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Energy demand and stock market development in OECD countries: A panel data analysis

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ABSTRACT

This paper investigates the impact of stock market developments on oil and electricity demand of OECD member countries. We conduct different panel data methodologies and use annual data ranging from 1996 to 2011. The overall findings substantiate that income, real prices, size of the stock market and liquidity are important determinants for both oil and electricity demand. We also compute long-run elasticity coefficients by using a simple Partial Adjustment Model (PAM) and find that the long run elasticity coefficients are larger than the short run parameters. Moreover, our results show that the demand for oil and electricity is inelastic with respect to both own real price and real income over the short-run and the long-run. From a policy making perspective, the findings suggest that potential policy tools to reduce energy consumption may not be useful as the demand for energy is inelastic with respect to energy prices. Our results also manifest that although stock market deepening variables do not have a large effect on energy use as energy price and economic growth have, market size and liquidity significantly affect energy consumption. Therefore, energy demand estimations based on solely energy price and income may be inaccurate when some stock market development indicators are excluded. The empirical findings of this paper provide further insights for policy makers, energy companies and energy economists in terms of demand management policies and pricing decisions.

1. Introduction

A stock market is the barometer of an economy as market prices mirror expectations of investors on future economic outlook. Stock market development helps achieve higher economic growth by providing extra income, increasing capital accumulation and diversifying risks. Economic growth also considerably hinges on energy since firms' production and household consumption are directly related to energy use, particularly to oil and electricity consumption. Therefore, there is a significant link between energy consumption and stock market development.

There are two main channels between stock market development and energy demand. The first channel is the short-run activity via wealth effect. As a leading indicator for future economic prospect, increased stock market activity affects consumer and business confidence which in turn increases demand for energy. Consumers can purchase "large-ticket" items such as automobiles and machinery that need a large amount of energy as stock market investments increase consumer spending by providing additional income and capital gains to individuals and firms. The second channel is the investment channel, which helps companies to access source of funding with equity financing. As business activities boost, production raises in an economy, so the demand for energy increases.

Apart from these two main channels, stock market activity can also affect environmental quality. A well-developed stock market may provide additional capital to the renewable energy sector and also increase the amount of funds for investing in clean energy projects (Chang [1], Paramati et al. [2]). In this respect, stock market development can help improve environmental quality. Furthermore, stock markets allow listed companies to promote innovations and technological progress which reduces energy consumption (Tamazian et al. [3]) For these reasons, energy demand estimations based on solely energy price and income can be inaccurate when stock market development is excluded (Sadorsky [4]).

In previous literature, most of the empirical studies concentrate upon the nexus between energy consumption and economic growth. As stated by Chang [1], earlier studies cite mixed results about the links between energy use and income. This may be a result of omitting some important variables, such as stock market development indicators, as these variables significantly affect energy demand estimations.

Despite the clear impacts of stock markets on energy consumption, the related studies are relatively sparse. The previous studies mostly

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use “domestic credits to private sector” as a broad financial development indicator. However, this indicator does not assess the effect of stock market activity and only measures the impact of the accessible credits supplied on the level of energy use. Very few studies investigate the links between stock markets and energy use however they reach no consensus due to different econometric specifications and data limitations.

This paper makes a contribution to the present literature in regard to the nexus between energy (oil and electricity) demand and stock market development in Organization for Economic Co-operation and Development (OECD) countries. For this, we investigate the impact of stock market developments, measured with market capitalization of listed companies (% of GDP), turnover ratio, stock traded total value (% of GDP) and number of listed companies, on oil and electricity consumption by using static and dynamic panel methodologies and annual panel data from 1996 to 2011. A partial-adjustment model (PAM) is employed to compute long run elasticities of energy demand with regard to income, real prices and stock market indicators. To our knowledge, no empirical study has examined the impact of stock market activities on both oil and electricity use in OECD countries despite oil and electricity are important energy sources in production process and stock market development is one of the key determinants of energy consumption. Furthermore, another important contribution is to compute long-run coefficients via the PAM that allows short-run and long-run demand dynamics to differ whereas the majority of the previous papers in the related field have estimated only short-run parameters.

In this paper, the choice of OECD countries is motivated by several reasons: OECD member countries represent a large share of world's income; the OECD accounts for nearly 45% of global GDP. In this sense, our study is comprehensive as the OECD group includes the most industrialized and developed nations in the world. Additionally, the member countries comprise a large portion of total primary energy supply (TPES). For example, in 2013, the OECD countries’ TPES corresponds to 40% of the global energy supply. Moreover, the OECD countries are still important energy consumers although the consumption declines at a slow rate over the last years.

Our research differs from the previous researches in three dimensions: First, the paper presents estimates of OECD countries’ demand for both oil and electricity by different panel specifications. In this way, we compute short-run elasticities, which allow us to measure immediate impacts of price, national income and stock market development on energy use. Second, this study estimates a dynamic econometric model and quantifies the partial adjustment of oil and electricity demand. By doing so, we calculate long-run elasticities which enables us to measure the total response. Third, our study obtains more efficient estimates compared to the studies investigating a single country since panel data sets are typically larger than the cross-sectional or time series data sets and explanatory variables vary over two dimensions – countries and time – rather than one. Estimators based on panel data are quite often more accurate than from other sources.[1]

The rest of the paper is as follows: Section 2 presents literature review, Section 3 explains methodology and data. Section 4 presents the results, Section 5 discusses the results. Section 6 concludes.

2. Literature review

2.1. Energy consumption and economic growth

Understanding the links between energy use and economic growth is very important, particularly for policy makers in mitigating the problem of environmental degradation and designing sustainable energy policies. For this reason, the energy economics line of research heavily focuses on “energy consumption-economic growth” nexus. Nevertheless, the existing empirical studies have not reached a consensus on the effects of national income on energy use.

In previous literature, a large body of empirical papers is devoted to analyze the “energy-growth” links by utilizing different econometric methodologies. Belke et al. [6] investigate the long-run relations between oil consumption and economic growth in a panel of 25 OECD countries from 1981 to 2007. Their results show that oil use and income are important determinants of each other. Conducting a time series methodology based on Granger causality tests in the frequency domain, Bozoklu and Yılancı [7] examine the oil-growth link for 20 OECD countries. The empirical results are mixed across the countries, however a general result is that there are significant temporal and permanent causalities. In a more recent study, Isik and Shahbaz [8] use panel data of some selected OECD countries during 1980–2010 and document the highly significant effects of economic growth on oil demand.

Apart from the OECD related studies, the related literature has comprehensively examined the links between oil consumption and income for an individual country or a group of countries. Ozturk et al. [9] analyze oil-growth relation by using panel data and dividing 51 countries into low income, lower middle income and upper middle income groups. Their findings demonstrate uni-directional causality running from GDP to energy consumption in low-income countries and bidirectional causality between energy consumption and GDP for middle-income countries. Fuinhas and Marques [10] employs ARDL bound testing procedure to investigate the nexus between oil use and economic growth for Portugal, Italy, Greece, Spain and Turkey. They report bi-directional causality both in the short-run and the long-run. Analyzing the data into three groups namely all sample, Visegrad countries (V4) and old 14 EU countries, within a panel framework, Streimikiene and Kasperowicz [11] find that the relation between energy consumption, gross fixed capital and economic growth is positive.

In the energy economics literature, scholars also explore the nexus between electricity usage and economic growth. For the economic community of West African States (ECOWAS), Ouedraogo [12] studies on panel cointegration and panel Granger causal relations between electricity use and growth as well as between oil consumption and growth. Their empirical findings show that GDP and energy consumption as well as GDP and electricity co-move in the long-run. Estimating panel vector error correction models and focusing on 88 countries categorized into four panels (high, upper middle, lower middle, and low income) during the period from 1990 to 2006, Apergis and Payne [13] document significant casual relations between electricity consumption and economic growth. In a panel framework, Acaravcı and Ozturk [14] manifest that there is no significant impact of electricity consumption on the real output levels in case of transition countries. In a more recent study, Rafindadi and Ozturk [15] provide evidence that economic growth, exports, imports, and trade openness Granger-cause electricity consumption in Japan.

2.2. Energy consumption and financial development

Despite the clear role of stock market advancements on energy consumption, the vast majority of previous studies measure the impacts of financial developments on energy demand by mainly using two financial indicators, namely the domestic credits provided by financial sector and domestic credit to the private sector.[2] Shahbaz and Lean [24], for example, utilize cointegration and causality tests and show the presence of long-run association between financial develop-

[1] See Verbeek [5], for more details.

[2] Apart from the studies cited in the literature section, you can also refer to Javid and Shariff [16], Shahbaz [17], Al-mulali et al. [18], Alam et. al. [19], Omri et al. [20], Dogan and Turkekul [21], Tang and Tan [22], Farhani and Ozturk [23].

ment (proxied by domestic credit to private sector as a share of GDP), economic growth, energy consumption, industrialization and urbanization in Tunisia. Besides, they find bi-directional causalities between financial development and energy consumption. Islam et al. [25] provide evidence that financial development causes energy consumption in the long run but energy consumption causes financial development both in the short and the long run in Malaysia. Komal and Abbas [26] analyze the links between financial development, economic growth and energy consumption in Pakistan. They demonstrate positive and statistically significant impact of financial development on energy consumption via the channel of economic growth.

Al-mulali and Sab [27] use panel cointegration and panel causality techniques to explore the effects of energy consumption and CO_2 emissions on the economic and financial development in 19 selected countries. Their results indicate that the countries achieve high economic and financial development as a result of increased energy consumption. Al-mulali and Lee [28] find that financial development (domestic credits by banking sector) is an important factor increasing energy use in the Gulf Cooperation Council (GCC) countries. Alam et al. [29] document that financial development indicators has a larger effect on energy demand, followed by GDP per capita and foreign direct investment (FDI) in South Asian Association for Regional Cooperation (SAARC) countries. Analyzing the finance-energy nexus for Asian countries, Furuoka [30] adopts heterogenous panel causality tests and finds unidirectional causality running from energy consumption to financial development but not vice versa. The study of Le [31] investigates the finance-energy link in sub-Saharan African countries by utilizing panel techniques. The results reveal bidirectional causality and suggest that financial development has a direct impact on energy consumption and vice versa.

The nexus between stock market development and energy consumption is investigated by very few researchers. In his seminal paper, Sadorsky [4] reports a positive relationship between financial development and energy consumption in a sample of 22 emerging countries when financial development is measured with stock market variables. In another study, Sadorsky [32] investigates 9 Central and Eastern European (CEE) countries and finds that stock market turnover has a positive and statistically significant effect on energy consumption. The study of Zhang et al. [33] examine the influence of stock market developments on energy use in China and show that stock market capitalization is a key driver for energy consumption both in the aggregate and industry level. Dividing the European Union as new and old members, Çoban and Topçu [34] document that greater financial development leads to an increase in energy consumption in the old members, regardless of whether financial development is measured using banking sector or stock market. However, no significant relationship between stock market and energy use is found in the case of new members. Hasnaoui [35] analyzes the finance-energy nexus in a dynamic panel setting for 25 OECD member countries and find that stock market developments have significant effects on energy consumption. Using Granger causality technique, Ersoy and Unlu [36] study on the interactions between stock exchange and energy consumption in Turkey. Their results indicate a unidirectional causality from stock market to energy use.

The topic has aroused more interest among researchers with the increasing dependency on energy and growing financial markets around the globe. Recent studies explore the impact of stock market development on energy use by various econometric methodologies, but the results still remain elusive. Analyzing nonlinear effects of financial development on energy consumption, Chang [1] demonstrate that energy consumption increases with financial development measured by private and domestic credits in non-high income regime. However, energy consumption slightly decreases with financial development in high-income advanced countries, but increases in the higher income developing countries when financial development indicator is measured with value of traded stocks and stock market turnover. Ziaei [37] evidences positive effect of stock market shock on energy consumption in Asian and Oceania countries. In a panel study of 20 emerging markets, Paramati et al. [2] focus on the effects of stock market growth on the clean energy use over the period 1991–2012. Their empirical findings suggest that stock markets play a positive role on the clean energy consumption.

3. Methodology and data

3.1. Methodology

In order to estimate the oil and electricity demand of OECD countries and to obtain the short-run and the long-run elasticities of price, income and stock market development indicators, the paper employs panel estimation techniques in which both cross-section and time dimensions increase efficiency of estimates by allowing more degrees of freedom. We start with log-log functional form of an empirical model of energy demand for each country as[3]:

$$\ln ed_{it} = \beta_0 + \beta_1 \ln P_{it} + \beta_2 \ln Y_{it} + \beta_3 \ln SD_{it} \tag{1}$$

where ed_{it} is the aggregate energy consumption (oil or electricity) per capita. P_{it}, Y_{it} and SD_{it} represent real average prices of energy, income per capita and an indicator of stock market development, respectively. The coefficients are associated elasticity coefficients since all the variables are expressed in logarithms. The Eq. (1) can be treated as "fixed effect" or "random effect" model. In "fixed effect" model, the individual-specific effect is a random variable correlated with the explanatory variables. The intercept β_O vary with country or time or both, while the other parameters are homogeneous. In "random effect" model, it is assumed that the individual-specific effect is a random variable that is uncorrelated with the explanatory variables.

Eq. (1) is a static model for energy demand and does not give the main picture of how demand responds to change in price, income and stock market indicator through time. Generally, it takes time for demand to adjust its equilibrium level once price, income and the other exogenous variables change. A partial adjustment mechanism (PAM) [38] in its simplest form allows us to estimate this adjustment process. In our model, the PAM captures the energy demand dynamics by modeling oil and electricity demand elasticities with respect to each of the determinants in both the short-run and the long-run. The derivation of the partial adjustment energy demand model begins with a static representation of a long-run demand function. Let ed_{it}^* denotes the level of energy consumption per capita in a given country. In our partial adjustment model, the change in log actual energy demand between t-1 and t is some fraction (represented by γ) of the difference between log actual demand in period t-1 and the log of the long run equilibrium demand in period t, ed_{it}^*. This leads to a dynamic panel data model of the demand for energy capturing its target adjustment level as

$$\ln ed_{it} - \ln ed_{it-1} = \gamma(\ln ed_{it}^* - \ln ed_{it-1}), \tag{2}$$

Eq. (2) is a distinct model in which the short-run and the long-run behavior of the energy demand may be studied. The optimal or target level of energy consumption of a country at time t is assumed to depend upon country characteristics, known at time t-1 and related to the level of price, income and stock market development. In Eq. (2), we have the constraint of $0 \le \gamma \le 1$ where the coefficient γ measures the adjustment speed and is assumed to be identical across countries.[4]

Let ed_{it}^* represents long run equilibrium energy demand per capita for oil or electricity at t. Then the desired equilibrium can be

[3] In the methodology part, we report only one equation for energy demand. In the estimations, we run the same equations for both oil and electricity consumption.

[4] If $\gamma = 0$, consumer groups adjust immediately and completely to their target level of energy demand.

represented as

$$ed_t^* = \alpha P_E^{\psi} \exp(X\vartheta), \tag{3}$$

where ψ is the long term own price elasticity of energy demand and X is a vector of exogenous variables, such as income and stock market development indicators, and ϑ is the vector of parameters. To avoid cluster, the subscript i is omitted.

Substituting (3) into (2) gives

$$\ln ed_t - \ln ed_{t-1} = \gamma \ln \alpha + \gamma\psi \ln P_E + \gamma X\vartheta - \gamma \ln ed_{t-1},$$
$$\ln ed_t = \gamma \ln \alpha + \gamma\psi \ln P_E + \gamma X\vartheta + (1-\gamma)\ln ed_{t-1} + \varepsilon. \tag{4}$$

The short-run price, income and financial development elasticities are log of regression coefficients. The long-run elasticities can be computed by dividing the short run elasticities by the estimate of γ.

This paper models the dynamic version of the energy demand in OECD countries based on the partial adjustment mechanism as

$$\ln ed_{it} = \beta_0 + \beta_1 \ln ed_{i,t-1} + \beta_2 \ln P_{it} + \beta_3 \ln Y_{it} + \beta_4 \ln SD_{it} + \eta_{it}. \tag{5}$$

First, we estimate Eqs. (1) and (5) as static and dynamic versions of panel data, respectively. One of our objectives is to examine how the magnitude of both short-run and long-run elasticities alters when we employ static methods; fixed effect (Least Square Dummy Variable, LSDV) and random effect (Generalized Least Square, GLS) and dynamic panel data technique.

3.2. Some notes on methodology and parameter estimation

In panel estimations, there exists some important issues to be considered. First, the paper employs a static panel estimation technique to account for unobserved heterogeneity in panel data. The paper uses fixed (LSDV) and random (REM) effect models. Second, we estimate dynamic panel model in which LSDV and REM estimators are inconsistent and biased due to autocorrelated lagged dependent variable resulting correlation with the error term. The bias gets larger when time period gets large. In case of large cross section with a short time period, the two estimators remain inconsistent and biased.

To circumvent these problems and derive a consistent estimator, Arellano and Bond [39] impose moment conditions.[5] Any additional moment conditions whose numbers vary with T increases the efficiency of the estimators. All these can be exploited in a Generalized Methods of Moments (GMM). The instrumental variables go into the model as weight into optimal weight matrix. This matrix is estimated without imposing that the error term is. i.i.d. over cross sections. Additional assumptions of the absence of autocorrelation, combined with a homoskedastic variance are required to obtain such estimates. On the other side, in practice, Arellano and Bond [39] has small sample bias which increases with the number of instruments and orthogonality conditions between the lagged dependent variable and the error term (Alberini and Flippini [40]).

Blundell and Bond [41] extend standard GMM estimators, suggesting a system GMM estimation in which a set of instruments for first-difference and level equations are used. They empirically show that sample properties of the estimators improve dramatically and their system GMM estimation procedure is more efficient than standard GMM estimation. Therefore, this paper utilizes a system GMM estimation proposed by Blundell and Bond [41] to obtain more consistent and efficient parameters.

[5] A moment condition is usually derived from the availability of an instrument or instrumental variable. An instrumental variable z_{2t}, say, is a variable that can be assumed to be uncorrelated with the model's error term but correlated with the lagged value of endogenous variable [5].

3.3. Data

This study uses balanced annual panel data of energy demand, energy prices, income and the indicators of stock market development for 22 OECD countries from 1996 to 2011.,[67] Real average oil and electricity prices are extracted from International Energy Agency (IEA). Income (GDP per capita), oil consumption (use in kg of oil per capita), electric power consumption (kWh per capita) and the stock market indicators are collected from World Development Indicators (WDI) of World Bank. We consider four stock market indicators: market capitalization of listed companies (% of GDP), turnover ratio, stock traded total value (% of GDP) and number of listed companies. All of the selected financial variables reflect stock market deepening. Market capitalization variable refers to the company size; investors often rank companies based on their size. The turnover ratio is mostly used to assess liquidity to measure how easily investors can buy and sell financial assets. Stock traded total value represents the total number of shares traded, including both domestic and foreign assets, hence it reflects market size. Number of listed company is another indication of market size; the total number of listed companies in developed countries is generally higher than that of emerging economies. All the variables are transformed to natural logarithms.[8]

Table 1 documents the simple correlations among variables. The pairwise correlations show that oil (lnenc) and electricity consumption (lnelc) are highly correlated. They are substantially and positively correlated with income (lngdp) as well. Stock market turnover ratio (lnturnover) exhibits the lowest correlation with oil and electricity consumption.[9] Expectedly, some pairs of stock market development indicators are highly correlated (e.g. 0.827 between lnmarketcap and lnturnover; 0.768 between lnturnover and lnsttv). For this reason, we run regressions using each stock market deepening indicator separately to avoid possible multicollinearity problem. We also provide a visual representation (scatter diagrams) of the relationship between oil and electricity use and each stock market development indicator in Fig. 1. It is evident that there is a positive relationship between energy use (oil and electricity) and stock market development indicators.

4. Empirical results

We utilize static and dynamic panel data methodologies to investigate the impact of stock market development indicators on oil and electricity demand. The results yield corresponding price, income and stock market development elasticities of energy demand in the short-run (direct estimates from the dynamic models).

Tables 2 and 3 document the results from static models of fixed effect (LSDV) estimated for oil and electricity demand, respectively.[10] The results reveal that income is an important determinant for both oil and electricity consumption in OECD countries, verified from positive and statistically significant coefficients of lngdp. We observe that all oil price coefficients are negative, consistent with the downward slopping demand curve.[11] Hence, OECD countries decrease their oil consump-

[6] The countries under investigation are Australia, Austria, Czech Rep, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, S. Korea, Netherlands, New Zealand, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.

[7] We select the countries and time period according to data availability.

[8] Through the paper, for the ease of representation, the prices of oil and electricity, consumption of energy and electricity, GDP per capita number of listed companies, market capitalization, turnover ratio and stock traded total value are denoted as lnoilp, lnelp, lnenc, lnelc, lngdp lnlistedcom, lnmarketcap, lnturnover, lnsttv, respectively.

[9] All the technique details and explanations for variables can be seen on the website of worldbank: http://data.worldbank.org/data-catalog/world-development-indicators.

[10] The Hausman test performed indicates that fixed effect model over random effcet is selected.

[11] Consumer Price Index (CPI) can be used as a proxy for energy prices. In this case, some studies (see Sadorsky [4]) find that CPI is not a very good indicator of the prices, evidenced from positive price elasticity coefficients. The results we obtain, hovewer,

Table 1
Correlations between the variables.

	lnenc	lnoilp	lnelc	lnelp	lngdp	lnlistedcom	lnmarketcap	lnsttv	lnturnover
Lnenc	1								
Lnoilp	0.262	1							
Lnelc	0.934	0.304	1						
Lnelp	0.161	0.896	0.167	1					
Lngdp	0.667	0.223	0.754	0.041	1				
Lnlistedcom	0.302	−0.214	0.255	−0.273	0.259	1			
lnmarketcap	0.499	0.102	0.549	−0.102	0.641	0.478	1		
Lnsttv	0.406	0.122	0.432	−0.036	0.513	0.593	0.827	1	
Lnturnover	0.100	0.053	0.074	0.037	0.100	0.475	0.312	0.768	1

tion, when oil prices rise. Interestingly, we observe positive but statistically insignificant price coefficients (lnelecp) for the electricity models in Table 3.

For the energy demand equations represented in Table 2, three of the stock market development indicators; lnmarketcap, lnsttv and lnlistedcom are positive and statistically significant. In Table 3, the results reveal that lnmarketcap and lnlistedcom have positive impacts on electric power consumption. Turnover ratio as one of the stock market development indicator has negative and significant effect on the electricity demand. The stock market turnover has negative effect on both oil and electricity markets, though it is statistically significant effect on the latter market.

Tables 4 and 5 present the empirical findings from the Blundell and Bond - system GMM estimations. The results from the dynamic models show that the parameters of lagged energy and electricity demand variable are positive and highly significant, validating the use of a dynamic panel technique. Therefore, estimating the energy demand in static panel form may mislead researchers into inaccurate inferences. The statistically significant lagged variable also implies that the current level of energy consumption is extremely affected from the consumption level in the previous year.

All the price and income elasticity coefficients have the expected signs, therefore the dynamic models produce more realistic results. The model results demonstrate that the level of consumption declines as a response of an upward energy price movement. As for the stock market development indicators, the empirical findings suggest that the size of the market (lnmarketcap) and the liquidity of the stock market (lnsttv) positively and significantly affect the level of both oil and electricity consumption. The other market variables, lnturnover and lnlistedcom, do not have any significant impact on energy use. For model diagnostics, AR (1) and AR (2) tests of Arellano and Bond [39] are reported, which tests for first and second order serial correlation in the first differenced errors. The test results display no evidence of serial correlation in the first differenced error terms of all the models.

5. Discussion and policy implications

Our results show that the magnitude and significance of elasticity coefficients differ from one model to another, using static and dynamic panel models. For the fixed effect models, the price elasticities range from −0.024 to −0.014 for the oil models and from 0.15 to 0.24 for the electricity models. Income elasticities range between 0.231 and 0.293 for the oil equations and between 0.657 and 0.720 for the electricity equations. In the dynamic panel models, we provide evidence that income (lngdp) positively impact the level of both oil and electricity demand, while the demand declines with an upward price movement. For the oil equation, we document that the short run income elasticity coefficients depicted in Table 4 range from 0.033 to 0.043, indicating a 1% increase in national income leads to an increase in oil demand at a varying magnitude between 0.033% and 0.043%. In the electricity models in Table 5, the income elasticities vary from 0.072 to 0.081, which is two times higher than those in the oil models. The short run price elasticities are found to be negative and statistically significant in all GMM estimations of both oil and electricity equations.

The empirical findings show that oil and electricity use in OECD countries are price-inelastic when estimating dynamic panel GMM specification. This indicates that a change in energy prices leads to a small change in energy demand and hence suggests that energy consumption is mostly a necessity. The results also show that electricity demand in OECD countries is much more sensitive to the changes in income per capita than oil demand. Furthermore, our model results reveal that both oil and electricity consumption are more income responsive and less sensitive to price movements, which demonstrates that the consumption level of energy in OECD countries changes with income more than the price itself. Our estimation of price and income elasticities may offer significant insights for energy companies and policy makers. Elasticities play an important role in demand management policies and pricing decisions for energy companies while they are of particular importance to governments for energy taxation. In terms of potential policies, the results imply that potential policy tools to reduce energy consumption may not be useful as the demand for energy is inelastic with respect to energy prices.

Our results of energy demand elasticities in OECD countries are partially in line with previous studies. For example, Lee and Lee [42] study on energy elasticities in OECD countries and report that oil demand is income inelastic and price inelastic, whereas electricity demand is income elastic and price inelastic. We find similar results, except for income elasticity of electricity demand. In a more recent study, Belke et al. [6] document price inelasticity of the final energy consumption in kilograms of oil equivalent per capita.

For the stock market deepening variables, dynamic GMM-type estimation indicates that oil demand increases with the size of the local stock market, measured with lnmarketcap (Table 4); the associated coefficient is significant at the 5% level. Liquidity variable (lnsttv) also has positive and slightly significant impact on the demand for oil at the 10% significance level. The electricity demand (Table 5) is also found to be significantly affected from both lnmarketcap and lnsttv; the corresponding parameters are statistically significant at the 10% level. As the size of the stock market (lnmarketcap) increases by 1% percent, demand for oil and electricity increases by 0.012% and 0.007%, respectively. A 1% increase in the liquidity variable (lnsttv) increases the use of oil and electricity by 0.007% and 0.006%, correspondingly. The two remaining variables (lnturnover and lnlistedcom) have no effect on the consumption level of both oil and electricity consumption as shown by the dynamic panel models.

We report long-run elasticity coefficients in Tables 6 and 7 for the oil and electricity equations, respectively. The long run coefficients are computed by dividing the short run estimates in Tables 4 and 5 by one minus the estimated coefficients on the lagged energy (lnenergyc (−1)) and electricity (lnelecc (−1)). For all the models, the long run elasticity coefficients are larger than the short run parameters, as expected from

(*footnote continued*)
illustrate the expected sign for the price elasticity of energy demand.

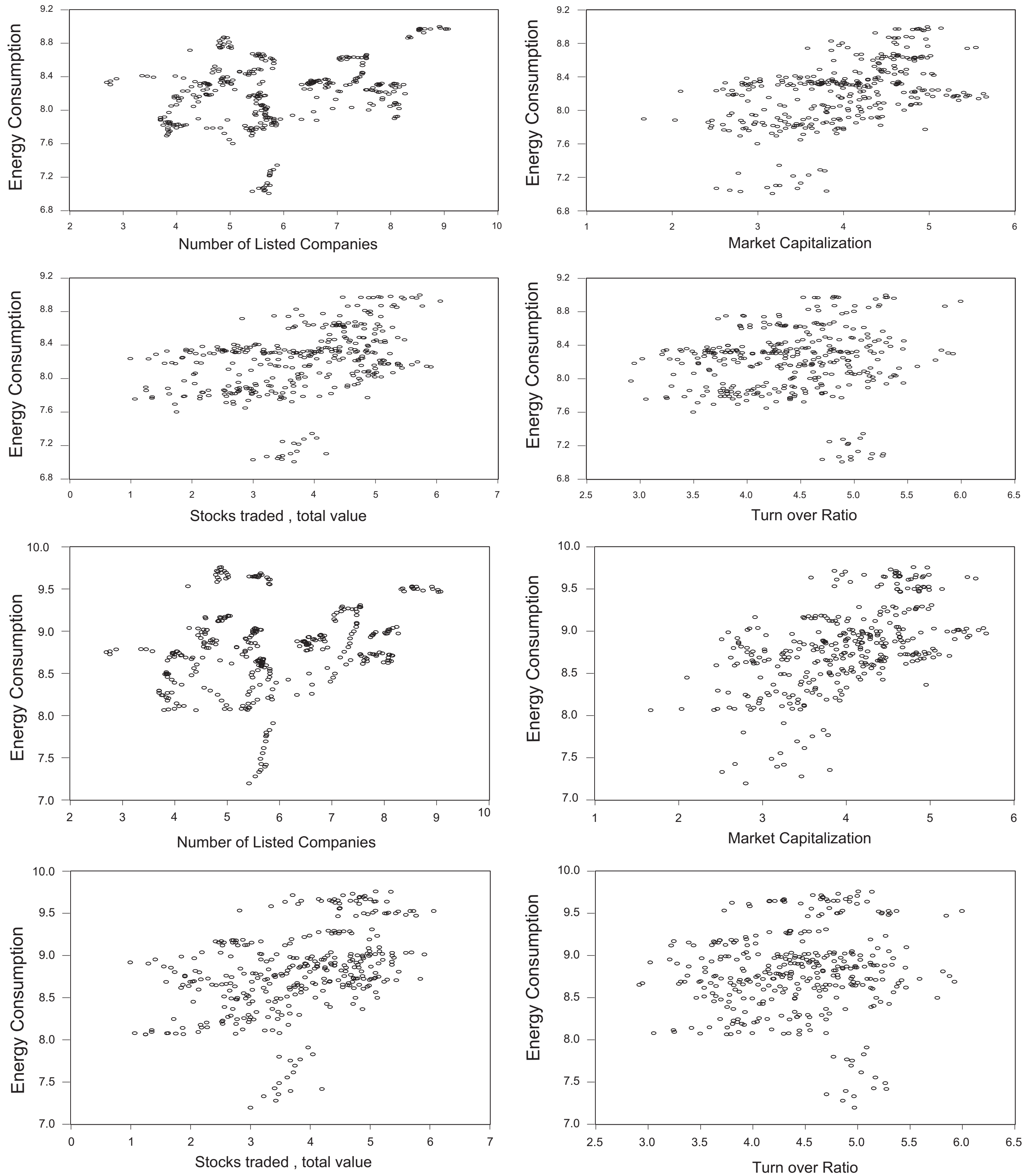

Fig. 1. Scatter Diagrams of pairwise correlations.

the mainstream theoretical approaches. The oil and electricity demand elasticities with respect to income per capita range from 0.540 to 0.759 and from 0.514 to 0.555, correspondingly. The long run price elasticity of demand varies between −0.462 and −0.327 for the oil models and between −0.116 and −0.085 for electricity models.

Stock market development indicators also display larger values of the long run coefficients than the short-run parameters. A one percentage increase in size (lnmarketcap) and liquidity (lnsttv) variables raises the demand for oil by 0.196% and 0.127% in the long run, respectively, while the estimated coefficients are 0.012% and 0.007% in the short run. The associated long run parameter estimates are 0.050 and 0.043 for the electricity equation as shown in Table 7. Moreover,

Table 2
Static Fixed Effect (LSDV) Model for the energy (oil) equation.

	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	5.389*** (0.000)	5.772*** (0.000)	5.768*** (0.000)	5.362*** (0.000)	5.273*** (0.000)
Lngdp	0.287*** (0.000)	0.231*** (0.000)	0.242*** (0.000)	0.293*** (0.000)	0.290*** (0.000)
Lnoilp	−0.022** (0.021)	−0.014 (0.142)	−0.021** (0.029)	−0.022** (0.025)	−0.024** (0.015)
Lnmarketcap		0.0372*** (0.000)			
Lnsttv			0.0182*** (0.003)		
Lnturnover				−0.007 (0.399)	
Lnlistedcom					0.016** (0.026)
R-sq within	0.196	0.254	0.217	0.197	0.208
R-sq between	0.436	0.450	0.441	0.435	0.448
R-sq overall	0.429	0.443	0.434	0.429	0.442

Notes. The values in the parentheses are the associated p-values. (***), (**) and (*) denotes statistical significance at the 1%, 5% and 10%, respectively.

Table 3
Static Fixed Effect (LSDV) Model for the electricity equation.

	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	1.601*** (0.000)	1.884*** (0.000)	1.787*** (0.000)	1.493*** (0.000)	1.534*** (0.000)
Lngdp	0.701*** (0.000)	0.657*** (0.000)	0.679*** (0.000)	0.720*** (0.000)	0.689*** (0.000)
Lnelecp	0.015 (0.262)	0.024* (0.073)	0.017 (0.203)	0.015 (0.259)	0.021 (0.115)
lnmarketcap		0.030*** (0.001)			
Lnsttv			0.008 (0.291)		
Lnturnover				−0.019* (0.061)	
Lnlistedcom					0.027*** (0.003)
R-sq within	0.602	0.615	0.603	0.606	0.613
R-sq between	0.571	0.577	0.573	0.570	0.576
R-sq overall	0.572	0.579	0.574	0.571	0.578

Notes. The values in the parentheses are the associated p-values. (***), (**) and (*) denotes statistical significance at the 1%, 5% and 10%, respectively.

the long-run stock market development variables are found to be smaller than both long-run income and long-run price elasticities. Therefore, our results manifest that although stock market deepening variables do not have a large effect on energy consumption as energy price and economic growth have, market size and liquidity significantly affect energy use both in the short-run and the long-run.

In overall, the results are in line with theoretical expectations and previous literature. Many studies have shown profound impacts of income per capita and real price on energy demand estimations (see, for example, Belke et al. [6], Bernstein and Madlener [43], Lee and Lee [42]). As for the stock market variables, our findings depict that the two

Table 4
Dynamic System GMM model for the energy (oil) equation.

	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	0.139 (0.410)	0.208 (0.228)	0.174 (0.306)	0.135 (0.435)	0.084 (0.633)
lnenergyc (−1)	0.945*** (0.000)	0.939*** (0.000)	0.945*** (0.000)	0.946*** (0.000)	0.943*** (0.000)
Lngdp	0.041*** (0.007)	0.033** (0.041)	0.035** (0.024)	0.041*** (0.007)	0.043*** (0.000)
Lnoilp	−0.025*** (0.000)	−0.020*** (0.003)	−0.025*** (0.000)	−0.025*** (0.000)	−0.025*** (0.000)
lnmarketcap		0.012** (0.044)			
Lnsttv			0.007* (0.098)		
Lnturnover				0.000 (0.930)	
Lnlistedcom					0.008 (0.299)
AR (1)-pvalue	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
AR (2)-pvalue	(0.134)	(0.142)	(0.131)	(0.140)	(0.134)

Notes. The values in the parentheses are the associated p-values. (***), (**) and (*) denotes statistical significance at the 1%, 5% and 10%, respectively.

Table 5
Dynamic System GMM model for the electricity equation.

	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	0.519*** (0.000)	0.522*** (0.000)	0.525*** (0.000)	0.529*** (0.000)	0.509*** (0.000)
lnelecc (−1)	0.858*** (0.000)	0.860*** (0.000)	0.863*** (0.000)	0.856*** (0.000)	0.854*** (0.000)
Lngdp	0.080*** (0.000)	0.072*** (0.000)	0.072*** (0.000)	0.080*** (0.000)	0.081*** (0.000)
Lnelecp	−0.015*** (0.007)	−0.012* (0.055)	−0.016*** (0.007)	−0.015** (0.017)	−0.014** (0.014)
lnmarketcap		0.007* (0.099)			
Lnsttv			0.006* (0.075)		
Lnturnover				−0.001 (0.707)	
Lnlistedcom					0.003 (0.561)
AR (1)-pvalue	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
AR (2)-pvalue	(0.893)	(0.801)	(0.961)	(0.895)	(0.889)

Notes. The values in the parentheses are the associated p-values. (***), (**) and (*) denotes statistical significance at the 1%, 5% and 10%, respectively.

variables, size (lnmarketcap) and liquidity (lnsttv), increase the demand for energy, while the number of listed companies (lnlistedcom) and the turnover ratio (lnturnover) are found to have no effect on the consumption level of energy in OECD countries. The stock market variable that increases the oil consumption most is the size variable measured with market capitalization % of GDP (lnmarketcap), while the electricity demand is mostly affected from the liquidity variable

Table 6
Long run elasticity coefficients of the oil equation.

	Model 1	Model 2	Model 3	Model 4	Model 5
Lngdp	0.745	0.540	0.636	0.759	0.754
Lnoilp	−0.450	−0.327	−0.454	−0.462	−0.438
lnmarketcap		0.196			
Lnsttv			0.127		
lnturnover				0.000	
lnlistedcom					0.140

Note: The long run elasticities are all implied values that are extracted from the estimates of parameters.

Table 7
Long run elasticity coefficients of the electricity equation.

	Model 1	Model 2	Model 3	Model 4	Model 5
Lngdp	0.536	0.514	0.525	0.555	0.554
Lnelecp	−0.105	−0.085	−0.116	−0.104	−0.095
lnmarketcap		0.050			
Lnsttv			0.043		
Lnturnover				−0.006	
Lnlistedcom					0.020

Note: The long run elasticities are all implied values that are extracted from the estimates of parameters.

(lnsttv).

As Sadorsky [4] explains, the effect of stock markets on energy consumption has two grounds. The first one is the "level effect", which relates to the increased investor confidence as a result of improved financial regulations. The second is "efficiency effect", reflecting that stock markets enable higher return, higher liquidity and additional funds for risky investments. Our empirical results support the existence of these two effects. The stock market size (lnmarketcap) and the total value of shares traded (lnsttv) have positive and statistically significant impact on both demand for oil and electricity in OECD countries even if some of the associated parameters are slightly significant at the 10% level. On the one hand, a liquid stock market with a high market value enables companies to increase their capital gains which can be used for energy projects. On the other hand, it raises confidence for future economic outlook, attracting foreign investors. These two effects increase demand for energy of a given economy via the channel of economic growth.

The positive effect of stock market development on energy use is consistent with some of the previous work. For example, Hasnaoui [35] finds significant effect of stock market developments on energy use for OECD countries by conducting Principal Component Analysis (PCA). We separately use the market variables in panel regressions and report the same results. Sadorsky [4] select market capitalization, turnover ratio and total value of traded stocks as market indicators and document that all these variables substantially increase energy use in emerging markets. However, in another study, Sadorsky [32]'s results reveal that only stock market turnover has a positive and significant impact on energy demand in CEE countries. For the EU countries, the study of Çoban and Topçu [34] show that stock market developments do not have a significant effect on energy use in general however they significantly influence energy consumption for the old member countries. Chang [1]'s paper also provide evidence of different conclusions with regard to country groups; the value of traded stocks and stock market turnover negatively affect energy use in developed economies while they positively influence energy demand in developing countries. In this regard, our empirical findings offer fresh evidence on energy-finance nexus for OECD countries as previous literature cite mixed results for different country groups and time periods.

From the policy making perspective, our results are of paramount importance. Energy conservation policies and demand estimations based only on price and income variables tend to be inaccurate when some stock market indicators, particularly market size and liquidity are excluded. The policy makers also should account for the specification of the models when designing optimal energy policy as the results from static and dynamic panel models show different conclusions.

6. Conclusion

Although price and income have widely investigated in the energy market literature, little has done on the effects of stock market development on energy demand. This study uses stock market development indicators to examine the links between financial markets and energy demand in OECD countries since majority of firms' performance listed in the stock market is directly or indirectly related to energy consumption in an economy.

As an econometric procedure, we adopt static and dynamic panel data models to estimate the short-run parameters. Furthermore, the associated long-run coefficients are computed by using the Partial Adjustment Model (PAM). The estimation results reveal that long run elasticities are larger that short run elasticities all of which are less than unity suggesting that energy demand is insensitive to price, income, and stock market deepening indicators and energy is mostly a necessity. The GMM results further suggest that income, size and liquidity variables are all positive and significantly affect energy demand while number of listed companies and turnover ratio do not have a significant impact. In the short-run, a one percentage increase in size (lnmarketcap) and liquidity (lnsttv) variables raises the demand for oil by 0.012% and 0.07% while the associated parameters are 0.196% and 0.127% in the long run. As for the electricity use, a one percentage rise in size and liquidity increases the consumption by 0.007 and 0.006 in the short-run and 0.05 and 0.043 in the long-run, respectively. In overall, our empirical findings show that stock market advancements, namely size and liquidity, have become one of the key driving forces for an expansion of energy consumption in OECD countries, apart from price and income.

The corresponding results on estimates of elasticities may provide policy makers some indications of the extent to which both monetary and public policy tools would be applied to adjust the equilibrium in energy market. These may range from tax policy to financial regulation in energy market imposed by Kyoto Protocol came into force in 2005. Additionally, our empirical findings are indicative for authorities and energy companies in terms of demand management and pricing decisions.

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