Energy Economics Letters
ISSN(e): 2308-2925
DOI: 10.18488/journal.82.2021.81.42.48
Vol. 8, No. 1, 42-48.

URL: www.aessweb.com

THE IMPACT OF FINANCIAL DEVELOPMENT ON RENEWABLE AND NON-RENEWABLE ENERGY CONSUMPTION

Burcak Polat
Siirt University, Business and Economics Faculty, Department of Economics, Siirt, Turkey.
Email: burcakpolat@hotmail.com

(+ Corresponding author)

Article History
Received: 10 November 2020
Revised: 14 December 2020
Accepted: 4 January 2021
Published: 28 January 2021

Keywords
Financial market development
Renewable energy
Non-renewable energy
Energy consumption
Dynamic panel data
Financial markets.

JEL Classification:
G1; C33; C36; Q43.

ABSTRACT

To date, a sufficient number of studies have dealt with the effect of financial development on energy consumption. Yet, most of these studies have neglected diversification between renewable and non-renewable energy consumption. In fact, financial development may affect renewable energy consumption differently than non-renewable energy consumption. This is because renewable energy production necessitates high-cost investments. Therefore, the main objective of this study is to estimate the impact of financial development on renewable and non-renewable energy consumption in 37 OECD countries by employing the one-step system generalized method of moments (GMM) for the period 2002–2015. The findings statistically proved that financial development is positively linked with renewable energy consumption, but it is not related to non-renewable energy consumption. This paper also confirmed the existence of a negative correlation between the openness index and renewable energy consumption with non-renewable energy consumption. Intuitively, it was expected that renewable energy production engages in high-cost investments compared to non-renewable energy production. Thus, renewable energy consumption is more responsive to a solid and well-structured financial market than non-renewable energy consumption.

Contribution/ Originality: This study is one of very few studies which have investigated the effect of financial development on both renewable and non-renewable energy consumption by employing one step system GMM. The paper's primary contribution is finding that financial development is linked with renewable energy consumption positively.

1. INTRODUCTION

Energy is the primary source for economic growth and a higher standard and quality of living in developed and developing countries. It is also necessary for sustainable development in developing countries. Some factors affecting the need for energy include economic development, increased population rates, industrialization, and technological progress. According to the World Bank report, energy usage rose by 44% between 1971 and 2014, and fossil fuel resources accounted for a 78.4% increase in total energy consumption during this period. As the US (EIA, 2019) declared, world energy consumption is expected to rise by 50% from 2018 to 2050. However, higher energy consumption is likely to deteriorate the energy supply and may cause a risk for importing countries' energy security. The disruption of the supply–demand balance is likely to produce severe economic problems, leading energy-dependent economies to adopt conservation policies to prevent energy consumption usage.

The link between financial development and energy consumption has received great attention from scholars in recent years. However, the impact of financial development on energy consumption is complicated, and there is ongoing debate in the literature about this topic. As Sadorsky (2010); Sadorsky. (2011) noted, financial development may increase energy needs in three different ways: First, financial development provides monetary support to consumers so that they can easily borrow funds from financial markets to buy durable products such as refrigerators, automobiles, and so on. Thus, the usage of these durable goods accelerates the need for energy. Second, a well-structured financial system enables firms to easily access the funds needed for capital and current assets so that they can increase their investments for a higher production level. This second effect is known as the business effect of financial development on energy consumption. Third, a rise in stock market activities may cause a wealth effect, which in turn leads both firms and consumers to feel confident about the market and therefore increase their economic activities. In contrast, financial development may also affect energy consumption negatively. Foreign investors may be more willing to invest in a country with a well-structured financial market. In other words, financial development may attract new foreign direct investments so that firms can easily find funds to invest in advanced and new technologies that reduce energy demand.

The main objective of this study is to determine the effect of financial development on renewable and non-renewable energy consumption in 37 Organization for Economic Cooperation and Development (OECD) countries[1] by using the one-step system generalized method of moments (GMM) technique. Since renewable energy consumption began increasing after 2002 in developed and developing countries and there are no data points after 2015, the study covers the time span of 2002–2015. This paper contributes to the energy literature in the following ways: First, previous studies mostly analyzed the effect of financial development on total energy consumption. However, the effect of financial development on renewable and non-renewable energy may differ from each other. Since investments in renewable energy involve higher costs compared to investments in non-renewable energy, renewable energy may be more dependent on a solid financial system compared to non-renewable energy. Second, some variables may be endogenous in nature; by employing system GMM, the endogeneity among these variables can be captured. Additionally, the dynamic panel data model enables us to determine if there is a substitution or a complementary correlation between renewable and non-renewable energy consumption. Third, by using an appropriate model, the empirical findings of the study can be pursued and interpreted.

The rest of the paper is organized as follows: The second section discusses previous research findings. Following this, the third section presents the data and methodology. The fourth section interprets the empirical findings, and finally, the last section summarizes and concludes the study with policy implications.

2. LITERATURE REVIEW

On the one hand, financial development allows firms and consumers to access funds for new investments easily; therefore, financial development may positively affect energy consumption. On the other hand, financial development may also cause energy-saving technology inflows from abroad through foreign direct investments, which in turn, reduce energy usage. Thus, financial market development may also affect energy consumption negatively. An analysis of the literature shows mixed evidence regarding the effect of financial development on energy consumption. Some researchers support a positive link, while others support a negative link. Still, others support no link between these two variables. Some authors argue that financial development leads to higher energy consumption. Sadorsky (2010) measured the relationship between financial development and energy consumption by employing the GMM method for 22 emerging countries. The results revealed that financial development

[1]OECD Country List: Australia, Austria, Belgium, Canada, Chile, Colombia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, the Netherlands, New Zealand, Poland, Norway, Portugal, Slovak Rep., Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

measured by stock market variables leads to higher energy consumption in this country group. Another study by Sadorsky. (2011) investigated the impact of financial development on energy consumption for nine countries in Central and Eastern European economies. It concluded that financial development increases energy demand. Coban and Topçu (2013) investigated the relationship between financial development and energy consumption in the EU between 1990 and 2011. They argued that financial development accelerates energy consumption in old members of the EU. Komal and Abbas (2015) analyzed the relationship between finance-growth and energy variables by employing the GMM method for Pakistan between 1972 and 2012. They concluded that financial development affects energy consumption positively. Mahalik, Babu, Loganathan, and Shahbaz (2017) explored the relationship between financial development and energy consumption for Saudi Arabia between 1971 and 2011. They found that financial development led to higher energy demand, and they also confirmed the existence of a U-shaped relationship between financial development and energy consumption. Furthermore, Gaies, Kaabia, Ayadi, Guesmi, and Abid (2019) analyzed the link between financial development and energy consumption for MENA countries for the 1996–2014 period. They employed both linear and non-linear dynamic panel models. Finally, they concluded that there is a positive link between the banking system and energy consumption. They also found a U-shaped relationship between financial development and energy usage: energy usage first increases with financial development, and then at a turning point, it starts to decline. Moreover, Sare (2019) study examined the threshold effect of financial development on energy consumption in Africa for the period 1973–2017. The findings showed that financial development increases energy consumption. However, below the threshold, the effect declines, and above the threshold, it increases. Mukhtarov, Humbatov, Seyfullayev, and Kalbiyev (2020) analyzed the relationship between economic growth, financial development, and energy consumption. They found that financial development causes energy demand to increase.

On the contrary, some other researchers support a negative relationship or no relationship between financial development and energy consumption. Furuoka (2015) studied the relationship between financial development and energy consumption in Asia for the period 1980–2012. The author found unidirectional causality running from energy consumption to financial development, but they could not find any evidence supporting the effect of financial development on energy consumption. Topçu and Payne (2017) investigated the effect of financial development on energy consumption in 32 high-income countries for the period between 1990 and 2014 by employing principal component analysis. They could not find a statistical relationship between these two variables. Yet, they found that an increase in the stock market index may even cause a decline in energy consumption. Destek (2018) examined the relationship between financial development, energy price, real income, and energy consumption in 17 emerging economies by employing the common correlated effect estimator. The author concluded that bond market development is the most efficient variable to reduce energy consumption. Eren, Taspinar, and Gokmenoglu (2019) examined the impact of financial development and economic growth on energy consumption in India over the period 1971–2015. They confirmed that renewable energy responds positively to financial development. Chiu and Lee (2020) research explored the country risk effect on the relationship between financial development and energy consumption for 79 countries by employing the smooth transition regression model. They concluded that under a stable country risk environment, financial development decreases overall energy consumption.

3. DATA AND METHODOLOGY

3.1. Data

There are two dependent variables: renewable and non-renewable energy consumption. Renewable energy consumption as a percentage of gross domestic product (GDP) has been used as an indicator of renewable energy consumption and fossil fuel energy consumption as a percentage of GDP as an indicator of non-renewable energy consumption. The main explanatory variable is financial development. Domestic credit to the private sector as a percentage of GDP has been used as an indicator of financial development in OECD countries. Furthermore,

control variables that may be related to the dependent variable have been incorporated. These control variables are the openness index (which is calculated by dividing the summation of export and imports to the GDP) and GDP as an indicator of market size and inflation rates. All variables were obtained from World Bank Data (www.worldbank.org) and measured in US dollars.

3.2. Methodology

Panel data combines both time series and cross-sections and provides important advantages. First, panel data allows us to analyze individual groups, such as countries, sectors, or firms. Second, panel data involves more information compared to time series. Third, panel data reduces the degree of multicollinearity among variables. Fourth, panel data models eliminate estimation bias due to the aggregation of groups in a time series. The problem with panel data is that country-specific factors may be correlated with explanatory variables. Traditional panel data models eliminate the country-specific factor by using Fixed Effect (FE) or Random Effect (RE) techniques. However, in the case of dynamic panel data models, the multicollinearity problem cannot be overcome by using FE or RE since the dynamic panel data model incorporates lagged levels of the dependent variable, which remain correlated. A dynamic panel data model can be written as follows:

$$y_{i,y} = \beta_0 + y_{i,t-1} + \sum_{i=2}^{N=5} X_{i,t} + a_i + u_{i,t},$$

$y_{i,t}$ represents both renewable and non-renewable energy consumption as our dependent variables; $y_{i,t-1}$ represents the lagged value of renewable and non-renewable energy consumption; and $\sum_{i=2}^{N=5} X_{i,t}$ exhibits the explanatory variables, our main explanatory variable, financial development, alongside other control variables. Finally, a_i exhibits the individual country fixed effects, and $u_{i,t}$ denotes the error term.

RE or FE eliminates a_i by first differencing yet, $y_{i,t-1}$ will remain correlated with the error term. Thus, Arellano and Bond (1991) suggested using lagged dependent variables as instruments, which is known in the literature as Difference GMM. Yet, if lagged dependent variables are weak instruments, Arellano. and Bover (1995) and Blundell and Bond (1998) recommended using system GMM, which can be performed by adding additional moment conditions. System GMM has advantages over Difference GMM. First, system GMM is a more suitable model when variables are random walk. Second, system GMM performs more consistent estimates when variables are persistent over time. Third, unbalanced panel data produce more consistent estimates under system GMM compared to Difference GMM. The only problem with system GMM is that it can produce more instruments compared to Difference GMM, but this problem can be solved by using (Rootman, 2009) reduction technique. Both system GMM and Difference GMM must be tested in terms of the number of instruments and second-order correlation in the error term. Over-identification problems among instruments can be detected by the Hansen Test (Hansen, 1982). Second-order correlation in the error term can be detected by checking the Arrelano Bond AR (2) test. High statistical values of Hansen Test and Arrelano Bond AR (2) test reveal that System GMM estimation results perform well.

4. EMPIRICAL RESULTS

To measure the effect of financial development on renewable and non-renewable energy consumption in 37 OECD countries, two one-step system GMM specifications have been estimated and labeled as Table 1 and Table 2, respectively. Diagnostic test results have been provided at the bottom of the tables. Clearly, both Hansen Test and

Arellano Bond AR (2) test results provide confidence about the consistency of the system GMM estimates. Additionally, Wald Ch^2 Test results also reveal that system GMM performs well.

Table-1. GMM Results for Renewable Energy Consumption

Variables	Coefficients
Renewable Energy $_{t-1}$	0.9943 (0.000)**
Non-renewable Energy	-0.0580 (0.157)
Financial Development	0.0052 (0.039)*
GDP	-0.0004 (0.361)
Openness	0.0022 (0.157)
Inflation	-0.0289 (0.585)
Arellano Bond Test AR(2)	0.532
Hansen Test	0.284
Wald Ch^2 (5)	69480.47 (0.000)**

As clearly seen in Table 1, financial development has a significant positive effect on renewable energy consumption. In other words, financial development represented by domestic credit to the private sector contributes to renewable energy consumption. This finding is not surprising, since renewable energy production necessitates costly investments compared to non-renewable energy production. Shifting from non-renewable to renewable energy production is challenging because renewable energy production is very costly. There are many financial obstacles that make renewable energy production costly. For example, higher infrastructure, start-up, and operating costs lead to renewable energy production depending on a solid financial system. Therefore, a deep and well-structured financial system enables OECD countries to make investments in renewable energy. Conversely, we could not find any significant effect of other variables (namely GDP, openness, and inflation) on renewable energy consumption.

Table-2. GMM results for non-renewable energy consumption.

Variables	Coefficients
Non-renewable Energy $_{t-1}$	0.9077 (0.000)**
Renewable Energy	-0.1497 (0.023)*
Financial Development	-0.0006 (0.888)
GDP	-0.0013 (0.224)
Openness	-0.0114 (0.017)**
Inflation	-0.0331 (0.764)
Arellano Bond Test AR(2)	0.119
Hansen Test	0.477
Wald Ch^2 (5)	97542.12 (0.000)**

According to the effect of financial development on non-renewable energy consumption, one can easily read from Table 2 that financial development does not have a significant effect on non-renewable energy consumption. However, there is strong evidence supporting the negative effect of renewable energy consumption and the openness index on non-renewable energy consumption. These empirical findings can be interpreted as follows: The

existence of a negative correlation between renewable energy consumption and non-renewable energy consumption implies that the two energy consumption types are substitutes for each other. Since renewable energy is costly and may be an alternative to non-renewable energy, one may normally assume that these two energy types could replace each other. However, the negative effect of the openness index on non-renewable energy consumption implies that as countries become more involved in international trade, they are more likely to reduce their non-renewable energy consumption. This result is very rational. Since firms engaged in international trade have higher potential foreign markets to serve, they must increase their production. As production capacity increases, firms need more energy to use in the production process. Yet, it is obvious that energy is a scarce resource in the world. Thus, firms must shift from non-renewable to renewable energy consumption to meet their higher energy needs as their production capacity increases due to their level of involvement with the rest of the world. Conversely, no significant effect of other control variables (namely GDP and inflation) on non-renewable energy consumption was found.

5. CONCLUDING REMARKS

To date, a sufficient number of studies have dealt with the effect of financial development on energy consumption. However, most of these studies have neglected diversification between renewable and non-renewable energy consumption. In fact, financial development may affect renewable energy consumption differently than non-renewable energy consumption. This is because the cost of investments for renewable energy production is higher compared to non-renewable energy production. Thus, it is expected that renewable energy consumption may be more responsive to developments in the financial system than non-renewable energy consumption. Therefore, the main objective of this study was to estimate the impact of financial development on renewable and non-renewable energy consumption in 37 OECD countries by employing a one-step system GMM for the period 2002–2015.

This paper contributes to the energy literature in the following ways: First, energy consumption type was divided into two groups: renewable and non-renewable energy consumption. By doing so, more consistent and accurate GMM estimates regarding the effect of financial development on energy consumption were produced. Second, a one-step system GMM was employed to overcome the endogeneity problems between explanatory and dependent variables. Third, by employing the current model, a substitution or complementary effect, if any, could be detected between renewable and non-renewable energy consumption. At the end of the study, it was statistically proved that financial development is linked with renewable energy consumption positively, while it is not related to non-renewable energy consumption. Intuitively, it was expected that renewable energy production engages in high-cost investments compared to non-renewable energy production. Thus, renewable energy consumption is more responsive to a solid and well-structured financial market than non-renewable energy consumption. Moreover, the findings also show that the openness index and renewable energy consumption are negatively correlated with non-renewable energy consumption. This means that as countries' degree of openness to the rest of the world increases, the production amount that uses higher energy levels also increases, making firms use alternative energy types (i.e., renewable energy). Furthermore, the results show that renewable and non-renewable energy consumption are substitutes for each other. Yet, there was no evidence supporting the correlation between other control variables and renewable and non-renewable energy consumption. Based on these empirical findings, the following policy implications are proposed: First, these OECD countries should take important steps to improve the financial system within the country since a better, well-organized financial market enables firms and governments to invest in high-cost renewable energy production. Second, renewable energy production can occur if these countries are more involved in the international market. Thus, the government should implement new policies that incentivize a higher level of exports and imports in the country.

Funding: This study received no specific financial support.
Competing Interests: The author declares that there are no conflicts of interests regarding the publication of this paper.

REFERENCES

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, *58*(2), 277–297.

Arellano., M., & Bover, O. (1995). Another look at the instrumental variable estimation error components model. *Journal of Econometrics*, *68*(1), 29–51.Available at: https://doi.org/10.1016/0304-4076(94)01642-d.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, *87*(1), 115–143.

Chiu, Y.-B., & Lee, C.-C. (2020). Effects of financial development on energy consumption: The role of country risks. *Energy Economics*, *90*(C), 104833.

Coban, S., & Topçu, M. (2013). The nexus between financial development and energy consumption in the EU: A dynamic panel data analysis. *Energy Economics*, *39*, 81–88.Available at: https://doi.org/10.1016/j.eneco.2013.04.001.

Destek, M. A. (2018). Financial development and energy consumption nexus in emerging economies. *Energy Sources, Part B: Economics, Planning and Policy*, *13*(1), 76–81.

EIA. (2019). Retrieved from: https://www.eia.gov/outlooks/ieo/pdf/ieo2019.pdf. [Accessed 01-01-2021].

Eren, B. M., Taspinar, N., & Gokmenoglu, K. K. (2019). The impact of financial development and economic growth on renewable energy consumption: Empirical analysis of India. *Science of the Total Environment*, *663*, 189–197.Available at: https://doi.org/10.1016/j.scitotenv.2019.01.323.

Furuoka, F. (2015). Financial development and energy consumption: evidence from a heterogeneous panel of Asian countries. *Renewable and Sustainable Energy Reviews*, *52*, 430–444.Available at: https://doi.org/10.1016/j.rser.2015.07.120.

Gaies, B., Kaabia, O., Ayadi, R., Guesmi, K., & Abid, I. (2019). Financial development and energy consumption: Is the MENA region different? *Energy Policy*, *135*, 111000.

Hansen, L. P. (1982). Large sample properties of generalized method of moment estimators. *Econometrica*, *50*(4), 1029–1054.

Komal, R., & Abbas, F. (2015). Linking financial development, economic growth and energy consumption in Pakistan. *Renewable and Sustainable Energy Reviews*, *44*, 211–220.Available at: https://doi.org/10.1016/j.rser.2014.12.015.

Mahalik, M. K., Babu, M. S., Loganathan, N., & Shahbaz, M. (2017). Does financial development intensify energy consumption in Saudi Arabia? *Renewable and Sustainable Energy Reviews*, *75*, 1022–1034.Available at: https://doi.org/10.1016/j.rser.2016.11.081.

Mukhtarov, S., Humbatov, S., Seyfullayev, I., & Kalbiyev, Y. (2020). The effect of financial development on energy consumption in the case of Kazakhstan", . *Journal of Applied Economics*, *23*(1), 75–88.

Rootman, D. (2009). How to do xtabond 2: An introduction to difference and system GMM in Stata. *The Stata Journal*, *9*(1), 86–136.

Sadorsky, S. (2010). The impact of financial development on energy consumption in emerging economies. *Energy Policy*, *38*(5), 2528–2535.Available at: https://doi.org/10.1016/j.enpol.2009.12.048.

Sadorsky., S. (2011). Financial development and energy consumption in central and Eastern European frontier economies. *Energy Policy*, *39*(2), 999–1006.Available at: https://doi.org/10.1016/j.enpol.2010.11.034.

Sare, Y. A. (2019). Effect of financial sector development on energy consumption in Africa: Is it threshold specific? *International Journal of Green Energy*, *16*(15), 1637–1645.

Topçu, M., & Payne, J. E. (2017). The financial development-energy consumption nexus revisited. *Energy Sources, Part B: Economics, Planning and Policy*, *12*(9), 822–830.