to financial capital. Financial development enables businesses to obtain cheaper financial resources in order to expand their operations or establish a new company, hence increasing energy consumption. The wealth impact is caused by firms and families' confidence in established stock markets. In 2010, Sadorsky discovered a direct correlation between financial progress and energy use. In his key study, Sadorsky, (2010) employed the dynamic panel approach to examine the impact of financial development on energy consumption in 22 developing countries from 1990 to 2006. His findings showed that there is a considerable positive association between financial progress and energy usage. Sadorsky used a similar strategy to investigate the relationship between finance and energy in nine Central and Eastern European nations between 1996 and 2006, and discovered a positive relationship between the variables (Sadorsky 2011).

Negative influence

In this situation, financial development may cut energy use by enabling the development of innovative technology. The technological effect refers to the negative impact of financial development on energy consumption, which pushes the implementation of energy-saving and efficient technologies. It reduces energy use and CO_2 emissions. It also increases energy efficiency by preserving technical innovation.

2.2 *Empirical review*

In recent years, empirical research has focused on the relationship between financial development and energy usage, with varied results. On the one hand, several studies have found that more financial development leads to increased energy use. For example, Shahbaz *et al.* (2010) used the ARDL bounds testing approach to investigate the effects of financial development on energy usage in Pakistan and discovered a considerable positive effect. Similarly, Islam *et al.* (2013) employed the vector error correction model (VECM) to determine how economic growth and financial development effect energy consumption in Malaysia. Meanwhile, Tang and Tan (2014) conducted research on the Malaysian economy from 1972 to 2009 utilizing the Johansen-

Juselius cointegration test and the boundary testing approach. They discovered a long-term correlation between energy usage and financial progress. Xu (2012) used the GMM system to investigate financial development and energy consumption in 29 Chinese provinces from 1999 to 2009. His findings revealed a positive and statistically significant relationship between financial development and energy consumption when financial development is measured by the ratio of a financial institution's loans to GDP and the ratio of FDI to GDP.

Coban and Topcu (2013) used the System GMM model to study the relationship between financial development and energy use in the European Union (EU) from 1990 to 2011. Their empirical findings give solid evidence that financial development has a positive impact on energy usage in the elderly, regardless of whether it originates from the banking sector or the stock market. Chang's (2015) analysis is based on a sample of 53 nations from 1999 to 2008, separated into two categories: high-income and non-high-income. Their findings revealed that in a non-high-income regime, energy consumption rises in tandem with financial development, which is measured by private and domestic credit. However, financial progress is measured by the value of traded shares and stock market turnover; in advanced nations, energy consumption declines slightly while increasing in higher-income countries in emerging and developing economies. Rashid and Yousaf (2015) discovered a positive and significant correlation between financial development and power use. Rafindadi and Ozturk (2016) discovered that financial development had a favorable impact on energy usage in Japan from 1970 to 2012. Paramati *et al*. (2016) examined the impact of foreign capital and stock market development on renewable energy usage in 20 emerging economies, using data from 1991 to 2012. They discovered that foreign capital and stock market development have a significant impact on enhancing renewable energy use across all country groupings. Kahouli (2017) used the autoregressive distributed lag limits (ARDL) approach to investigate the relationship between energy use and financial development in southern Mediterranean countries. It discovered evidence of a long-term beneficial relationship between financial development and energy use in Israel, Morocco, and Tunisia. Liu *et al*. (2018) used the ARDL limits technique and discovered that between 1980 and 2014, financial development in China had a favorable short- and long-run impact on energy demand.

Other research, however, shows a negative relationship between financial progress and energy usage. For example, in a sample of 20 developing nations, Mielnik and Goldemberg (2002) discovered a clear drop in energy intensity when FDI (a measure of financial progress) grew. Sadorsky (2010) demonstrated that financial development could cut energy use by enabling the development of innovative technologies. The negative influence of financial development on energy consumption is known as the technology effect (Tamazian *et al*. 2009, Jalil and Feridun 2011, Shahbaz *et al*. 2013, Mahalick and Mallick 2014, Shahbaz *et al*. 2017). Later, Topcu and Payne (2017) investigated the impact of financial development on energy use in a panel of 32 high-income countries from 1990 to 2014. Their findings indicate that there is no statistical correlation between the total financial development index and energy use. They do, however, demonstrate that an increase in the stock market index results in a modest drop in energy use. Destek (2018) investigated the relationship between financial development, energy prices, real income, and energy consumption in 17 rising economies from 1991 to 2015 using a three-dimensional financial development management model (banking sector, stock market, and bond market). The empirical findings indicate that the development of the banking and bond markets has a negative and statistically significant impact on energy usage.

Ouyang and Li (2018) used the GMM panel VAR technique to analyze the endogenous relationship between financial development, energy consumption, and economic growth in China, using quarterly frequency data from 30 Chinese provinces from 1996 to 2015. Their findings indicated that financial development in terms of M2, credit, and inventory turnover might dramatically cut energy use. More recently, Canh *et al*. (2020) examined the relationship between financial development and the energy intensity of consumption and production in 81 economies from 1997 to 2013. Their studies demonstrated that over time, financial institutions had a greater impact on energy intensity than financial markets. Furthermore, in the event of an oil shock, nations with higher levels of financial development see a decrease in the energy intensity of their output, whereas those with stronger financial institutions see a decrease in the energy intensity of their consumption. From 1984 to 2015, Chiu and Lee (2020) investigated the relationship between energy consumption, financial development, and country risk in 79 nations and two subgroups. Their findings revealed that under a stable country-risk context, financial development leads to less energy usage. Benkraiem *et al.* (2019) claimed that positive and negative shocks to financial development affect energy usage in opposite directions.

Aside from the research cited above, which examines the relationship between financial development and traditional energy consumption, just a few publications address renewable energy consumption. Wu and Broadstock (2015) evaluated data from 22 emerging nations between 1990 and 2010, and discovered that financial development and institutional quality have a favorable and significant impact on renewable energy use. Best (2017) used data from up to 137 nations from 1998 to 2013 to study the role of financial capital in the growth of energy use. He discovered that financial capital facilitates the shift to more capital-intensive energy sources. For high-income countries, financial capital serves as a stimulus for the shift from fossil fuels to modern renewable energy sources, particularly wind power. Kutan *et al.* (2017) examined data from Brazil, China, India, and South Africa from 1990 to 2012 and found that FDI flows and stock market development have a significant impact on renewable energy use. Similarly, Burakov and Freidin (2017) examined the causal relationship between financial development, economic growth, and renewable energy usage in Russia from 1990 to 2014. Their findings indicated that there was no causal relationship between financial development and renewable energy consumption.

Ji and Zhang (2019) demonstrated, using a time series analysis of Chinese stock market data from 1992 to 2013, that financial development is critical and accounts for more than 40% of the variation in the evolution of renewable energy share. Anton and Nucu (2020) conducted empirical research based on a fixed-effects panel model using panel data from 28 EU nations between 1990 and 2015 to investigate the effect of financial development on renewable energy usage. The results they obtained show that various components of financial development (banking sector, bond market, and capital market) raise the proportion of renewable energy use. They also stated that the expansion of the capital market had little impact on renewable energy use in the new EU member states.

Our paper differs from others in the literature in two ways. First, it is the first to investigate the role of financial development in determining renewable energy consumption while accounting for the ratio of commercial banks per adult and economic development as additional factors. Second, available literature indicates a growing interest in increasing renewable energy use. Clear evidence of the role of financial development has been found, but only in a select group of countries. While these cross-national studies provide important information on the impact of financial development on renewable energy usage, they do not address Cameroon's specific conditions. As a result, this article is one of the first to quantify the influence of financial development on Cameroon's renewable energy usage. The empirical findings may assist policymakers in taking steps to promote renewable energy consumption and create an economically efficient and environmentally sustainable energy system.

Given that renewable energies are more expensive than traditional energy sources (Anton and Nucu 2020), they require a greater access to financial resources (debt and/or equity). In other words, the growth of the financial industry can spur investment in clean and renewable energy. A positive relationship between financial development and renewable energy consumption is expected. Based on recent literature, the following hypothesis is tested: There is a positive relationship between financial development and renewable energy consumption in Cameroon.

Our equation model will represent a general specification, aimed at examining the role of financial development indicators on renewable energy consumption in Cameroon over a period from 2000 to 2022, where renewable energy consumption is treated as a dependent variable while banking, stock and bond indicators, FDI, the consumer price index and GDP per capita are treated as explanatory variables. We will therefore use time series econometrics.

3. Methodology

3.1 Data source and choice of variables

The data used in this article are based on the annual time series data for Cameroon over the period 2000 to 2022. The period was chosen on the basis of the availability of all the data series. The source of the data is the World Bank's World Development Indicators (WDI). The dependent variable is renewable energy consumption (REN), measured as the share of renewable energy in total final energy consumption. In line with previous work, Chang (2015); Coban and Topcu, (2013), Regean and Bulime, (2024), financial progress is possibly quantified by the factors below:

- Foreign direct investment (FDI) is measured as net inflows as a proportion of GDP.
- Domestic credit granted by the financial sector (CIF) (% of GDP): as an indicator of the development of the banking sector.
- Outstanding international private debt securities (ETDPI) in relation to GDP (%), as an indicator of the development of the bond market.
- The Consumer Price Index (CPI) is used as an indicator of energy prices, as data on energy prices is not readily available following previous studies.
- The ratio of commercial banks per adult (BCA): Represents the number of commercial banks likely to grant credit per 100,000 adults, and measures the accessibility of bank credit for adults.
- The economic development (ED): measured by GDP per capita based on purchasing power parity (PPP) (constant 2011 international).
- GDP growth (CPIB), (annual %): represents income, and is measured by the annual percentage growth rate of GDP per capita based on a constant local currency.

Table 1. *Description of variables*

Names	Abbreviations	Source
Renewable energy consumption	REN	WDI (World Development Indicators), World Bank 2022
Foreign direct Investment	FDI	
Domestic credit granted by the financial sector	CIF	
Outstanding international private debt securities	ETDPI	
Consumer Price index	CPI	
Commercial bank ratio per adult	BCA	
Economic development	ED	
GDP growth (annual %)	CPIB	

Source: author, taken from WDI

3.2 *Model specification*

Following the most relevant previous studies (Chang 2015; Regean and Bulime, 2024), our model is written as:

$RENt = a_0 + a_1\ FDIt + a_2\ CIFt + a_3\ ETDPIt + a_4\ CPIt + a_5\ BCAt + a_6\ EDt + a_7\ CPIBt + \mu_t,$

where the time period is denoted by the index t (t=1, ...T); a1 ,....,a7; a_0 and μ_t represent the constant and the error term respectively.

The regression coefficients are estimated by the regression analysis. They show that, assuming that the other variables remain fixed, an increase of one unit in an explanatory variable increase (or decreases) the renewable energy consumption of units "a". Before estimating the long-term relationship, the non-stationarity of the variables must be tested. The Augmented Dickey Fuller (ADF) test developed by Dickey and Fuller (1981) and the Phillips Perron (PP) test are used for this exercise. After indicating the integration of the variables in the same order, in the next stage the variables will be tested for a long-term cointegration relationship. The Johansen tests will be used to test the cointegrating relationship.

4. Results

4.1 *Descriptive statistics and Stationarity test*

We can see that the series analyzed show significant variations over time, and the standard deviation for all the variables is high (Table 2). We would check to see if our different variables are stationary, as they are usually stationary at the level (Greene, 2002). If they contain trends and hence are non-stationary, we must make them stationary to avoid the possibility of regressions across variables. This test will be performed using Stata 17 with the ADF (Augmented Dickey-Fuller) and PP (Phippips Perron) tests. From the Table 3, we can see that none of our variables is stationary at level according to the ADF and PP tests. On the other hand, for these same tests, all our variables become stationary in first difference.

4.2. *Optimal delay and cointegration*

To find the lag number (p) of our VAR model, we will use the Akaike (AIC) and SBIC criteria. Table 4 reports the results obtained. The optimal delay, i.e. the one that minimizes the AIC and SBIC criteria, is p=1, so our model is a VAR (1). To analyze the long-term relationship between our variables, we will use Johansen's cointegration test, with the following hypotheses:
H0: no cointegration;
H1: cointegration
The results of the cointegration test are shown in Table 5.

According to Table 5, we accept the hypothesis H0, *i.e.* that there is no cointegrating relationship at the 5% threshold, as the trace statistic is below the critical value (11.9671 < 15.41). The most suitable model for this analysis is therefore the VAR (Vector Autoregressive) model. The VAR technique is appropriate in this case because of its ability to characterize the dynamic structure of the model as well as its ability to avoid imposing excessive identification restrictions associated with different economic theories. The use of VAR in macroeconomics has generated a wealth of empirical evidence, providing fundamental support for many economic theories (Blanchard and Watson, 1984, Bernanke, 1986 among others). The VAR model is adopted for this study because of its predictive power relative to large structural models. Again, one of the common virtues of the VAR model is that it avoids having to decide which contemporaneous variables are exogenous, all variables being endogenous.

4.3 *VAR model results (1)*

The results of the estimation of the parameters of our VAR model (1) are summarized in Table 6. The regression results appear to be fairly satisfactory. The log likelihood is fairly high (Log likelihood = -1068.406), which means that our model fits well. The probability of the F-statistic (0.0000) is less than 5%, which shows that the model is significant overall. The selected variables significantly explain renewable energy consumption in Cameroon.

4.4. *Model validity tests*

4.4.1 Normality of residuals

To check the normality of the residuals of our VAR model, we use the Jarque-Bera test. This test is based on the Jarque-Bera (JB) (1980) statistic and follows a chi-square distribution with two degrees of freedom at the 5% threshold. It is used to determine whether or not the variables in the model follow a normal distribution. The results in the table below indicate that the Jarque-Bera probabilities are all greater than 5%, so we accept the normality of the residuals in our model, (Table 7).

4.4.2 Autocorrelation and Heteroscedasticity of residuals

In order to test the autocorrelation of the residuals, we will use the Lagrange multiplier (LM) test. The results below obtained by STATA 17 show that the LM probability is greater than 0.05. We therefore accept that the residuals are not autocorrelated (Table 8). The heteroscedasticity test is important in the sense that it reassures us if the residuals constitute white noise. According to our results obtained with STATA 17, the errors are homoscedastic because 0.5478 is greater than 0.05, (Figure 1).

4.4.3. Stability of the model

From the graph below showing the inverse of the roots of the characteristic polynomial of our model, we can say that all the roots of our polynomial lie inside the unit circle, so our model is quite stable.

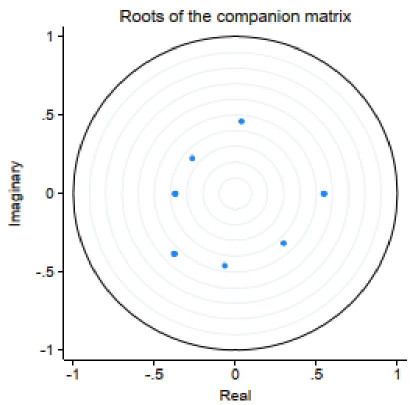

Figure 2. *Inverse of the roots of the characteristic polynomial*
Source: author, based on STATA 17

4.5 *Discussions*

The findings of Shahbaz *et al*. (2017), who used the Autoregressive Distributed Lag Model (ARDL) to examine the case of China between 1982 and 2012, show that FDI has a negative impact on renewable energy consumption. One possible explanation is that FDI encourages firms to invest and innovate, resulting in lower energy consumption.

Domestic credit provided by the financial sector (CIF), as a measure of financial development, has a favorable and considerable impact on renewable energy use. A 1% increase in domestic credit given by the banking sector leads to a 1.12% rise in renewable energy usage, which is statistically significant at the 5% level. Cameroon's relatively well-functioning banking system allows for medium-cost financing, which may enable some banks deliver more rapid liquidity while also improving capital accumulation and innovation in the development of renewable energy. Furthermore, the number of banks per adult (BCA) has a significant and positive effect on renewable energy consumption, implying that the availability of commercial banks stimulates adults to take out bank loans, resulting in the use of renewable energy. The findings indicate that the growth of the banking industry has a beneficial impact on renewable energy use. Our findings are consistent with those published by Wu and Broadstock (2015) for a sample of 22 developing market countries between 1990 and 2010. They employ the GMM system estimator, and their research notes certain commonalities between emerging market economies.

On the other side, changes in the bond market have a negative and statistically significant impact on renewable energy consumption. More specifically, a 1% rise in the outstanding quantity of private international debt securities (ETDPI) relative to GDP reduces renewable energy use by 2.49%, with a significant correlation at the 1% level. Cameroon's weak bond and stock markets do not encourage businesses to invest wisely and manage the risks of renewable energy initiatives. As a result, businesses are unable to raise the capital required for cost-effective technical innovation and the usage of sustainable energy. As a result, difficulties with asymmetric information persist, resulting in a lack of openness between lenders and borrowers. As a result, the issuance of shares and/or bonds (direct financing) has a large and negative impact on renewable energy usage in Cameroon. This confirms the findings of Topcu and Payne (2017), who discovered a negative relationship between changes in bond markets and energy usage for a panel of 32 high-income nations from 1990 to 2014.

The results show a negative link between energy prices and the consumer price index (CPI), implying that as energy prices rise, renewable energy usage will decrease, supporting the findings of Ouyang and Li, (2018). According to the Agence de Régulation de l'Électricité (ARSEL, 2022), in recent years Cameroon has seen a significant increase in energy prices in general, which climb year after year and may act as a brake on the actual consumption of renewable energies. The model also indicates a favorable correlation between economic development (ED), income (CPIB), and renewable energy consumption. This is explained by the fact that as development and income levels rise, so does renewable energy use. Following Caporale *et al*. (2009), we believe that this observation can be explained by Cameroon's underdeveloped financial and stock markets, which contribute to average renewable energy use. As a result, the direct and commercial effects are verified as essential pathways for economic growth and development to affect Cameroon's renewable energy consumption.

Definitively, our initial hypothesis was: There is a positive relationship between financial development and renewable energy consumption in Cameroon. We can therefore say from our results that it is valid for the variables of domestic credit provided by the financial sector (CFI), commercial bank ratio per adult (BCA), economic development (DE), and income (CPIB). They all have a positive effect on renewable energy consumption, whereas the variables of foreign direct investment (FDI), bond market developments (ETDPI), and energy prices (CPI) all have a negative effect on renewable energy consumption. Our study joins a vast body of knowledge seeking to explain the relationship between financial development and energy consumption. We focused on renewable energy consumption, which is understudied in the existing literature. Also, this study is among the first to quantitatively analyze the impact of financial development on renewable energy consumption in Cameroon, and finally we included a new variable which is the ratio of commercial banks per adult, representing the number of commercial banks, and measuring the accessibility of bank credit for adults.

5. Conclusion

In conclusion, this article has answered the central question about the impact of financial development on the consumption of renewable energy in Cameroon. To do this, we used VAR modeling over the period 2000 to 2022. The results of our model show that FDI has a negative effect on the consumption of renewable energy, domestic credit provided by the financial sector has a positive and significant impact on the consumption of renewable energy, also banking availability has a significant and positive effect on the consumption of renewable energy. On the other hand the evolution of the bond markets has a negative and statistically significant effect on the consumption of renewable energy. The results indicate a negative relationship between energy prices represented by the consumer price, and finally the model suggests a positive relationship between economic development, income and renewable energy consumption.

This article makes a significant contribution in methodological, theoretical and empirical terms. First, it enriches the understanding of the impacts of financial development on renewable energy consumption by highlighting new determinants of financial development, namely banking availability. Second, this paper is among the first to quantitatively analyze the impact of financial development on renewable energy consumption in Cameroon using autoregressive modeling, which is rarely used in the literature to model the impacts of financial development on renewable energy consumption. Understanding how financial development affects renewable energy consumption gives Cameroon the advantage of developing a competitive, robust society and a sustainable energy sector, while promoting a reduction in dependence on energy imports (oil, coal and natural gas, etc.). It is therefore important for the government to improve the business climate, the stock market and the energy pricing policy in Cameroon, to further raise the standard of living of the population and to promote inclusive and sustainable development.

These results may also have implications for emerging economies such as Bosnia and Herzegovina, in that financial development can effectively promote the country's inclusive economic growth. The country should further expand its financial development coverage, strengthen the construction of financial infrastructure, increase the number of customers of financial institutions and improve the actual use of financial products and services. In addition, the country should improve the inclusive financial services system, strengthen comprehensive planning, promote the rational allocation of financial resources, enable financial institutions to play a role and effectively guarantee economic development. Optimizing the energy structure and vigorously developing renewable energies are essential for this country, in particular by strengthening the reform of energy supply, actively guiding the transformation of the consumption structure from fossil fuels to renewable energies and achieving sustainable energy. Finally, the country should formulate active renewable energy policies in order to provide subsidies for the development of renewable energies, combine their resources with technological endowment, expand potential energy reserves and mitigate climate pressure It would also be important to develop an appropriate approach in the search for financing opportunities for energy projects in Cameroon, namely bank credit (indirect financing) and the issue of shares and/or bonds (direct financing). Financing development plays an important role in increasing renewable energy consumption. It is therefore necessary to define a framework for deploying capital in the renewable energy sector, in order to provide competitive options and costs for customers, with the ultimate aim of developing higher value-added services. The current research has produced what is believed to be the first study on the relationship between financial development and renewable energy consumption in Cameroon, which is an important topic with a long-term vision. Our study is not without limitations. First, the inferences derived from this study are limited by the data on which the results are based. Given the availability of data, our total sample size is relatively medium. The numerical results should therefore not be over-interpreted, as they may be sensitive to any significant variation in the variables. They may be sensitive to any significant variation in the variables. Nevertheless, the general message should remain the same. Secondly, the analysis uses a limited number of variables determining renewable energy consumption, so future studies should take into account other variables likely to explain renewable energy consumption in Cameroon.

References

1. Anton and Nucu (2020). The effect of financial development on renewable energy consumption. A panel data approach. *Renewable Energy*, 147(P1), pp. 330-338.
2. ARSEL (2022) *Annual report on electricity regulation in Cameroon*. Retrieved from. https://ARSEL.cm.org [Accessed on 6 May 2024].
3. Blanchard OJ, Watson MW. (1984). *Are business cycles all alike?* In American Business Cycle, Gordon RJ (ed.). Chicago: University of Chicago Press, pp. 123-56.
4. Benkraiem, R. Lahiani, A. Miloudi, A. and Shahbaz, M. (2019). The asymmetric role of shadow economy in the energy-growth nexus in Bolivia, *Energy Policy*, 125, pp. 405-417.
5. Bernanke B. S. (1986). Alternative explanation for money-income correlation. *Carnegie-Rochester Conference Series on Public Policy*, vol. 25, pp. 49-98.
6. Best, R. (2017). Switching towards coal or renewable energy? The effects of financial capital on energy transitions. *Energy Economics*, 63, pp. 75-83.
7. Burakov, D. & Freidin, M. (2017). Financial development, economic growth and renewable energy consumption in Russia: a vector error correction approach. *International Journal of Energy Economics Policy*, 7(6), pp. 39-47.

8. Canh, P. Thanh, S. & Nasir, M. (2020). Nexus between financial development & energy intensity: Two sides of a coin? *Journal of Environmental Management*, 270, pp. 110-902.
9. Chang C (2015) Effects of financial developments and income on energy consumption, *Int. Rev. Econ. Financ*. 35 (2015), pp. 28-44.
10. Chiu, Y, Lee, C. (2020). Effects of financial development on energy consumption: The role of country risks, *Energy Economics*, 90, pp. 104-833.
11. Çoban S, & Topcu M, (2013), The nexus between financial development and energy consumption in the EU: a dynamic panel data analysis, *Energy Econ*. 39 (2013), pp. 81-88.
12. Caporale. G, Rault. C, Sova. R, &. Sova. A, (2009), *Financial Development and Economic Growth: Evidence from Ten New EU Members*, vol. 940, German Institute for Economic Research.
13. Destek M, (2018), Financial development and energy consumption nexus in emerging economies, *Energy Sources Part B 13* (2018), pp. 76-81.
14. Dickey, D.A. & Fuller, W.A. (1981) Likelihood Ratio Statistics for Autoregressive Time Series with Unit Root. *Econometrica*, 49, pp. 1057-1072, DOI: 10.2307/1912517.
15. Fung, M. K., (2009). Financial development and economic growth: convergence or divergence? *Journal of International Money and Finance* 28, pp. 56–67.
16. Greene, WH (2002) *Econometric Analysis*. 5th edition, Prentice Hall, Upper Saddle River, 802.
17. Habiba & Xinbang, (2023), The contribution of different aspects of financial development to renewable energy consumption inE7 countries using the quantile moments regression method (MMQR), *Renewable Energy*, 203, pp. 703-714.
18. IFDD (2022) *Rapport d'activités 2022 de l'IFDD*. Retrieved from. https://www.ifdd. francophonie. org/publications/ rapport-dactivites-2022-de lifdd/[Accessed on 6 May 2024].
19. Islam F, Shahbaz M, Ahmed A, & Alam M, (2013), Financial development and energy consumption nexus in Malaysia: a multivariate time series analysis, *Econ. Modell*. 30 (2013), pp. 435-441.
20. Jalil, A. & Feridun, M. (2011). The impact of growth, energy and financial development on the environment in China: a cointegration analysis, *Energy Economics*, 33, pp. 284-291.
21. Ji & Zhang (2019). How much does financial development contribute to renewable energy growth and upgrading of energy structure in China? *Energy Policy*, 128(C), pp. 114-124.
22. Kahouli, B. (2017). The short and long run causality relationship among economic growth, energy consumption and financial development: Evidence from South Mediterranean countries (SMCs), *Energy Economics*, 68, pp. 19-30.
23. Kutan, S, Paramati, M. Ummalla, A and Zakari (2017), Financing renewable energy projects in major emerging market economies: evidence in the perspective of sustainable economic development, *Emerg. Mark. Finance Trade* 54 (2017), pp. 1761-1777.
24. Levine, R., (1997). Financial Development and economic growth: views and agenda. *Journal of Economic Literature*, 35 (2), pp. 688–726.
25. Liu, H., Kim, H., Liang, S., & Kwon, O. (2018). Export diversification and ecological footprint: A comparative study on EKC theory among Korea, Japan and China. *Sustainability*, 10, pp. 1-12.
26. Mahalick, M. K., 6 Mallick, H. (2014). Energy consumption, economic growth and financial development: Exploring the empirical linkages in India, *Journal of Developing Areas*, 48, pp. 139-159.
27. MINEE (2016) *Report on the energy situation in Cameroon 2016*. Retrieved from.: https://minee.cm [Accessed on 3 May 2024].
28. Mielnik, O, & Goldemberg, J. (2002). Foreign direct investment and decoupling between energy and gross domestic product in developing countries. *Energy Policy*, 30(2), pp. 87-89.
29. Ouyang, Y., & Li P (2018), On the nexus of financial development, economic growth, and energy consumption in China: new perspective from a GMM panel VAR approach, *Energy Econ*. 71 (2018), pp. 238-252.
30. Paramati S, Sinha E, & Dogan (2017). The significance of renewable energy use for economic output and environmental protection: evidence from the Next 11

developing economies, *Environ. Sci. Pollut. Res.* 15 (2017), pp. 13546-13560.

31. Paramati S, Ummalla, N & Apergis T (2016), The effect of foreign direct investment and stock market growth on clean energy use across a panel of emerging market economies, *Energy Econ*. 56 (2016), pp. 29-41.
32. Rafindadi A, & Ozturk, A. (2016), The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey, *Energy Econ*. 36 (2013), pp. 262-267.
33. Rashid, A., & Yousaf, N. (2015). Linkage of financial development with electricity growth, nexus of India and Pakistan, *Euro Economica*, 34, pp. 151-160.
34. REN 21, (2017). *Renewables 2017 global status report*. Paris. Retrieved from. http://www.ren21.net/wpcontent/uploads/2017/06/178399_GSR_2017_Full_Report_0621_Opt. pdf. [Accessed on 3 May 2024].
35. Regean, M. & Bulime, E., (2024). Double win: how can African finance promote economic growth and the renewable energy transition? *Renewable Energy Volume* 224, April 2024, pp. 120-165.
36. Shahbaz, M., & Lean, (2012). Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia, *Energy Policy*, 40, pp. 473-479.
37. Shahbaz, M, Van Hoang, T, Mahalik M., & Roubaud D, (2017), Energy consumption, financial development and economic growth in India: new evidence from a nonlinear and asymmetric analysis, *Energy Econ*. 63 (2017), pp. 199-212.
38. Shahbaz M, Khan S, & Tahir M, (2013). The dynamic links between energy consumption, economic growth, financial development and trade in China: fresh evidence from multivariate framework analysis. *Energy Econ.* 40, pp. 8-21.
39. Shahbaz, M., Ahmad, N., & Wahid, N. (2010), Savings-investment correlation and capital outflow: The case of Pakistan, *Transition Studies Review*, 17, pp. 80-97.
40. Sadorsky, (2011). Financial development and energy consumption in Central and Eastern European frontier economies, *Energy Policy* 39 (2011), pp. 999-1006.
41. Sadorsky, P (2010), The impact of financial development on energy consumption in emerging economies, *Energy Policy*, 38 (2010), pp. 2528-2535.
42. Tamazian, A. Chousa, J. & Vadlamannati, C. (2009). Does higher economic and financial development lead to environmental degradation? Evidence from BRIC countries, *Energy Policy*, 37, pp. 246-253.
43. Tang C, Tan B, & Ozturk I, (2016). Energy consumption and economic growth in Vietnam. Renew. *Sust. Energ. Rev*. 54, pp. 1506-1514.
44. Topcu, M., & Payne, J., (2017), The financial development energy consumption nexus revisited, *Energy Sources Part B 12,* pp. 822-830.
45. Wei L., Yedan, S., & Razzaq, A. (2023). How investments in renewable energy, environmental regulations and financial development drive an energy transition: evidence from G7 countries. *Renewable Energy*, 26, pp. 1188-1197.
46. Wu. L; & Broadstock. D, (2015), Does economic, financial and institutional development matter for renewable energy consumption? Evidence from emerging economies. *Int. J. Econ. Policy Emerg. Econ*. 8 (2015), pp. 20-39.
47. Wurgler J, (2000) Financial markets and the allocation of capital. *J. Financ. Econ*. 58 (1), pp. 187-214.
48. World Bank, (2017a and b). *Global financial development database*. Retrieved from. https://data. worldbank. org/data-catalog/global-financial-development. [Accessed on 3 May 2024].
49. Xinbang (2023) Investigating the impact of financial development on carbon emissions: Does the use of renewable energy and green technology really contribute to achieving low-carbon economies? *Gondwana Research*, 121, pp. 472-485.
50. Xu, S. (2012). The impact of financial development on energy consumption in China: based on SYS-GMM estimation. In Advanced Materials Research, 524, pp. 2977-2981.
51. Xu, Z., (2000). Financial development, investment, and economic growth. *Economic Inquiry,* 38, pp. 331–344.

APPENDICES:

Table 2. *Descriptive statistics*

Variable	Obs	Mean	Std. dev.	Min	Max
REN	23	73.97696	23.55312	0	86.31
FDI	23	-4.97e+08	3.24e+08	-9.09e+08	-2.32e+07
CIF	23	8.79971	4.815336	0	14.68208
ETDPI	23	7.948045	4.832158	1.554565	18.74088
CPI	23	102.2416	15.65507	77.61427	132.068
BCA	23	1.212174	.854182	0	2.2
ED	23	7.19e+10	1.89e+10	4.43e+10	1.04e+11
CPIB	23	1.093179	1.317109	-2.422434	4.150729

Source: author, based on STATA 17

Table 3. *Results of the stationarity test*

Variables	ADF		PP		Order of integration
	Level	Primary difference	Level	Primary difference	
REN	-0.604	-4.067**	-1.644	-8.021**	I (1)
FDI	-1.473	-4.777**	-0.852	-5.325**	I (1)
CIF	-1.062	-5.750**	-0.772	-5.053**	I (1)
ETDPI	-1.398	-5.552**	-1.871	-10.147**	I (1)
CPI	-0.042	-3.987**	-1.731	-9.322**	I (1)
BCA	-1.651	-5.212**	-1.827	-9.872**	I (1)
ED	-0.781	-3.088**	-0.697	-5.048**	I (1)
CPIB	-1.689	-4.785**	-1.926	-10.786**	I (1)

** : significance at seuil de 5%

Source: author, based on STATA 17

Table 4. *Determination of the optimum delay*

Lag	LL	LR	Df	P	FPE	AIC	HQIC	SBIC
0	-1109.38	NA	NA	NA	1.7e+41	117.619	117.686	118.017
1	-909.549	399.66*	64	0.000	2.0e+35	-103.321*	-103.927*	-106.9*
2	1211.5	4242.1	64	0.000	6.3e-56	-113.21	-112.066	-106.45
3	3493.49	4564	64	0.000	NA	-351.736	-350.458	-344.181
4	3593.96	200.93	64	0.000	NA	-362.311	-361.033	-354.756

*Indithat the optimum delay

Source: author, based on STATA 17

Table 5. *Results of the cointegration test*

Johansen test for cointegration		
Rank	Trend : Constant	Number of obs : 22
	Sample : 2001 thru 2022	Number of lags : 1
	Trace statistic	Critical value 5%
0	32.2375	29.68
1	11.9671*	15.41
2	1.3955	3.76

*selected rank

Source: author, based on STATA 17

Table 6. *VAR model regression results (1)*

Variables	Coef	T-Stat
REN (1)		
FDI	-1.99**	0.021
L1.	(8.63)	
CIF	1.119**	0.046
L1.	(0.561)	
ETDPI	-2.489***	0.000
L1.	(0.670)	
CPI	-5.493***	0.000
L1.	(1.181)	
BCA	14.243*	0.065
L1.	(7.725)	
ED	3.02***	0.000
L1.	(7.90)	
CPIB	2.974**	0.055
L1.	(1.551)	
Cons	385.402	0.000
	(81.923)	
Sample: 2001 thru 2022	Number of obs = 22	
Log likelihood = -1068.406	AIC = 103.6733	
FPE = 2.20e+35	HQIC = 104.5144	
Det (Sigma_ml) = 2.10e+32	SBIC = 107.244	
P>chi2 = 0.0000		

*Note: ***, ** and * represent significance at 1%, 5% and 10% respectively Figures in brackets are standard deviations.*

Source: Author, based on STATA 17

Table 7. *Results of normality test for residuals*

Equation	Chi2	Df	Prob > chi2
REN	1.922	2	0.78258
FDI	1.309	2	0.51959
CFI	1.296	2	0.88318
ETDPI	0.046	2	0.97717
CPI	0.441	2	0.80224
BCA	1.278	2	0.52783
ED	0.017	2	0.99139
CPIB	0.300	2	0.86065
ALL	22.609	16	0.12459

Source: author, based on STATA 17

Table 8. *Autocorrelation test results for residuals*

Lag	Chi2	df	Prob>chi2
1	34.0907	25	0.10598
2	60.4348	25	0.28799

Source: author, based on STATA 17

```
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of REN

H0: Constant variance

    chi2(1) =  20.17
Prob > chi2 = 0.5478
```

Figure 1. *Breusch-Pagan test result*

Source: author, based on STATA 17