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The nexus between financial development and energy consumption in the EU: A dynamic panel data analysis

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ABSTRACT

The relationship between financial development and energy consumption has newly started to be discussed in energy economics literature. This paper investigates this issue in the EU over the period 1990–2011 by using system-GMM model. No significant relationship is found in the EU27. The empirical results, however, provide strong evidence of the impact of the financial development on energy consumption in the old members. Greater financial development leads to an increase in energy consumption, regardless of whether financial development stems from banking sector or stock market. By contrast, we find for the new members that the impact of financial development on energy consumption depends on how financial development is measured. Using *bankindex* the impact of financial development displays an inverted U-shaped pattern while no significant relationship is detected once it is measured using *stockindex*.

1. Introduction

In the European Union (2020) energy strategy, energy-efficiency is listed among five priorities. The European Commission (2010) Energy report propounds that the EU is aiming for a 20% cut in Europe's annual primary energy consumption by 2020. For this purpose, it is very crucial to determine the dynamics of energy consumption in the EU. This learning also helps to understand how energy demand in the EU countries is going to change in the future.

The relationship between energy consumption and economic growth is certainly well-documented both theoretically and empirically (see, for example, Apergis and Payne, 2010; Apergis and Tang, 2013; Narayan and Smyth, 2008; Narayan et al., 2010; Sari and Soytas, 2007, etc.). There also exist several studies exploring this issue in the case of the EU (see, for example, Ciaretta and Zarraga, 2010; Menegaki, 2011; Pirlogea and Cicea, 2012). On the other hand, a consensus has emerged about the vital role of financial development on economic growth in recent years (see, for example, Al-Yousif, 2002; Fung, 2009; Kar et al., 2011; Masten et al., 2008, etc.) and it is also possible to find some empirical evidences from the EU (see, for example, Antonios, 2010; Wu et al., 2010; Zagorchev et al., 2011).

Over the last three decades, the papers focusing the nexus between energy consumption and economic growth or financial development and economic growth have commonly found a significant relationship. It is therefore rational to anticipate a significant running between financial development and energy consumption as well. Theoretically, Sadorsky (2011) explains how financial development affects energy consumption in three ways (see, for detailed discussion, Sadorsky (2011)). These ways, presented in Table 1, could be named as effect channels. Nonetheless, Sadorsky (2010) points out that the theoretical relationship between the variables in question is unclear, and it could only be resolved through empirical analysis.

In energy economics, the relationship between financial development and energy consumption has been attractive in recent years. Chtioui (2012) finds a uni-directional causal running from energy consumption to financial development both in the short and in the long run in Tunisia. Shahbaz and Lean (2012) find a long run relationship among energy consumption, economic growth, financial development, industrialization and urbanization in Tunisia. However, a long run bi-directional causality is also found between energy consumption and financial development, which do not support Chtioui (2012). Sadorsky (2010) examines the impact of financial development on energy consumption in twenty two emerging economies by using various

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Table 1
Effect channels of financial development over energy consumption.

Effect channels	Reflection of the effects
Direct effect	When there is improved financial development, consumers can borrow easier and cheaper in order to buy durable consumer goods which consume energy a lot.
Business effect	Improved financial development helps businesses in accessing to financial capital easily and less costly. Additionally, stock market development can also affect businesses by providing them additional funding source. These ones can let businesses expand their present business potential and increase energy demand.
Wealth effect	Increased stock market activity usually affects the confidence of consumers and businesses by creating wealth effect. Increased economic confidence may expand the economy and promote energy demand.

Source: Sadorsky (2011): 1000.

financial development indicators over the period 1990–2006. It is found that financial development affects energy consumption positively in this panel sample. In his further study, Sadorsky (2011) investigates the same issue on nine frontier economies of Central and Eastern Europe (CEE) during the period 1996–2006. This time he divides financial development indicators into two parts and shows that the impact of financial development has a significant positive impact when financial development is measured using bank related variables. Measurement using stock market variables, however, reveals that only stock market turnover has a significant positive impact on energy consumption. Islam et al. (2013) examine the relationship among energy consumption, aggregate production, financial development and population in Malaysia and they find that economic growth and financial development are effective on energy use both in the short and in the long run. Tang and Tan (2012), another paper in Malaysia, find that energy consumption and financial development are correlated in the long run and energy is a prominent resource for financial sector development. Xu (2012) investigates the nexus between financial development and energy consumption during the period 1999–2009 with a panel data set in 29 provinces of China, using system-GMM. The results indicate a positive significant relationship between financial development and energy consumption when financial development is measured using the ratio of loans in financial institution to GDP and the ratio of FDI to GDP. On the other hand, the results of Jalil and Feridun (2011) suggest that financial development leads to a decrease in environmental pollution in China. Kakar et al. (2011) imply that while financial development affects energy consumption in the long run; there is no significant relation in the short run in Pakistan. Moreover, the results fail to prove any causal running between financial development and energy consumption. Ozturk and Acaravcı (2013) yield evidence of a long run relationship between per capita energy consumption and financial development in Turkey. In addition, they reveal that while per capita energy consumption causes financial development in the short run; financial development does cause changes in per capita energy consumption in the long run. Mehrara and Musai (2012) conclude that financial development and energy consumption is cointegrated in the case of Iran. Al-mulali and Sab (2012a) find that energy consumption enables selected 19 countries to achieve high economic and financial development. In another paper, Al-mulali and Sab (2012b) also conclude that energy consumption plays an important role in increasing financial development in the Sub Saharan African countries. Mielnik and Goldemberg (2002) point out that foreign direct investment as an indicator of financial development has a significant negative impact on energy intensity on a sample of twenty developing economies.

The purpose of this study is to examine the impact of financial development on energy consumption in the EU. In this regard we employ generalized method of moments (GMM) during the period 1990–2011. We further divide sample size into two groups as the old members, EU15, that joined before 1996 and the new members that joined in 2004 and 2007 enlargements.[1] Although there are some studies on this issue as is mentioned above; to the best of our knowledge there is no other published study in the case of the EU. This paper therefore aims to fulfill this gap and contributes to empirical literature. Moreover, we construct two indexes representing banking and stock market variables as an indicator of financial development employing Principle Component Analysis (PCA).

The rest of the paper proceeds as follows: Section 2 describes empirical model and data, Section 3 presents PCA and GMM methodology, and Section 4 reveals empirical findings and discussion. Finally, we conclude in the last section.

2. Empirical model and data

In this paper, we investigate the dynamic linkages between energy consumption and financial development for the EU countries during the period 1990–2011 using system-GMM model with a strongly balanced data. Following Sadorsky (2010), the empirical model is identified as a reduced form dynamic panel model of energy demand. Energy demand (*energy*) is described as a function of income (y), price (p) and financial development (fd).

$$energy_{it} = \alpha_i energy_{it-1} + \beta_{i1} y_{it} + \beta_{i2} p_{it} + \beta_{i3} fd_{it} + \nu_i + \phi_t + \varepsilon_{it} \qquad (1)$$

where i indicates the country ($i = 1, \ldots, 27$) and t indicates the time period ($t = 1990, \ldots 2011$).

We gathered annual data on energy consumption, real GDP per capita, energy prices and financial development indicators for the period 1990–2011. The data of energy consumption is measured as energy use in *kg* of oil equivalent per capita and real GDP per capita is measured as constant 2005 US dollars. Real oil prices are represented by energy prices.[2] Since foreign direct investment is regarded as an emerging financial market determinant, it is added into the model. It is measured as net inflows as a share of GDP and denoted by *fdi*. All the data are sourced from the World Bank World Development Indicators (WDI) database.

We divide financial development indicators into two main parts: baking variables and stock market variables as mentioned in the previous studies. Considering Beck and Demirguc-Kunt (2009), eleven banking variables and four stock market variables[3] are chosen as financial development indicators. The bank related variables used in the paper are deposit money bank assets to GDP (*dbagdp*), financial system deposits to GDP (*fdgdp*), liquid liabilities as a share of GDP (llgdp), private credit to GDP (*pcrdbgdp*), bank overhead costs (*overhead*), net interest margin (*netintmargin*), concentration ratio (*concentration*), return on assets (*roa*), return on equity (*roe*), cost-income ratio, (*costinc*) and z-score. On the other hand, the stock market variables used in the paper are stock market turnover ratio (*stturnover*), stock market capitalization to GDP (*stmktcap*), stock market value traded to GDP (*stvaltraded*) and number of listed companies per 10,000 people (*listco_pc*). The data of these variables are gathered from the World Bank Financial Structure Database (2012).

Modeling various related financial development indicators in a same equation could lead to multicollinearity. Additionally, observing aggregate effect of these indicators may be more efficient rather than

[1] The 15 "old" member states of the EU are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom. The 12 "new" member states of the EU are: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia and Slovenia.

[2] Energy price data are obtained by dividing Brent crude oil prices to each country's consumer price index (cpi, 2005 = 100).

[3] Although a good number of stock market variables can be used as financial development indicator, only four of them are included in the study due to missing data matter for the most of the countries.