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Research article

# The role of financial systems in energy demand: A comparison of developed and developing countries

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## HIGHLIGHTS

- Developing countries rely on domestic credits to provide their energy demand.
- Developed countries rely on money supply to provide their energy demand.
- The financial system in both groups is a long-term driver for creating energy demand.
- FDI has a significant impact on creating energy demand in developing countries.

## ARTICLE INFO

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## ABSTRACT

This study investigates the role of the financial system in energy demand in the cases of developed and developing countries. Time-series analyses are carried out using the annual data period from 2000 to 2015. Results indicate that the financial system and financial markets are long-term catalysts for energy consumption in both groups under consideration. Results show that domestic credits by banks positively impact energy demand in developing countries, while this is money supply impacting positively on energy demand in the case of developed nations. The results of this study reveal important policy implications.

## 1. Introduction

An investigation between energy issues, environmental pollution, and economic growth has found considerable attention from researchers in the relevant literature. Moreover, the relationship of energy with the particular segments or sectors of the economy deserves attention, and the financial system is one of them. Since the financial system provides funds and financing to the markets, the role of the financial system in creating energy demand will likely be significant.

The role of the financial system has been extensively tested under (1) the supply leading and (2) the demand following hypotheses since Patrick (1966). It is widely found that the financial system is an engine of growth in some countries while it is demand-driven in others.

Therefore, the link between the financial system and the energy sector received interest from scholars in the last decade. However, the great majority of previous studies focused on the link between the financial sector and environmental pollution (Köksal et al., 2020). The linkage between energy demand and the financial system found very rare attention from scholars. Sadorsky (2010) is one of the first studies investigating the relationship between financial development and energy demand in developing countries. Their results conclude that the increases in financial development lead to a rise in the demand for energy in developing countries. Alam et al. (2015) prove the energy-led financial development hypothesis in SAARC countries throughout 1975–2011.

Moreover, they find that financial development indicators have a bigger influence on increasing energy demand. Farhani and Solarin (2017) find opposing results in the U.S. that financial development decreases energy demand. According to them, the reason is the investment in energy efficiency technologies rises as the financial development deepens in the U.S. Saud et al. (2018) found that financial development leads to an increase in energy demand for the case of China. A more recent study by Köksal et al. (2021) find that financial development

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indicators have a weak relationship with renewable energy demand in OECD countries.

In the literature, some studies are trying to investigate the nexus between energy prices and financial development. For example, Katircioglu et al. (2018) find that there are significant links between oil prices and financial sectors' performances as well. Shaeri and Katircioglu (2018) find that stock prices of oil, technology, and transportation firms are significantly linked to oil prices. Katircioglu et al. (2020) also find that oil prices exert a statistically significant impact on bank profitability.

Development in the financial system contributes to the income of economies and leads to an increase in the level of energy, especially in energy importing countries (Katircioglu and Köksal, 2020). Financial system development might likely be statistically related to energy consumption. Therefore, against this backdrop in the relevant literature, this article searches the role of the financial system in energy demand from developed and developed countries as ranked by the United Nations (2020). To the best of our knowledge, this study is the first of its kind in the relevant literature and is likely to provide important policy messages.

The following section describes data and methodology, section 3 presents results and discussions, and section 4 concludes the study.

## 2. Data & methodology

### 2.1. Data and modelling

This study uses an annual dataset ranging from 2000 to 2015 as obtained from World Bank (2020). The ranking of developed and developing nations is sourced from the United Nations (2020), and aggregate time series data for both categories are constructed from World Bank (2020).

The nexus between energy demand and the financial system can be analyzed using the analytical framework set up by Sadorsky (2010, 2011) and Jalil and Feridun (2011). On the other hand, Katircioglu et al. (2014a; 2014b) estimated energy demand models for the cases of tourism and higher education. Referring to these studies, this study proposes the following functional relationship to estimate the effects of the financial system on energy demand:

$$E_{i,t} = f\,(FS_{i,t}, GDP_{i,t}, FDI_{i,t}, Trade_{i,t}, Climate_{i,t}) \quad (1)$$

where E stands for energy usage for "i" country at "t" period. FS is a proxy for the financial system, GDP stands for gross domestic product, FDI is foreign direct investment, Trade is the volume of trade (exports of goods and services plus imports of goods and services), and climate is a proxy for environmental pollution as it is closely related with energy consumption.

Equation (1) can be written in double logarithmic, linear function to capture growth effects of regressors concerning the dependent variable:

$$lnE_{i,t} = \beta_0 + \beta_1(lnFS_{i,t}) + \beta_2(lnGDP_{i,t}) + \beta_3(lnFDI_{i,t}) + \beta_4(lnTrade_{i,t}) + \beta_5(lnClimate_{i,t}) + \varepsilon_{i,t} \quad (2)$$

where ln stands for the natural logarithm of series and ε is the error disturbance. In addition to the proxy of the financial system, the other regressors in Eqs. (1) and (2) are added as control variables where they are believed to impact the energy demand and financial system nexus.

Data used in this study is obtained from World Development Indicators (2020), as mentioned earlier. They are (1) dependent variable:

**Table 1.** Descriptive statistics.

*Panel (a). Developed Countries*

| | E | DC | M2 | GDP | FDI | TRADE | CO2 |
|---|---|---|---|---|---|---|---|
| Mean | 4345.735 | 72.44195 | 89.37577 | 26854.42 | 1.670025 | 45.83605 | 10.95028 |
| Median | 4525.349 | 79.43457 | 98.44307 | 26552.30 | 0.991593 | 42.61985 | 11.33756 |
| Maximum | 5071.911 | 94.73622 | 121.4960 | 41098.32 | 5.890372 | 63.03313 | 12.21238 |
| Minimum | 2764.767 | 36.29022 | 55.58657 | 11624.58 | 0.315813 | 30.63435 | 7.413876 |
| Std. Dev. | 610.6762 | 18.28205 | 20.54764 | 9051.304 | 1.463195 | 9.362646 | 1.253944 |
| Skewness | -1.109112 | -0.482850 | -0.186748 | -0.000695 | 1.131089 | 0.496448 | -1.583486 |
| Kurtosis | 3.468360 | 1.762389 | 1.638711 | 1.734785 | 3.359748 | 2.239736 | 4.530148 |
| Jarque-Bera | 11.99304 | 5.544577 | 4.400340 | 3.735133 | 10.05649 | 2.997366 | 28.86583 |
| Probability | 0.002487 | 0.062519 | 0.110784 | 0.154499 | 0.006550 | 0.223424 | 0.000001 |
| Sum | 243361.1 | 3911.866 | 4736.916 | 1503848. | 76.82115 | 2108.458 | 613.2158 |
| Sum Sq. Dev. | 20510899 | 17714.36 | 21954.70 | 45168940 | 96.34225 | 3944.661 | 86.48070 |

*Panel B. (Developing Countries)*

| | E | DC | M2 | GDP | FDI | TRADE | CO2 |
|---|---|---|---|---|---|---|---|
| Mean | 818.1415 | 38.66856 | 50.25117 | 2100.345 | 1.624902 | 35.20576 | 2.347762 |
| Median | 874.7561 | 37.48167 | 42.09615 | 1955.216 | 1.323303 | 31.12229 | 2.316283 |
| Maximum | 1331.169 | 91.87208 | 122.2464 | 4265.047 | 3.751137 | 60.01260 | 3.495109 |
| Minimum | 449.2045 | 11.91991 | 20.07194 | 982.5251 | 0.425307 | 16.89805 | 1.409007 |
| Std. Dev. | 270.4777 | 19.37277 | 26.70960 | 860.8417 | 1.082330 | 14.44706 | 0.548392 |
| Skewness | 0.312949 | 0.637389 | 0.880928 | 0.972086 | 0.299774 | 0.280874 | 0.354967 |
| Kurtosis | 1.905520 | 2.817008 | 2.842708 | 3.196230 | 1.537765 | 1.642322 | 2.750714 |
| Jarque-Bera | 2.914331 | 3.731725 | 7.039978 | 8.909396 | 4.787048 | 5.037316 | 1.321018 |
| Probability | 0.232895 | 0.154763 | 0.029600 | 0.011624 | 0.091307 | 0.080568 | 0.516588 |
| Sum | 35998.22 | 2088.102 | 2713.563 | 117619.3 | 74.74547 | 1971.523 | 131.4747 |
| Sum Sq. Dev. | 3145802. | 19891.13 | 37810.34 | 40757666 | 52.71468 | 11479.47 | 16.54033 |

**Table 2.** Correlation coefficients.

*Panel (a). Developed Countries*

| | lnCO2 | lnDC | lnE | lnFDI | lnGDP | lnM2 | lnTRADE |
|---|---|---|---|---|---|---|---|
| lnCO2 | 1 | | | | | | |
| lnDC | 0.252 | 1 | | | | | |
| lnE | 0.570 | 0.814 | 1 | | | | |
| lnFDI | 0.289 | 0.734 | 0.863 | 1 | | | |
| lnGDP | 0.207 | 0.849 | 0.895 | 0.917 | 1 | | |
| lnM2 | 0.101 | 0.922 | 0.829 | 0.848 | 0.959 | 1 | |
| lnTRADE | 0.078 | 0.654 | 0.755 | 0.872 | 0.926 | 0.842 | 1 |

*Panel (b). Developing Countries*

| | lnCO2 | lnDC | lnE | lnFDI | lnGDP | lnM2 | lnTRADE |
|---|---|---|---|---|---|---|---|
| lnCO2 | 1 | | | | | | |
| lnDC | 0.584 | 1 | | | | | |
| lnE | 0.579 | 0.947 | 1 | | | | |
| lnFDI | 0.267 | 0.839 | 0.862 | 1 | | | |
| lnGDP | 0.786 | 0.905 | 0.920 | 0.783 | 1 | | |
| lnM2 | 0.623 | 0.974 | 0.947 | 0.859 | 0.949 | 1 | |
| lnTRADE | 0.450 | 0.911 | 0.940 | 0.908 | 0.869 | 0.932 | 1 |

energy use (kg of oil equivalent per capita) and (2) regressors: domestic credit provided to the private sector by banks (as a percent of GDP) and broad M2 money (as a percent of GDP) as proxies for the financial system, gross domestic product per capita at constant (2010 = 100) USD prices, foreign direct investment net inflows (FDI as a percent of GDP), trade volume (as a percent of GDP), and carbon dioxide emissions ($CO_2$, metric tons per capita) as a proxy for climate change. Descriptive statistics of series at their levels are presented in Table 1.

### 2.2. Methodology

Before econometric estimations, this study adapts unit root tests using the Phillips-Perron approach (Phillips and Perron, 1988) to investigate the nature of integration levels of series under consideration. Expecting that series might be mixed of orders, then after, model estimations are done by using the autoregressive distributed lag (ARDL) approach (Pesaran et al., 2001). Bounds tests for level relationships, long-run and short-run coefficients in Eq. (2), error correction terms, and diagnostic tests for econometric deviations, including autocorrelation.

## 3. Results & discussions

Table 2 presents correlation coefficients among the logarithmic series in Eq. (2) for both developed and developing nations. It is evident that energy use is correlated with regressors in Eq. (2) at high levels, and this is an indication that there will be strong evidence of a long-run relationship among them.

As a next step, the results of unit root tests are presented in Table 3. In the case of developed countries, it seems that all series are integrated of order one, I (1), since all PP statistics (including trend and intercept) are statistically significant. However, in the case of developing countries, money supply (M2) seems to be stationary at levels without differencing; therefore, money supply volume in developing countries is integrated of order zero, I (0). The rest of the series are integrated of order one, I (1).

Phillips and Perron (1988) unit root tests exhibit mixed orders of integration in series. Therefore, the ARDL mechanism would be ideal for estimating Eq. (2) of this study. Tables 4 and 5 present the results of bounds tests for level relationships, long-run, and short-run model estimations, error correction terms, and diagnostic test statistics. All the

**Table 3.** Phillips-Perron (1988) unit root tests.

| Variable | Region | Level Statistics | First Difference | Conclusion |
|---|---|---|---|---|
| lnE | Developed | -2.060 | -7.379* | I (1) |
| | Developing | -2.752 | -6.624* | I (1) |
| lnDC | Developed | -1.115 | -4.620* | I (1) |
| | Developing | -2.775 | -9.094* | I (1) |
| lnM2 | Developed | -1.689 | -5.461* | I (1) |
| | Developing | -3.616** | -16.015* | I (0) |
| lnGDP | Developed | -1.803 | -5.490* | I (1) |
| | Developing | -1.000 | -3.442** | I (1) |
| lnFDI | Developed | -2.691 | -5.099* | I (1) |
| | Developing | -1.904 | -8.233* | I (1) |
| lnTrade | Developed | -2.563 | -7.077* | I (1) |
| | Developing | -2.114 | -7.277* | I (1) |
| $lnCO_2$ | Developed | -2.071 | -5.583* | I (1) |
| | Developing | -1.520 | -5.277* | I (1) |

Note: * and ** Show statistical significance at the 0.01 and 0.05 levels.

**Table 4.** Model estimation for developed countries.

| Models | Variables | Coefficient | Std. Error | T-test | P-value |
|---|---|---|---|---|---|
| Long term model | lnDC | -0.0427 | 0.0304 | -1.4028 | 0.1746 |
| | lnM2 | 0.1610** | 0.0627 | 2.5647 | 0.0177 |
| | lnGDP | 0.5028* | 0.0913 | 5.5022 | 0.0000 |
| | lnFDI | -0.0265* | 0.0056 | -4.6879 | 0.0001 |
| | lnTRADE | 0.0810** | 0.0300 | 2.6945 | 0.0132 |
| | lnCO2 | 0.8407* | 0.0891 | 9.4279 | 0.0000 |
| Short term model | Δln DC | -0.1874* | 0.0361 | -5.1866 | 0.0000 |
| | Δln M2 | 0.2777* | 0.0488 | 5.6817 | 0.0000 |
| | Δln M2(-1) | 0.0153 | 0.0323 | 0.4759 | 0.6388 |
| | Δln GDP | 0.6571* | 0.1183 | 5.5528 | 0.0000 |
| | Δln FDI | -0.0037 | 0.0030 | -1.2353 | 0.2297 |
| | Δln CO2 | 0.7329* | 0.0670 | 10.9292 | 0.0000 |
| | Δln CO2(-1) | -0.1265* | 0.0368 | -3.4323 | 0.0024 |
| | ecm(-1) | -0.7509* | 0.0445 | -16.8549 | 0.0000 |

Note: (1) All the estimations are done with Case 5 option from Pesaran et al. (2001), which includes both unrestricted trends and unrestricted intercepts. (2) *,** and *** indicate the level of significance of 1%, 5%, and 10%, respectively. (3) $\overline{R}^2 = 0.9648$, $DW = 1.9324$.

| F-Bounds Test | | Null Hypothesis: No levels relationship | | |
|---|---|---|---|---|
| Test Statistic | Value | Signif. | I(0) | I(1) |
| | | Finite Sample: n = 40 | | |
| F-statistic | 31.88748 | 10% | 2.831 | 4.04 |
| k | 6 | 5% | 3.327 | 4.7 |
| | | 1% | 4.527 | 6.263 |

**Table 5.** Model estimation for developing countries.

| Models | Variables | Coefficient | Std. Error | T-test | P-value |
|---|---|---|---|---|---|
| Long term model | lnDC | 0.4577*** | 0.2406 | 1.9017 | 0.0668 |
| | lnM2 | -0.2069 | 0.4558 | -0.4539 | 0.6531 |
| | lnGDP | -2.2219*** | 1.1129 | -1.9964 | 0.0550 |
| | lnFDI | 0.3650** | 0.1754 | 2.0803 | 0.0461 |
| | lnTRADE | 0.3568 | 0.3017 | 1.1826 | 0.2463 |
| | lnCO2 | 2.3886** | 1.0809 | 2.2098 | 0.0349 |
| Short term model | Δln M2 | -0.633992* | 0.062844 | -10.08834 | 0.0000 |
| | Δln FDI | -0.036306 | 0.023400 | -1.551529 | 0.1313 |
| | Δln FDI(-1) | -0.117043* | 0.027812 | -4.208383 | 0.0002 |
| | Δln CO2 | 0.129118 | 0.138431 | 0.932726 | 0.3584 |
| | ecm(-1) | -0.332595* | 0.049637 | -6.700579 | 0.0000 |

Note: (1) All the estimations are done with Case 5 option from Pesaran et al. (2001), which includes both unrestricted trends and unrestricted intercepts. (2) *,** and *** indicate the level of significance of 1%, 5%, and 10%, respectively. (3) $\overline{R}^2 = 0.7605$, $DW = 2.5517$.

| F-Bounds Test | | Null Hypothesis: No levels relationship | | |
|---|---|---|---|---|
| Test Statistic | Value | Signif. | I(0) | I(1) |
| | | Finite Sample: n = 45 | | |
| F-statistic | 5.344971 | 10% | 2.796 | 3.97 |
| k | | 5% | 3.267 | 4.584 |
| | | 1% | 4.364 | 6.006 |

estimations are done with Case 5 option from Pesaran et al. (2001), which includes both unrestricted trends and unrestricted intercepts.

Firstly, as far as developed countries are concerned in Table 4, there is strong evidence of cointegration in Eq. (2) since bounds F-statistic are significant. Therefore, the null hypothesis of no level relationship is rejected at the 0.01 level. It enables us to estimate long-run and short-run coefficients for Eq. (2). Estimations of long-run coefficients are presented in the level equation section of Table 4. Results show that although domestic credits by banks do not exert statistically significant effects on energy use, money supply (M2) exerts a positively significant effect on energy use ($\beta = 0.161$, $p < 0.05$). This finding reveals that an expansion of the money supply in the circulations of developed countries would lead to significant increases in energy demand. Table 4 shows that the other regressors except FDI exert positively significant effects on the energy demand of developed countries. Table 4 shows that energy demand in developed countries does not come with FDI since the coefficient of FDI is negatively significant. The error correction model (ECM) regression shows that estimations of short-run coefficients are very similar to those of long-run coefficients except in the case of FDI. The short-run coefficient of FDI is not statistically significant. The speed of adjustment is reasonably high and negatively significant ($\beta = -0.750$, $p < 0.01$). Durbin-Watson statistic shows that there isn't any autocorrelation problem in model estimations for developed countries in Table 4.

Secondly, Table 5 presents the same estimations this time for developing countries, which shows that there is evidence of cointegration in Eq. (2) since bounds F-statistic is again significant. Therefore, the null hypothesis of no level relationship is rejected at the 0.01 level. This again enables us to estimate long-run and short-run coefficients for Eq. (2). Estimated long-run coefficients show that this time it is domestic credit by banks that exerts positively significant effects on energy use ($\beta = 0.457$, $p < 0.10$), while money supply (M2) does not. This finding reveals that an expansion of domestic credits by banks in the circulations of developing countries would lead to significant increases in energy demand. The long-run coefficient of FDI is also positively significant ($\beta = 0.365$, $p < 0.05$). It shows the importance of private sector financing and foreign direct investments for the energy sector in developing nations. The coefficient of trade volume is not statistically significant in Table 5. The speed of adjustment is at a moderate level but negatively significant ($\beta = -0.332$, $p < 0.01$). Durbin-Watson statistic shows that there isn't any autocorrelation problem in model estimations for developing countries as well in Table 5.

## 4. Conclusion

This study is unique in two dimensions. First, previous studies extensively used money supply (M2) and domestic credits data, however in this study, IMF financial development data have been used, which brings novelty to this research. Secondly, this study, for the first time, uses aggregate data analyzing the financial development and energy demand for developed and developing countries in comparison.

This study investigates the role of the financial system in generating additional energy demand for developed and developing nations. Time series analysis exhibits that the financial system in both groups is a long-term driver for creating energy demand. In the case of developed countries, it is money supply in circulation rather than domestic credits provided by banks leading to positively significant changes in energy demand. In contrast, in the case of developing countries, it is domestic credits. It can be concluded that the savings are not enough in developing countries, and domestic credit supply leads to an increase in creating additional energy demand, be it in the private and public sectors. Thus, domestic credits are of great importance for developing countries, especially for energy importing countries. Developed countries, on the other hand, rely on money supply to provide their energy demand. They are predominantly energy-importing countries, and Table 4 shows that trade volume is statistically significant in the model, which proves the need for imports to fulfill their energy needs.

The results of the study prove that in developed areas increasing or printing money in the markets will positively impact the energy demand of the sectors. But, in the case of developing countries, domestic financing, and foreign direct investments, have significant driving forces for the energy demand of the sectors. This study does not find any

significant effect of FDI on energy demand in developed countries. Future studies can be done for all individual countries grouped as developed and developing areas for comparison purposes with the results of this study.

## Declarations

### *Author contribution statement*

Setareh KATIRCIOGLU: Conceived and designed the experiments; Wrote the paper.

Cihat KÖKSAL: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Salih KATIRCIOGLU: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

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### *Data availability statement*

Data will be made available on request.

### *Declaration of interests statement*

The authors declare no conflict of interest.

### *Additional information*

No additional information is available for this paper.

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