



Impact of Financial Development on Energy Consumption in Middle Income Countries

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Abstract: The study investigated the impact of financial development on energy consumption in middle income countries using panel data (2001-2016) within the dynamic generalized methods of moments (GMM) econometric estimation technique. Unlike previous similar research work that suffers from omitted variable bias, this study introduced a third variable, known as trade openness. Apart from model 5, all the other four models produced results which show that financial development had a significant positive effect on energy consumption in middle income countries. These results are to a very large extent supported by literature. The study therefore urges middle income countries to implement policies that ensures that financial development plays a critical role in developing clean and efficient energy usage machinery and equipment. Except for model 5, the study also noted that the complementarity between financial development and trade openness had a significant positive impact on energy consumption in models 1, 2, 3 and 4. In other words, trade openness was found to be a channel through financial development increased its positive influence on energy consumption in middle income countries. The study therefore urges middle income countries to import machinery and equipment that are energy consumption saving and efficient in order to complement financial sector's effort to contribute towards development of clean energy and energy efficient technology. Further research must investigate other channels that shapes financial development's influence on energy consumption not only in middle income countries but in other economic groupings as well.

Keywords: financial development; energy usage; middle income countries; panel data

JEL Classification: O10

1. Introduction

1.1. Background of the Study

According to Sadorsky (2010), energy is an integral part of all economic activities in the country because it is an input in the manufacturing, distribution and usage of goods and services and services. On the other hand, enhancing economic growth needs higher amount of energy to drive the manufacturing of goods and services. It is for this reason that a thorough comprehension of the factors that determines energy consumption is a contentious but a hot topic for policymakers and researchers. Such a research on the determinants of energy consumption has been done extensively using different economic groupings or countries.

One of the determinants of energy consumption is financial development, consistent with earlier research work done by Samuel et al (2013), among others. Financial development influence energy consumption through (1) advancing loans to consumers to purchase durable goods which consumes a lot of energy such as machinery, cars, refrigerators and houses and (2) availing funding which is directed at developing technologically superior and energy saving machinery and equipment (Sadorsky. 2010). Empirical research on the subject matter produced results which are quite conflicting, an indication that

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research on the influence of financial development on energy consumption is mixed, conflicting, inconclusive and far from being a settled matter. It is against this background that this study intends to further contribute to the body of knowledge through empirically testing the impact of financial development on energy consumption in middle income countries, taking into consideration the main gaps identified in the literature.

1.2. Contribution of the Study

The study was done on the backdrop of mixed findings on the influence of financial development on energy consumption with some empirical researchers noting a positive impact, others observing a negative influence whilst others produced a non-linear U-shaped mimicking result. In order to further seek clarity on the subject matter, an empirical investigation focusing on middle income countries had to be undertaken. The study was also done to tell a story which is currently non-existent on the impact of financial development on energy consumption in middle income countries. None of the empirical research work available to the best of the author's knowledge investigated this topic exclusively focusing on middle income countries. Although there is an acknowledgement that the influence of financial development on energy consumption is determined by the availability of other factors (Yessengali and Murat, 2018), none of the empirical research work the author is aware of explored the complementarity effect or the channels through which financial development enhances or lowers energy consumption.

Unlike prior similar research, this study used the most recent data set. Contrary to majority of similar empirical studies on the subject matter, this study used the dynamic GMM approach, an econometric estimation methodology which addresses the endogeneity problem and decisively deal with the persistent nature of the energy consumption data (its dynamic nature).

1.3. Structure of the Paper

The rest of the paper is structured into six main sections. Section 2 discusses the impact of financial development on energy consumption from both a theoretical and empirical angle, Section 3 discusses the influence of trade openness on energy consumption whilst Section 4 describes how control variables affect energy consumption from a theoretical point of view. Research methodological framework is described and explained in Section 5. Section 6 focus on data analysis, results discussion and interpretation. Section 7 summarizes the paper.

2. Impact of Financial Development on Energy Consumption

There are five theoretical rationales which explains the influence of financial development on energy consumption. Firstly, the houses and properties purchased using financial sector's secured loans requires a lot of energy usage to heat or cool them depending on the prevailing weather conditions, according to Sadorsky (2010). Secondly, financial sector which is developed enables consumers to easily borrow money to buy not only houses but also automobiles which pushes up the quantity of energy consumption by virtue of them being powered by petroleum linked products. The argument is consistent with Dumrul (2018).

Thirdly, the financial sector provides affordable loans to enterprises or firms that does research and produce energy saving innovative products, according to Sadorsky (2010) and Dumrul (2018). Such kind of innovation saves energy that the whole economy could have wasted within a given time period, in line with Xu (2020). Fourthly, low cost equity or debt finance is availed by a developed financial system in order to enable building and setting up of new manufacturing plants in the economy. These new plants use more energy, consistent with Yessengali and Murat (2018) and Sadorsky (2010).

Empirical research on the influence of financial development on energy consumption was extensively done (see Table 1).

Table 1. Impact of Financial Development on Energy Consumption - Empirical Literature

Author	Country/Countries of study	Period	Methodology	Results
Sadorsky (2010)	22 emerging countries	1990-2006	Panel data analysis	Financial development had a significant positive effect on energy consumption. These results were obtained when stock market capitalization (% of GDP), stock market value trade (% of GDP) and stock market turnover were used as measures of financial development.
Dumrul (2018)	Turkey	1961-2015	Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS)	Both financial development and economic growth had a separate positive but significant effect on energy consumption in Turkey
Xu (2020)	China	Panel data (1999-2009) on 29 provinces	System GMM estimation approach	Financial development as measured by loans in financial institution (% of GDP) was found to have had a statistically significant positive influence on energy consumption
Yessengali and Murat (2018)	Transitional economies	1990-2011	System GMM	The impact of financial development on energy consumption was non-linear and characterised by a U-shape.
Salman and Atya (2014)	North African countries (Egypt, Algeria, Tunisia)	1980-2010	Error Correction Model (ECM)	In Tunisia and Algeria, financial development was found to have had a positive impact on energy consumption. In Egypt, financial development had a deleterious influence on energy consumption.
Mahalik and Mallick (2014)	India	1971-2009	Autoregressive Distributive Lag (ARDL)	Financial development had a significant negative impact on energy consumption in both the short and long run.
Khan et al (2020)	184 countries world-wide	1990-2017	System GMM	Financial development led to a reduction in energy consumption and consequently carbon emissions.
Abosedra et al (2015)	Lebanon	2000-2010	ARDL, ECM	Financial development boosted both energy consumption levels and economic growth in Lebanon
Kassi (2020)	123 countries world-wide	1990-2017	GMM approaches	Renewable energy consumption levels were enhanced by the ability of the financial sector to invest in clean energy related infrastructure.
Ibrahim et al (2016)	Nigeria	1971-2014	ARDL approach	In both the short and long run, financial development was found to have had a significant positive influence on energy demand and consumption in Nigeria.
Nkalu et al (2020)	Sub-Saharan Africa	1975-2017	Panel Vector Error Correction Model	A uni-directional causality relationship running from financial development towards energy consumption without feedback was detected only in the long run in Sub-Saharan Africa.
Sekantsi and Timuno (2017)	Botswana	1981-2011	ARDL, ECM	In both short and long run, financial development had a significant positive impact on electricity consumption in Botswana.
Eren et al (2019)	India	1971-2015	Dynamic Ordinary Least Squares	Financial development drove energy consumption levels in the long run in India.
Kahia et al (2016)	Middle East and North African (MENA) region	1980-2012	Panel data analysis	Financial development is a source of increasing the levels of renewable energy consumption.

	countries			
Pramahesti et al (2020)	ASEAN+3 countries	1990-2013	GMM approach	Financial development had a positive influence on energy consumption. However, banking sector development had a more significant positive influence on energy consumption in comparison to the share market.
Shi and Deng (2020)	Chinese provinces	1998-2017	Panel threshold regression model	The influence of financial development on energy consumption changed from negative to positive with the scale and level of economic development.
Ghorashi and Rad (2018)	Iran	1989-2016	Panel data analysis	Financial development had a significant deleterious effect on energy consumption and carbon emissions across Iran's economic sectors.
Mukhtarov et al (2018)	Azerbaijan	1992-2015	ARDL, VECM	A significant positive relationship running from financial development (measured by private credit as a ratio of GDP) towards energy consumption was detected.
Aye and Edoja (2017)	Developing countries	1971-2013	Dynamic panel threshold regression model	Financial development increased the level of energy consumption in developing countries at higher levels of economic growth.

Source: Author Compilation

3. Influence of Trade Openness on Energy Consumption

Consistent with Xu (2020), the movement of goods or products/inputs/raw materials from one country to another for either consumption or manufacturing purposes is enhanced by high level of trade openness the countries have. According to Shahbaz et al (2014), the movement of such products or inputs/raw materials for manufacturing purposes consumes quite a lot of energy. Trade openness was also argued to have an upward energy consumption effect because it increases the size of domestic manufacturing levels as more resources, inputs and or raw materials becomes available from other countries (Shahbaz et al. 2014, p. 126). The argument was also corroborated by Matheus (2018).

4. Other Factors that Influence Energy Consumption

Table 2 discusses the explanatory variables' influence on energy consumption from a theoretical angle.

Table 2. Theory Intuition and a Priori Expectation

Variable	Proxy used	Theory intuition	Expected sign
Economic growth (GROWTH)	GDP per capita	Growth of the real sector of the economy pushes up the overall level of energy consumption especially in a more energy consumption dependent nation (Nindi and Odhiambo. 2014). The argument is consistent with other empirical work done by Ouedraogo (2013) and Sharma and Bruce (2013). In contrast, a study done by Huang et al (2008) produced results which shows that energy consumption was negatively affected by economic growth.	+/-
Foreign direct	Net FDI inflows (%)	According to Tang (2009), FDI inflows pushes up	+



investment (FDI)	of GDP)	the level of industrialization, transport and manufacturing related activities which all consumes a lot of energy. Empirical research work conducted by Doytch and Narayan (2016) and Abdouli and Hammami (2017) supported the argument.	
Population growth (POP)	Population growth (annual %)	Liddle (2004) observed that road energy consumption was negatively influenced by the size of the household in Organisation for Economic Cooperation and Development (OECD) group of countries, in contradiction to majority of available empirical work on the subject matter. However, Liu et al (2015) argued that governments must invest in more infrastructure such as education, road, transport, health, rail and air in response to an increasing size of the population. This is done to satisfy the needs of the enlarged size of the population. The development and usage of more infrastructure requires the use of more energy.	+/-
Infrastructure development (INFR)	Fixed telephone subscription (per 100 people)	Reddy et al (2001) noted that infrastructure development and maintenance are the greatest users of energy in the economy. Empirical studies done by Sadorsky (2010) and Yessengali and Murat (2018) also resonated with such an observation.	+

Source: Author compilation

Energy consumption is measured by energy use (kg of oil equivalent per capita), financial development is proxied by domestic credit by financial sector (% of GDP) whilst trade openness is measured by total trade (% of GDP) in this study.

5. Research Methodological Framework

The energy consumption function (equation 1) is consistent with prior similar research done by Sadorsky (2010), Dumrul (2018), Xu (2020) and Yessengali and Murat (2018), among others. In other words, the choice of explanatory variables in this energy consumption function was to a larger extent influenced by these empirical studies.

$$\text{ENERGY} = f(\text{FIN}, \text{OPEN}, \text{GROWTH}, \text{FDI}, \text{POP}, \text{INFR}) \tag{1}$$

Where ENERGY stands for energy consumption, FIN is financial development, OPEN is trade openness, GROWTH represents economic growth, FDI is foreign direct investment, POP stands for population growth whilst infrastructural development is represented by INFR in equation 1. The econometrically expressed equation of the energy consumption model is shown next.

$$\text{ENERGY}_{it} = \beta_0 + \beta_1 \text{ENERGY}_{it-1} + \beta_2 \text{FIN}_{it} + \beta_3 \text{OPEN}_{it} + \beta_4 (\text{FIN}_{it} \cdot \text{OPEN}_{it}) + \beta_5 X_{it} + \mu + \varepsilon \tag{2}$$

β_0 stands for intercept, β_1 is a co-efficient of the lag of energy consumption variable whereas β_2 represents the financial development variable's co-efficient. β_3 is trade openness's co-efficient, X_{it} is the vector of control variables and β_4 is the co-efficient of the complementarity variable (between financial development and trade openness). β_5 is the co-efficient of a matrix of control variables. μ represents the time invariant and unobserved country specific effect whereas ε is the error function. Time is represented the subscript t whilst i is a subscript which stands for country. If β_4 is positive and significant, the results show that the complementarity between financial development and trade openness increases energy consumption in middle income countries. On the other hand, energy

consumption levels are reduced by the interaction between financial development and trade openness if the same coefficient is negative. An econometric estimation approach which addresses endogeneity and the persistent nature of the energy consumption data (consistent with Sadorsky, 2010) was used. It's the dynamic GMM approach.

6. Data Analysis, Results Discussion and Interpretation

The paper used panel data (2001-2016) to investigate the impact of financial development on energy consumption in middle income countries. The data was extracted from World Bank Indicators, United Nations Development Programme, International Financial Statistics, South Africa Statistics Agency and African Development Bank. The following sections focuses on correlation results, panel unit root tests, panel-co-integration tests and main data analysis.

6.1. Pre-Estimation Diagnostics

Table 3. Correlation Results

	ENERGY	FIN	OPEN	GROWTH	FDI	POP	INFR
ENERGY	1.00						
FIN	0.2167***	1.00					
OPEN	0.0025***	0.6172*	1.00				
GROWTH	0.3768***	0.3281**	-0.2178*	1.00			
FDI	0.6529***	0.2381*	-0.6716*	0.0267***	1.00		
POP	0.1668***	0.3428**	-0.6137*	-0.2348**	0.0028**	1.00	
INFR	0.4318***	-0.0367*	0.1783**	0.1372*	0.1347**	-0.2167*	1.00

Note: ***/**/* denotes statistical significance at the 1%/5%/10% level respectively.

Source: Author compilation from E-Views

Table 3 shows that all the explanatory variables of energy consumption used in the study (financial development, trade openness, economic growth, foreign direct investment, population growth, infrastructural development) were positively and significantly correlated with the dependent variable (energy consumption). The correlation results are supported by literature discussed in Section 2, 3 and 4 (Table 2). Multicollinearity is absent between the variables studies as all the correlation values are less than 70%, consistent with Aye and Edoja (2017).

6.2. Panel Unit Root Tests

Four panel unit root methods were used to investigate the stationarity of the data, consistent with Tembo (2018). These are Levin et al (2002), Im et al (2003), Augmented Dick Fuller Fisher Chi Square and Phillip Peron (PP) Chi square tests (see results in Table 4).

Table 4. Panel Root Tests – Individual Intercept

	Level				First difference			
	LLC	IPS	ADF	PP	LLC	IPS	ADF	PP
LENERGY	-1.21**	0.45	37.54***	77.92**	-5.83***	-2.43**	-4.92***	55.23***
LFIN	-2.56***	-1.58*	38.19*	28.18	-9.11***	-7.18***	109.37***	112.09***
LOPEN	-0.76	2.11	2.87	6.14	-6.18**	-12.98***	112.18***	271.02***
LGROWTH	-4.88***	-1.27**	40.11*	20.18	-2.95***	-3.92***	80.18***	85.18***
LFDI	-3.54**	-2.76**	42.11*	70.18**	-11.83***	-10.17***	123.94***	303.17***
LPOP	-1.45*	-3.16**	49.18**	79.14**	-7.13***	-8.18***	111.83***	200.18***
LINFR	-7.93***	-4.83***	73.18**	80.18**	-9.18***	-5.18***	72.18**	87.18**

Note: LLC, IPS, ADF and PP stands for Levin, Lin and Chu; Im, Pesaran and Shin; ADF Fisher Chi Square and PP Fisher Chi Square tests respectively. *, ** and *** denote 1%, 5% and 10% levels of significance, respectively.

Source: Author’s compilation - E-Views figures

Unlike at level, all the data was found to be stationary at first difference (integrated of order 1). The results mean that all the data was stable at first difference, hence clearing way for panel co-integration tests using Kao (1999) approach.

6.3. Panel co-integration tests

Other empirical studies which used Kao (1999) to estimate long run relationship between and or among variables arranged in a panel data set up include Tembo (2018) and Tsurai (2020).

Table 5. Results of Kao (1999) Co-Integration Tests

Series	ADF t-statistic
ENERGY DCF FIN OPEN GROWTH FDI POP INFR	-2.0023***
ENERGY DPC FIN OPEN GROWTH FDI POP INFR	-1.3271***
ENERGY SMC FIN OPEN GROWTH FDI POP INFR	-4.2210***
ENERGY VT FIN OPEN GROWTH FDI POP INFR	-3.9394***
ENERGY ST FIN OPEN GROWTH FDI POP INFR	-2.6626***

Source: Author compilation

Where DCF, DPC, SMC, ST and VT respectively represent domestic credit by the financial sector, domestic private credit, stock market capitalization, value traded and stock market turnover. Consistent with Kahia et al (2016), the variables across all the five models had a long run relationship. Such results allowed the study to proceed with causality analysis using the dynamic GMM econometric estimation methodology.

6.4. Results Presentation and Interpretation

Table 6. Dynamic Generalised Methods of Moments (GMM) Results

	Model 1	Model 2	Model 3	Model 4	Model 5
ENERGY _{it-1}	0.0237***	0.2184***	0.2381***	0.4128***	0.6128***
FIN	0.0036**	0.1274**	0.2188**	0.0019**	-0.1893***
OPEN	0.0032***	0.2188***	0.1004	0.2219	0.2710**
INTERACTION TERM	0.2178***	0.3100***	0.0177***	0.2176***	-0.0019***
GROWTH	0.0932*	0.2178**	-0.0431***	0.1893	-0.1272***
FDI	0.2188**	0.3189*	0.0011***	0.2724***	0.0176
POP	-0.1834	-0.3189	0.1823**	0.0013***	0.1724***
INFR	0.0087*	0.1666	0.0217	0.3219*	0.1892***
Adjusted R-squared	0.72	0.68	0.69	0.66	0.71
J-statistic	396	396	396	396	396
Prob(J-statistic)	0.00	0.00	0.00	0.00	0.00

***, ** and * Denote 1%, 5% and 10% Levels of Significance, Respectively.

Source: Author's compilation from E-Views

The different measures of financial development were used in this study. Model 1 used domestic credit by financial sector (% of GDP), model 2 employed domestic private credit (% of GDP), model 3 used stock market capitalization ratio, stock turnover ratio (% of GDP) was used in model 4 whilst value traded ratio (% of GDP) was employed in model 5.

Across all the five models used, the lag of energy consumption had a significant positive effect on energy consumption as per earlier arguments by Coban and Topcu (2013) and Sadorsky (2010). Models 1 to 4 noted a significant positive relationship running from financial development towards energy consumption, in line with Dumrul (2018) whose argument is that a developed financial system allows consumers to easily borrow money to buy not only houses but also automobiles which pushes up the quantity of energy consumption by virtue of them being powered by petroleum linked products. In model 5, financial development had a significant negative influence on energy consumption, results which resonate with both Dumrul (2018) and Sadorsky (2010) whose argument is that the financial sector provides funding which can be used towards developing clean energy.

In models 1, 2 and 5, energy consumption was positively and significantly affected by trade openness whilst trade openness had a non-significant positive effect on energy consumption in models 3 and 4. These results resonate with Shahbaz et al (2014) whose argument is trade openness has an upward energy consumption effect because it increases the size of domestic manufacturing levels as more resources, inputs and or raw materials becomes available from other countries.

The complementarity between financial development and trade openness was found to have had a significant positive influence on energy consumption in models 1 to 4, in line with Yessengali and Murat (2018) whose study observed that the relationship between the two variables is not only non-linear but is shaped by the availability of other factors. It is also clear in Table 6 by looking at the size of the co-efficients of the interaction term that trade openness enhanced financial development's positive influence on energy consumption in middle income countries. In model 5, the complementarity between financial development and trade openness had a significant negative impact on energy consumption. Judging by the size of the co-efficients of financial development, trade openness and the interaction term, it is evident that trade openness reduced financial development's overall negative influence on energy consumption (investment in clean energy) in middle income countries.

Economic growth's influence on energy consumption was found to be positive and significant in model 1 and 2 whilst in model 4, the positive impact of economic growth on energy consumption was non-



significant. The results are consistent with Nindi and Odhiambo (2014), whose study noted that growth of the real sector of the economy pushes up the overall level of energy consumption especially in a more energy consumption dependent nation. In line with Huang et al (2008) whose study showed that energy consumption was negatively affected by economic growth, models 3 and 5 produced results which shows that energy consumption was negatively and significantly influenced by economic growth.

A significant positive relationship running from FDI towards energy consumption was observed in models 1 to 4 whilst model 5 produced results which shows that FDI had a non-significant positive effect on energy consumption. The results agree with Tang (2009) whose study noted that FDI inflows pushes up the level of industrialization, transport and manufacturing related activities which all consumes a lot of energy.

A non-significant negative influence of population growth on energy consumption was observed in models 1 and 2, in agreement with Liddle (2004) whose study observed that road energy consumption was negatively influenced by the size of the household in Organization for Economic Cooperation and Development (OECD) group of countries. A significant positive relationship running from population growth towards energy consumption in models 3, 4 and 5 was observed, consistent with Liu et al (2015) argument that governments must invest in more infrastructure such as education, road, transport, health, rail and air in response to an increasing size of the population.

Models 1, 4 and 5 show that infrastructural development had a significant positive influence on energy consumption whilst models 2 and 3 produced results which show a non-significant positive impact of infrastructural development on energy consumption in middle income countries. The results resonate with Reddy et al (2001) who argued that infrastructure development and maintenance are the greatest users of energy in the economy.

7. Summary of the Paper

The study investigated the impact of financial development on energy consumption in middle income countries using panel data (2001-2016) within the dynamic GMM econometric estimation technique. This was done on the backdrop of mixed findings on the influence of financial development on energy consumption with some empirical researchers noting a positive impact, others observing a negative influence whilst others produced a non-linear U-shaped mimicking result. The study was also done to tell a story which is currently non-existent on the impact of financial development on energy consumption in middle income countries. None of the empirical research work available to the best of the author's knowledge investigated this topic exclusively focusing on middle income countries. Although there is an acknowledgement that the influence of financial development on energy consumption is determined by the availability of other factors (Yessengali & Murat, 2018), none of the empirical research work the author is aware of explored the complementarity effect or the channels through which financial development enhances or lowers energy consumption. Apart from model 5, all the other four models produced results which show that financial development had a significant positive effect on energy consumption in middle income countries. These results are to a very large extent supported by literature. The study therefore urges middle income countries to implement policies that ensures that financial development plays a critical role in developing clean and efficient energy usage machinery and equipment. Except for model 5, the study also noted that the complementarity between financial development and trade openness had a significant positive impact on energy consumption in models 1, 2, 3 and 4. In other words, trade openness was found to be a channel through financial development increased its positive influence on energy consumption in middle income countries. The study therefore urges middle income countries to import machinery and equipment that are energy consumption saving and efficient in order to complement financial sector's effort to contribute towards development of clean energy and energy efficient technology. Further research must investigate other



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