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Financial Development and Energy Consumption Nexus in 32 Belt and Road Economies

Kudaybergenov Janpolat[1], Shoirahon Odilova[1], Abdusalomova Nodira[2], Raufhon Salahodjaev[3,4,5]*, Anastas Khachaturov[6]

[1]Yeoju Technical Institute in Tashkent, Uzbekistan, [2]Tashkent State University of Economics, Tashkent, Uzbekistan, [3]AKFA University, Tashkent, Uzbekistan, [4]Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent, Uzbekistan, [5]Tashkent State University of Economics, Tashkent, Uzbekistan, [6]ERGO Analytics, Uzbekistan, *Email: salahodjaev@gmail.com

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ABSTRACT

Current study sheds the light on the financial development-energy nexus in 32 Belt and Road economies during 2000-2015. Financial development is proxied by domestic credit to private sector. We first examine the order of integration by employing five different panel unit-root tests. Further, we confirm long-term relationship between the variables by running Pedroni and Kao panel cointegration tests. Fully modified ordinary least squares (FMOLS) regression reveal positive long-term relationship between financial development and energy use. Results of Dumitrescu-Hurlin panel causality test fail to reveal causal relationship between financial development and energy in our sample.

Keywords: Energy Consumption, Financial Development, Belt and Road Countries
JEL Classifications: G2, O4

1. INTRODUCTION

The global level of energy consumption has increased by more than 50% since 1990 and has reached nearly 160,000 TWh in 1990. Therefore, investigating the drivers of energy consumption across regions and countries is important for policymakers and scholars. Research shows that economic growth (Chiou-Wei et al., 2008), trade (Sadorsky, 2011a), FDI (Sun et al., 2011), globalization (Shahbaz et al., 2018) and urbanization (Liu, 2009) are among causes of energy consumption.

At the same time, global data suggests that the levels of financial development across the world has also been increasing reaching on average 86% of GDP across countries. Therefore, it is essential to investigate whether financial development is related to energy consumption for a number of reasons. First, extant research suggests that financial consumption is causal to economic growth (Calderon and Liu, 2003). Therefore, it may directly and indirectly (via economic growth) has impact on energy consumption. Second, financial development may reduce energy consumption by fostering adoption of energy efficient technologies (Islam et al., 2013).

Therefore, the goal of this study is to investigate the relationship between financial development and energy consumption. While studies attempt to relate these two variables for Tunisia (Shahbaz and Lean, 2012), Eastern Europe (Sadorsky, 2011b), Turkey (Coban and Topcu, 2013), Saudi Arabia (Mahalik et al., 2017), no study has investigated this relationship for Belt and Road countries. We attempt to fill in this gap in empirical literature.

The vast number of studies is devoted to the relationships between economic growth and energy consumption (Huang et al., 2008; Apergis and Payne, 2010; Arouri et al., 2012; Rezitis and

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Ahammad, 2015; Sadikov et al., 2020). Kraft and Kraft (1978) provide the pioneering work which documents that increase in energy use from 1947 to 1974 in United States is caused by economic growth. The energy-growth nexus is described by four hypotheses which states the unidirectional causal relationships running from economic growth to energy consumption (conservation hypothesis); the causality from energy use to GDP growth (growth hypothesis); bidirectional causal relationships between growth and energy (feedback hypothesis); and absence of any relationships between these indicators (neutrality hypothesis). However, the finance-growth strand is studied less frequently than growth-energy nexus (Sadorsky, 2010; Sadorsky, 2011b; Shahbaz et al., 2013). As it is stated by Karanfil (2009) despite the large volume of studies dedicated to the income-energy nexus the nature of this relationships does not have a strong consensus. Karanfil (2009) supposes the existence of other variables including financial indicators which could affect the energy consumption. Current literature review aims to discuss the existing empirical findings on the relationships between financial development and energy consumption.

For instance, one of the early studies provided by Sadorsky (2010) indicates the significant positive relationships between state of financial development and energy consumption using several measures of financial development. Author applies Generalized Method of Moments (GMM) for the sample of 22 developing countries within a period of 1990-2006. Further, Sadorsky (2011b) examines the finance-energy nexus using dynamic panel demand models for the sample of 9 Central and Eastern European frontier economies. The results are consistent with previous findings and document the significant interrelationship between energy consumption and financial development presented by stock market and banking variables. In conformity with results of previous works Shahbaz and Lean (2012) document the existence of long-run association between development of financial sector and consumption of energy in Tunisia from 1971 to 2008. The results reveal bidirectional causality between chosen variables. Similarly, Islam et al. (2013) use time-series data Malaysia over the period from 1971 to 2008. Authors identify the existence of long-run cointegrating relationship based on the ARDL approach and apply Vector Error Correction Model (VECM) to test the presence of causal relationships between variables. According to the results energy consumption is Granger caused by financial development and economic growth in the short- and long-run. Coban and Topcu (2013) investigates the energy-finance strand in EU countries within a period of 1990-2011. The results of system-GMM approach demonstrate the existence statistically significant relationships between chosen variables regardless of whether financial sector expressed by banking system development or state of stock market among old members of the EU. However, results of the analysis of relatively new members of the EU, depend on the method of expression of the financial development. Similarly, Shahbaz et al. (2013) document the unidirectional causality from financial development to energy use in the long-run in China within a period between 1971 and 2011. However, according to the results energy consumption Granger causes financial sector development in the short- and long-run. Therefore, the results confirm the existing of feedback association between variables in the long-run. Further,The positive interrelationship between development of financial sector and energy use is identified by Salman and Atya (2014) in Algeria and Tunisia during the period from 1980 to 2010. However, they document negative relationship between observed variables in Egypt. Authors use Error Correction Model and apply Granger causality techniques to analyze the listed North African countries. More recent study conducted by Ali et al. (2015) employs the Autoregressive Distributed Lag (ARDL) approach to test the financial development – energy use nexus in Nigeria between 1972 and 2011. The findings reveal the presence of cointegration and short-run negative impact of financial development on fossil fuel consumption, but insignificant impact in the long-run. It is noticeable that using of banking system development reveals inverted U-shaped trend while the stock market development does not demonstrate the presence of any association. Similarly, Kakar (2016) document the results of VECM and Johansen cointegration approach for Malaysia and Pakistan over the period between 1980 and 2010. According to the findings there is long-run unidirectional causal relationships running from financial development to energy consumption in both countries. On the other hand, Mahalik et al. (2017) investigates the finance-growth nexus in Saudi Arabia from 1971-2011. The results of Pesaran's ARDL cointegration approach demonstrate the existence of long-run relationships between variables. The findings prove the non-linear inverted U-shaped association between financial development and consumption of energy. Authors document the unidirectional causal relationships running from development of financial sector to energy use.

One of the latest studies on the finance-growth interrelationship is provided by Gaies et al. (2019). Authors use the sample of MENA countries between 1996 and 2014 and the banking indicators as proxies for financial development. Using the model suggested by Sadorsky (2011b) they investigate linear and non-linear dynamic model. According to the results financial development expressed by intermediation capacity of the banking system has positive and statistically significant relationships with energy consumption. Moreover, the results prove the inverted U-shaped finance-energy relationships among MENA countries. In conformity with findings provided by Gaies et al. (2019), Yue et al. (2019) report the absence of any linear relationships between financial sector development and energy consumption. However, the results prove the non-linear inverted U-shaped linkage between financial development and energy use in 18 MENA countries within the period of 1996 and 2014. On the other hand, Ma and Fu (2020) document that financial development positively affects energy use through financial institutions and financial markets in developing countries. However, they do not identify this effect in case of developed countries. Authors employ GMM approach and investigates different periods of 1991-2014, 1981-2014, 1970-2014 and 1960-2014. The whole sample includes 120 countries.

As it can be observed from the provided review of existing literature on the linkage between financial sector development and consumption of energy, the character of the association between chosen indicators varies among countries, chosen periods and empirical methodology. The next sections of the study are as

follows: description of data and methodology, reporting of the findings, conclusion and policy recommendations.

2. DATA, MODEL AND METHODOLOGY

2.1. Data

Our study explores long-term relationship between financial development and energy consumption in 32[1] Belt and Road economies between 2000 and 2015. Independent variable in our study is energy use in kilograms of oil equivalent per $1,000 GDP (E). Control variables are GDP per capita (Y), industry development (IND) and trade (T) as percentage of GDP. The choice of control variables justified by (Azam et al., 2015; Baloch and Meng, 2019; Yue et al., 2019; Ma and Fu, 2020). The main independents variable is financial development (FD) measured as domestic credit to private sector as a percentage of GDP.

Data on selected indicators obtained from World Bank's World Development Indicators. Since we work with strongly balanced panel dataset, our final sample yields 512 observations. Table 1 provides summary statistics. Average energy use in our sample is 126 kg of oil equivalent per $1000 GDP while the share of domestic credit in private sector is almost 51%.

2.2. Model

Following Baloch and Meng (2019), Yue et al., (2019), Ma and Fu (2020), this study analyzes financial development-energy use link. Estimated model can be expressed as follows:

$$E_{i,t}=f(FD_{i,t}, Y_{i,t}, T_{i,t}, IND_{i,t}) \quad (1)$$

Where energy use I is explained by domestic credit to private sector (FD), per capita GDP (Y), industry (IND) and trade (T).

Paramati et al. (2017) explain that single measurement unit is significant advantage of log transformation as coefficients of regression represent elasticities. Zafar et al., (2020) state that logarithmic transformation improves distributional properties and prevent autocorrelation and heteroscedasticity issues.

Following previous studies, we transform Equation 1into the logarithmic form:

$$lnE_{i,t}=\alpha_i+\beta_1 lnFD_{i,t}+\beta_2 lnY_{i,t}+\beta_3 lnIND_{i,t}+\beta_4 lnT_{i,t}+\mu_{i,t} \quad (2)$$

Where E is natural log of energy use $\beta_{(1-4)}$, are the estimates of natural log of domestic credit to private sector, GDP per capita, industry and trade, i represents the countries, t indicates the period and μ_(i,t) is the error term.

2.3. Methods

2.3.1. Panel unit-root test

Time series and panel data is often subject to non-stationarity, which consequently leads to spurious regression results (Baloch and Meng, 2019). Therefore, panel unit-root is imperative before proceeding with other empirical estimation. Moreover, when analyzing long-term relationship between variables, order of integration is of particular importance as it arises in some linear combination of variables, which are individually integrated of order one and stationary (Pedroni, 1999). To check for the presence of unit-root in our data, we employ first- and second-generation panel unit-root tests as suggested by Baloch and Meng (2019). The stationarity of each variable is tested by Levin et al. (2002), Breitung and Das (2005), Im et al. (2003) and Fisher-type panel unit root tests proposed by Maddala and Wu (1999). Null hypotheses of the tests assume non-stationarity, while alternative states that some or at least one panel is stationary.

2.3.2. Pedroni's panel cointegration

This study employs Pedroni's (1999, 2004) one-tailed panel cointegration test for multivariate models. The methodology is widely applied in empirical literature in investigation long-term relationship (Gozgor et al., 2020; Umurzakov et al., 2020; Salahuddin et al., 2019). Pedroni's cointegration test is based on the seven group-mean and panel test statistics. The former averages the results of individual country test statistics and the latter pools the statistics along the within-dimension (Neal, 2014). The null hypothesis states no long-term relationship and may be rejected when the majority of tests favors the alternative one. Final decision is made on the basis of parametric and non-parametric estimators including panel v-statistic, panel p-statistic, panel t-statistic (non-parametric), panel t-statistic (parametric), group p-statistic, group t-statistic (non-parametric) and the group t-statistic (parametric) (Pedroni, 1999; Neal, 2014).

2.3.3. Long-term elasticities

After confirming cointegrating relationship Equation 2 may be re-estimated with fully modified ordinary least squares (FMOLS) regression (Pedroni, 2001). In contrast to Ordinary Least Squares (OLS) and Dynamic Ordinary Least Squares (DOLS), which usually provide relatively biased results and may cut degrees of freedom (Kao and Chiang, 1999), FMOLS provide more robust long-term coefficients with standard errors following normal distribution (Gozgor et al., 2020). As Phillips and Hansen (1990) explain, FMOLS tackles the issues of endogeneity and residual

1 Bangladesh, Bhutan, Bulgaria, Cambodia, China, Croatia, Czech Republic, Egypt, Arab Rep., Hong Kong SAR, China, Hungary, India, Iran, Islamic Rep., Israel, Jordan, Kenya, Kyrgyz Republic, Lebanon, Malaysia, Mongolia, Myanmar, Nepal, Oman, Pakistan, Philippines, Poland, Romania, Saudi Arabia, Serbia, Singapore, Sri Lanka, Tanzania, Vietnam.

Table 1: Descriptive statistics

Variable	E	FD	Y	IND	T
Indicator	Energy use (kg of oil equivalent) per $1,000 GDP (constant 2017 PPP)	Domestic credit to private sector (% of GDP)	GDP per capita (constant 2010 US$)	Industry (including construction), value added (% of GDP)	Trade (% of GDP)
Mean	126.2	50.5	15,980.7	29.9	99.5
Std. Dev.	53.4	37.3	16,172.2	11.8	80.6
Obs	512	512	512	512	512

autocorrelation by employing semi-parametric correction and resolves highly heterogeneous panels.

2.3.4. Dumitrescu-Hurlin panel causality test

Causality is investigated by employing panel Granger non-causality test developed by Dumitrescu and Hurlin (2012), which is "the latest version of the Granger noncausality test for panel data" (Baloch and Meng, 2019). The test is developed on the basis of Granger's (1969) methodology and provides two different statistics Wbar-statistics and Zbar statistics. The former calculates the average of the test and Zbar-statistics indicates a standard normal distribution. The null hypothesis of the test assumes no causal relationship between variables. In our sample with relatively large number of panels (N) and relatively small number of time periods (T), Lopez and Weber (2017) suggest to draw conclusions on the basis of Zbar tilde statistics. The benchmark model can be presented as follows:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_{ik} y_{i,t-k} + \sum_{k=1}^{K} \beta_{ik} x_{i,t-k} + \varepsilon_{i,t} \qquad (3)$$

where $x_{i,t}$ and $y_{i,t}$ are observations of two stationary variables for individual i in period and K is the lag order.

3. RESULTS

Table 2 provides results on panel unit-root test results. Some variables are non-stationary at the level form, yet after first differencing all variables demonstrate stationarity. All test verify that all series are integrated of order one and stationary, thereby satisfying the main condition for cointegration analysis.

Since order of integration is examined, we present the results of panel cointegration test in Table 3. At 1 percent significance level, we can confirm cointegrating relationship between variables in our model as v-stat, panel PP-stat, group rho stat, group PP stat rejects the null hypothesis of no-cointegration. We additionally employ Kao's panel cointegration test to verify the significance of long-term relationship between the variables. In other words, there is long-term relationship between energy consumption, financial development, economic development, trade and industry in 32 Belt and Road economies during 2000-2015.

Significant cointegrating relationship allows us to presents long-term elasticities estimated by FMOLS regression. Our results suggest positive long-term relationship between financial development and energy consumption (Table 4). In other words, countries with higher shares of domestic credit to private sector experience greater energy use at p<0.01. Our findings are in line with Baloch and Meng (2019), Yue et al. (2019) and Ma and Fu (2020). Financial development eliminates constraints on enterprises by providing more credits to private sector, which consequently encourages small business development and increases energy demand.

Economic development, however, negatively related to energy consumption in the long-term. Such negative relationship may be explained as in the long-term economic development may be associated with adopting energy-conservation policies. As Ozcan et al. (2020) explains, economic development and energy use contribute to environmental sustainability since countries develop environmental policies based on energy use and economic growth. Higher shares of industry in national accounts positively related to energy in the long-term (P<0.01) while for trade the opposite is true. Suri and Chapman (1998) explain that industrialized countries may import manufactured goods, thereby reducing energy use.

Finally, Table 5 reports Dumitrescu-Hurlin panel causality test results. We first test if financial development Granger-causes energy consumption. Because z-bar tilde statistic is higher than critical, we fail to reject the null hypothesis of non-causality. Similarly, energy

Table 2: Panel unit-root test

Form	Variable	Test				
		LLC	Breitung	IPS	ADF Fisher	PP Fisher
Level	ln E	–2.5106***	6.5645	2.9263	39.0370	44.1963
		(0.0060)	(1.0000)	(0.9983)	(0.9942)	(0.9721)
First-difference	Δ ln E	–10.5490***	–9.7839***	–9.7496***	240.9365***	466.3298***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Level	ln FD	–4.3932***	4.4488	1.9891	60.3937	92.9480**
		(0.0000)	(1.0000)	(0.9767)	(0.6048)	(0.0105)
First-difference	Δ FD	–9.1662***	–6.9097***	–5.9611***	211.1950***	221.4998***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Level	ln Y	–4.5510	9.9803	3.7926	51.0938	61.6472
		(0.0000)	(1.0000)	(0.9999)	(0.8786)	(0.5602)
First-difference	Δ ln Y	–9.0844***	–8.6661***	–9.4181***	262.4359***	494.1514***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Level	ln IND	–4.5490***	1.9081	–0.3405	76.9060	76.8221
		(0.0000)	(0.9718)	(0.3667)	(0.1292)	(0.1306)
First-difference	Δ ln IND	–5.5397***	–8.5740***	–8.3971***	165.0168***	424.5604***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Level	ln T	–3.4937***	0.8457	0.2984	62.3282	79.3950*
		(0.0002)	(0.8011)	(0.6173)	(0.5358)	(0.0930)
First-difference	Δ ln T	–7.9378***	–8.5831***	–8.4510***	219.1114***	393.5514***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. t-statistics in parentheses

Table 3: Panel cointegration tests results

Test statistic	Score
V-stat	–3.214***
Panel rho-stat	1.099
Panel PP-stat	–10.15***
Panel ADF-stat	–0.2923
Group rho stat	3.23***
Group PP stat	–11.99***
Group ADF stat	1.449
Kao's ADF	–12.2463***

***, ** and * indicate significance at 1%, 5% and 10% levels, respectively

Table 4: Long-term elasticities

Variables	FMOLS
Δ FD	0.06*** (15.09)
Δ ln Y	–0.25*** (-17.30)
Δ ln IND	0.09*** (6.45)
Δ ln T	–0.02*** (11.94)

Note: ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. t-statistics in parentheses

Table 5: DH panel non-causality test

Null hypothesis	Statistic z-bar tilde	Optimal number of lags (AIC)	Lags tested
Δ ln FD doesn't Granger-cause Δ ln E	1.4595 (0.1444)	4	1–4
Δ ln E doesn't Granger-cause Δ ln FD	–0.0985 (0.9216)	1	1–4

***, ** and * indicate significance at 1%, 5% and 10% levels, respectively

use does not Granger-cause financial development. Thus, we observe no causal relationship between financial development and energy use in 32 Belt and Road economies between 2000-2015.

4. CONCLUSION

The aim of this study is to contribute to an ongoing research on causes and correlates of energy consumption. While numerous studies attempt to shed light on the role that energy consumption plays in economic growth (Menegaki, 2014), we investigate the relationship between financial development and energy consumption in a sample of Belt and Road countries.

This is important for a number of reasons. First, financial development is essential ingredient of economic growth, trade, investment, and, therefore, may have significant effect on energy consumption across countries. Second, the rates of both energy use and financial development has been increasing in the developing nations. Therefore, understanding this relationship is crucial to forecast the demand for energy in the long-term perspective.

Current study sheds the light on the financial development-energy nexus in 32 Belt and Road economies during 2000-2015. Financial development is proxied by domestic credit to private sector. We first examine the order of integration by employing five different panel unit-root tests. Further, we confirm long-term relationship between the variables by running Pedroni and Kao panel cointegration tests. Fully Modified Ordinary Least Squares (FMOLS) regression reveal positive long-term relationship between financial development and energy use. Results of Dumitrescu-Hurlin panel causality test fail to reveal causal relationship between financial development and energy in our sample.

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