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The impact of financial development on energy consumption in emerging economies

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ABSTRACT

Financial development is often cited as a very important driver of economic growth in emerging economies and it is thus likely that financial development affects energy demand. This study uses generalized method of moments estimation techniques to examine the impact of financial development on energy consumption in a sample of emerging countries. Several different measures of financial development are examined. Using a panel data set on 22 emerging countries covering the period 1990–2006, the empirical results show a positive and statistically significant relationship between financial development and energy consumption when financial development is measured using stock market variables like stock market capitalization to GDP, stock market value traded to GDP, and stock market turnover. The implications of these results for energy policy are discussed.

1. Introduction

Understanding the determinants of energy consumption in emerging economies is an important research topic for several reasons. First, energy is used in the production of almost all goods and services and it is thus crucial to have a good understanding of the determinants of energy demand. Many emerging economies are growing very rapidly and as economic growth increases so too does the demand for energy. According to the International Energy Agency (IEA) (2007, p. 73), between 2005 and 2030 world primary energy demand is expected to grow at an average annual growth rate of 1.8%. Developing economies will contribute to 74% of the increase in global energy demand. Moreover, just two countries, China and India will together account for 45% of the increase in global energy demand. Over the period 2005–2030, primary energy demand in China and India is expected to grow at average annual growth rates of 3.2% and 3.6%, respectively (IEA, 2007, p. 73). Understanding the determinants of energy demand is essential to gaining a better understanding how the demand for energy in emerging countries is going to change in the future. Energy demand modeling is also crucial to gaining a better understanding of how to manage global emissions of greenhouse gases (GHGs) because energy-related GHG emissions make up the bulk of GHG emissions. According to the World Resources Institute, 61.4% of global GHG emissions come from the energy sector.[1] While most of the world's GHG emissions have historically come from the developed countries, this is set to change as developing countries are expected to release more GHG emissions as their economies continue to grow.

To date, there has been a large body of published research investigating the demand for energy in emerging economies but most of this research has focused on the relationship between energy consumption and income (see for example, the multi-country studies by, Akinlo, 2008; Al-Iriani, 2006; Apergis and Payne, 2009a, 2009b; Chontanawat et al., 2008; Lee, 2005; Lee and Chang, 2008; Mahadevan and Asafu-Adjaye, 2007; Sadorsky, 2009; Sari and Soytas, 2007;Wolde-Rufael, 2009). Despite the enormous volume of work that has been done investigating the relationship between energy demand and income, there appears to be no strong consensus as to which way the relationship goes. This point was recently made by Karanfil (2009). Moreover, Karanfil (2009) also suggests that there are other potentially interesting variables, like financial variables, that could impact the demand for energy. To date, however, very little is known about the relationship between financial development and energy demand. This study uses recently developed generalized method of moments estimation techniques that explicitly deal with endogeneity issues in dynamic models to examine the impact of financial development on energy consumption in a sample of emerging countries. In doing so, this paper takes an important step towards more fully understanding the relationship between financial development and energy demand.

Financial development, which refers to a country's decision to allow and promote activities like increased foreign direct investment (FDI), increases in banking activity, and increases in stock market activity, presents one possible avenue for which economic growth can be increased and this will affect the demand

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[1] http://cait.wri.org/figures.php?page=World-FlowChart&view=100.

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for energy. Financial development is important because it can increase the economic efficiency of a country's financial system. Financial development encourages a number of changes within a country including for example, a reduction in financial risk and borrowing costs, greater transparency between lenders and borrowers, access to greater financial capital and investment flows between borders and access to the latest energy efficient products and cutting edge technology all of which can affect the demand for energy by increasing consumption and business fixed investment. Financial development can affect the demand for energy in several ways. One of the most direct ways that financial development can affect the demand for energy is by making it easier for consumers to borrow money to buy big ticket items like automobiles, houses, refrigerators, air conditioners, and washing machines. In other words, financial development makes it easier for consumers to satisfy their wants and needs. These big ticket consumer items typically consume a lot of energy which can affect a country's overall demand for energy. Businesses also benefit from improved financial development because it makes it easier and less costly to gain access to financial capital which can be used to expand existing businesses (by buying or building more plants, hiring more workers, and buying more machinery and equipment) or create new ones. Stock market development is particularly attractive to businesses because it allows them access to an additional source of funding, equity financing, that can be used to grow their business in addition to debt financing. Increased stock market activity can increase risk diversification for both consumers and businesses alike which is an important component to generating wealth in an economy. Increased stock market activity also creates a wealth effect that in turn affects consumer and business confidence (Mankiw and Scarth, 2008). The stock market is often viewed as a leading economic indicator and increased stock market activity may be viewed as a sign of economic growth and prosperity which in turn bolsters consumer and business confidence. Increased economic confidence increases the demand for energy intensive goods.

The impact that financial development has on the demand for energy is a topic that has received very little attention. Mielnik and Goldemberg (2002) find a relationship between foreign direct investment and energy intensity while Tamazian et al. (2009) find that financial development lessens CO_2 emissions. Outside of these papers, however, there appears to be little research on the link between financial development and energy. The purpose of this paper is to investigate the impact of financial development on energy demand for a panel of 22 emerging economies. Empirical models are estimated using panel generalized method of moments (GMM) regression techniques. The following sections of the paper set out the theoretical background material, empirical model, data, empirical results and discussion, policy analysis and conclusions.

2. Economic growth, financial development and energy demand

There is an extensive literature looking into the relationship between financial development (especially FDI) and economic growth (Levine, 1997). One view is that financial development leads to greater economic growth (Schumpeter, 1911; Goldsmith, 1969; McKinnon, 1973; Shaw, 1973). From a theoretical perspective, differences between the quantity and quality of financial institutions are an important determining factor for economic growth. More specifically, there are two different channels through which financial development can lead to economic growth (Fung, 2009). Factor productivity is one channel through which financial development may lead to economic growth. In this channel, financial innovations and technologies lessen informational asymmetries and this leads to better monitoring and selection of investment projects (Townsend, 1979; King and Levine, 1993b; Baier et al., 2004). Financial liberalization improves risk sharing which should lower the cost of equity and increase investment, ultimately resulting in increased economic growth (Bekaert and Harvey, 2000; Bekaert et al., 2001, 2002, 2005). The second channel, factor accumulation, emphasizes the spread of organized financial systems over self-finance. Organized financial systems increase efficiency as previously unproductive resources are put to better uses (Gurley and Shaw, 1955; Bencivenga and Smith, 1991; Xu, 2000; Bell and Rousseau, 2001). Consistent with this view that financial development leads to greater economic growth is the likelihood that energy demand should be positively impacted by increases in financial development. Increased financial development makes it easier for consumers and business to save, invest and borrow money. As development occurs within an emerging economy's financial services sector consumers find it easier and cheaper to borrow money and buy goods and services. Consumer purchases of some big ticket items, like automobiles or houses, directly increases the demand for energy since automobiles are powered by petroleum products and houses are heated with or cooled by energy products. Financial development allows businesses cheaper and/or easier access to financial capital, either through lower borrowing costs or through new sources of financing like equity financing as a country's stock market develops, which can be used to expand existing operations or construct new plants and factories, all of which increase the demand for energy (both in the construction of new infrastructure and in the operation of new infrastructure).

Another view is that economic growth leads to financial development (Robinson, 1952; Lucas, 1988; Stern, 1989). Financial development increases as the demand for financial services grows and the demand for financial services is directly tied to economic growth. In this view financial development follows economic growth. Consistent with this view is the likelihood that energy demand should be relatively non-responsive to financial development.

Based on these two views, there is an ambiguity as to what effect, if any financial development has on the demand for energy. This ambiguity can only be resolved through empirical analysis.

3. Empirical model

The empirical model is specified as a reduced form dynamic panel model of energy demand. Energy demand (e) depends upon income (y), price (p), and a measure of financial development (d)

$$e_{it} = \alpha_i e_{it-1} + \beta_{i1} y_{it} + \beta_{i2} p_{it} + \beta_{i3} d_{it} + v_i + \psi_t + \varepsilon_{it} \quad (1)$$

where i denotes the country (i=1,…,22) and t denotes the time period (t=1990, …, 2006). Eq. (1) is a fairly general specification which allows for dynamic energy demand effects, individual fixed country effects (v), fixed time effects (ψ), and a stochastic error term (ε).

Eq. (1) is an example of a linear dynamic panel model (Arellano and Bond, 1991). This model contains unobserved panel-level effects which may be either fixed or random. By construction, the unobserved panel-level effects are correlated with the lag(s) of the dependent variable and this makes most standard estimation approaches inconsistent (Arellano and Bond, 1991). Arellano and Bond (1991) develop a generalized method of moments (GMM) estimator which yields consistent parameter estimates for models of this type. In their approach the unobserved firm-specific heterogeneity is eliminated by using a

first differencing transformation. The Arellano and Bond (1991) approach is specifically designed for situations where there are a large number of cross sections and a small number of time periods. Unfortunately, the Arellano and Bond (1991) approach can, in some instances, perform poorly if the autoregressive parameters are too large or the ratio of the variance of the panel-level effect to the variance of the idiosyncratic error is too large. Blundell and Bond (1998), building on the work of Arellano and Bover (1995), develop a system GMM estimator which addresses these problems by expanding the instrument list to include instruments for the level equation. In this present paper, we use the system GMM approach to estimate our models. In the estimation of Eq. (1), lagged energy consumption and income are each treated as endogenous. A comparison is provided between treating financial development as exogenous or endogenous.

4. Data

This study uses annual data on energy demand and financial development for 22 emerging countries. The panel data set is an unbalanced panel of 22 emerging countries followed over 17 years (1990–2006). The dimensions of the panel data set are chosen to include as many emerging countries as possible each with a reasonable time length of observations. Emerging economies are identified as those 22 countries listed in the Morgan Stanley Capital Income (MSCI) emerging market category (www.mscibarra.com). The term emerging markets is used to describe a nation's social or business activity in the process of rapid growth and industrialization. Currently, there are 22 emerging markets in the world. These countries are Argentina (ARG), Brazil (BRA), Chile (CHL), China (CHN), Colombia (COL), Czech Republic (CZE), Egypt (EGY), Hungary (HUN), India (IND), Indonesia (IDN), Israel (ISR), South Korea (KOR), Malaysia (MYS), Mexico (MEX), Morocco (MOR), Peru (PER), Philippines (PHL), Poland (POL), Russia (RUS), South Africa (ZAF), Thailand (THA), and Turkey (TUR).

Energy consumption is measured by energy use in kg of oil equivalent per capita (energy). Real GDP per capita is measured in constant 2005 international dollars (gdppcap). Energy price data are not easily available for all countries and so following Mahadevan and Asafu-Adjaye (2007) energy prices are proxied using the consumer price index (cpi, 2005=100).[2] All of these data are available from the World Bank World Development Indicators online data base.

Foreign direct investment is one of the financial development indicators used in this paper. Foreign direct investment can stimulate economic growth through technology transfer and diffusion, spillover effects, productivity gains, and the introduction of new processes, and managerial skills (Batten and Vo, 2009). Studies by Grossman and Helpman (1991), Barro and Sala-i-Martin (1995) and Hermes and Lensink (2003) suggest that FDI plays an important role in modernizing the economy and promoting economic growth in developing countries. Foreign direct investment is measured as net inflows as a % of GDP (fdigdp) and is available from the World Bank World Development Indicators online data base.

In addition to FDI, the following financial development variables are used in this paper, the ratio of deposit money bank assets to GDP (dbagdp) (Creane et al., 2007; Tamazian et al., 2009), the ratio of stock market capitalization to GDP (stmktcap), the ratio of stock market total value traded to GDP (stvaltraded), and the stock market turnover ratio (stturnover). All of these financial development data are available from the Beck et al. (2000) Financial Structure Data base (updated November 21, 2008).

The ratio of deposit money bank assets to GDP is a widely used financial development indicator (Creane et al., 2007; King and Levine, 1993a; Beck et al., 2000). Larger values indicate that more funds are available for loaning out which should stimulate consumption, investment, economic growth and energy demand.

There are two main theoretical reasons why increases in stock market activity should boost investment and economic activity (Minier, 2009). The first effect is the level effect. Stock market development increases the amount of funds available for investment projects. As stock markets develop so too do the regulations (accounting and reporting standards) associated with them which in turn increases investor confidence. This increase in investor confidence is particularly important in attracting foreign investors. The second theoretical effect is the efficiency effect. Stock market development increases diversification and liquidity which increases the amount of investment going to higher return and higher risk projects. Since stock market development increases the amount of funds available for investment projects, the expectation is that stock market development leads to more investment, economic growth, and demand for energy.

Table 1 show annual growth rates for each of the variables except the FDI variable (which is calculated as net FDI inflows and can take on negative values). Average annual growth rates in energy consumption vary widely among the countries. South Korea, Malaysia and Thailand have recorded the highest annual growth rates in energy consumption (each in excess of an average annual growth rate of 4% per year). Several countries, most notably Czech Republic, Hungary, and Russia (all countries from the former Soviet Union or central Europe) recorded negative average annual growth rates in energy consumption. In the case of the Czech Republic and Hungary, each of these countries experienced negative average annual growth rates in energy consumption while recording positive average annual growth rates in income. This indicates that for these countries, an increase in energy efficiency and intensity accompanied the increased economic growth.

China stands out as a particularly impressive emerging economy for its high average annual per capita GDP growth rate (approximately 9% per year) and relatively modest average annual inflation rate. After China, the next fastest growing economies are South Korea, India and Chile, all countries with average annual per capita GDP growth rates in excess of 4%. Russia is also noteworthy for having an average annual economic growth rate very close to zero, very high average annual inflation, and very high average annual values for stock market capitalization and stock market value traded. In the case of Russia, however, average annual growth rate in stock market turnover is negative. Russia has also experienced the highest average annual growth rates in stock market capitalization and stock market value traded with both values slightly over 50%. Some countries, like Brazil and Russia, recorded very high average annual rates of inflation and very low average economic growth rates.

Table 2 shows the correlations between the panel data variables. For modeling purposes, all variables, except fdigdp, are expressed in natural logarithms. The energy consumption variable shows the highest correlation with the income variable and the lowest correlation with the price variable. Notice that some of the stock market variables have higher correlations with energy consumption than do the FDI variable or the banking variable. The stock market variables are fairly highly correlated with each other.

[2] A country specific oil price variable could be constructed by multiplying the US price of NYMEX crude oil by the appropriate country specific exchange rate, but fuel prices to the end consumer are heavily regulated in some of the emerging countries studied. Consequently, an oil price variable constructed in this way would not provide much meaningful information on energy demand.

Table 1
Average annual growth rates over 1990–2006 (percent).

Country	Energy consumption (per capita)	Real GDP (per capita)	Inflation rate	Bank deposits to GDP	Stock market cap to GDP	Stock market value traded to GDP	Stock market turnover to GDP
Argentina	1.39	2.76	12.35	0.99	15.75	7.85	−7.89
Brazil	1.47	1.18	71.49	5.16	13.25	18.62	5.37
Chile	3.31	4.05	6.63	2.08	6.70	12.95	6.25
China	3.96	8.84	4.83	na	23.00	37.60	−3.50
Colombia	−0.44	1.48	13.66	6.15	15.48	24.10	8.62
Czech Republic	−0.33	1.77	4.97	−3.34	4.17	16.42	7.30
Egypt	2.34	2.27	7.36	2.44	18.75	31.36	12.62
Hungary	−0.03	2.22	13.44	1.88	22.45	29.12	17.56
India	1.89	4.33	6.96	3.63	12.45	14.51	2.06
Indonesia	2.07	2.96	11.34	−1.51	11.99	8.41	−3.58
Israel	0.93	1.85	6.34	−0.02	13.94	11.12	−2.80
Korea (South)	4.51	4.65	4.26	4.35	3.77	10.35	6.58
Malaysia	4.43	3.80	2.94	0.82	2.10	3.74	1.64
Mexico	0.88	1.59	12.25	0.51	7.55	4.50	−3.05
Morocco	2.69	1.99	3.05	7.46	19.29	28.66	9.38
Peru	0.45	2.70	20.89	6.62	17.11	15.62	−1.49
Philippines	0.96	1.43	6.86	3.39	5.13	7.84	2.71
Poland	−0.14	3.66	15.86	8.57	36.53	40.63	−5.05
Russia	−1.39	0.08	50.98	7.41	53.89	55.37	−14.70
South Africa	0.35	0.78	7.18	2.32	4.63	17.64	13.02
Thailand	4.38	3.61	3.75	0.98	4.93	3.25	−1.68
Turkey	1.95	2.40	43.68	6.62	9.75	16.75	6.99

Table 2
Correlations for the panel data set.

	lenergy	lgdppcap	lcpin	fdigdpn	ldbagdp	lstmktcap	lstvaltraded	lstturnover
lenergy	1.0000							
lgdppcap	0.8555	1.0000						
lcpin	0.0829	0.0606	1.0000					
fdigdpn	0.2657	0.3547	0.2602	1.0000				
ldbagdp	0.2289	0.1559	0.4036	0.1501	1.0000			
lstmktcap	0.1474	0.1319	0.4051	0.1600	0.5847	1.0000		
lstvaltraded	0.3154	0.2262	0.2302	0.0898	0.5782	0.7180	1.0000	
lstturnover	0.3017	0.1895	−0.0855	−0.0354	0.2301	0.0042	0.6991	1.0000

obs=339.

Table 3 reports the estimated coefficients obtained from estimating a linear regression model of each variable on a one period lag of itself. The panel data set used in this paper contains a large number of firms and a small number of time periods. The underlying asymptotic theory for the Arellano, Bond and Bover GMM estimator used in this paper assumes that the number of time periods remains fixed and the number of cross sections becomes large. Consequently, tests for unit roots can be carried out using standard t or F statistics (Bond et al., 2003). The income variable (lgdppcap) shows the highest degree of persistence (estimated coefficient closest to unity) while the FDI (fdigdp) series shows the least amount of persistence. For each of the variables, the unit root hypothesis is rejected.

5. Empirical results and discussion

Panel estimates for the system estimated GMM energy demand equations are reported in Table 4.[3] Model 1 is the baseline model which does not include a financial development variable while Models 2–6 include financial development variables. For each model, the estimated coefficient on the lagged energy demand variable is positive, highly persistent and statistically significant at the 1% level indicating that energy consumption in 1 year is heavily influenced by energy consumption in the previous year. The estimated coefficient on the income variable (real GDP per capita) is positive in each of the six models and statistically significant at the 5% level in four of the models. The estimated coefficient on the price variable is positive in each of the six models and statistically significant at the 5% level in three of the models. The positive estimated coefficient on the price variable indicates that either the CPI is probably not a very good proxy for energy prices or that fast growing countries, can over short periods of time, increase their demand for energy even when prices are rising.

The strongest results supporting the hypothesis that financial development increases energy consumption comes from the models using stock market variables as measures of financial development. The estimated coefficients on stock market capitalization, stock market value traded, and stock market turnover are

[3] The system GMM approach can generate a lot of instruments for the endogenous variables, which can weaken the significance of the estimated coefficients. Following the suggestions of Roodman (2007), the number of lagged instrumental variables was set at three. The reported empirical results are not very sensitive to the choice of using either two or four lags of the instrumental variables.

Table 3
Unit root tests from panel estimation fixed effects regression results.

	lenergy	lgdppcap	lcpi	fdigdp	ldbagdp	lstmktcap	lstvaltraded	lstturnover
lenergy(−1)	0.8369*** (24.86)							
lgdppcap(−1)		0.8564*** (19.03)						
lcpi(−1)			0.7753*** (18.58)					
fdigdp(−1)				0.4270*** (5.17)				
ldbagdp(−1)					0.8294*** (14.38)			
lstmktcap(−1)						0.7922*** (36.30)		
lstvaltraded(−1)							0.7234*** (14.95)	
lstturnover(−1)								0.6328*** (8.23)
H0:a1=1	23.47***	10.17***	28.99***	48.06***	8.74***	90.69***	32.66***	22.77***

Heteroskedasticity robust t statistics reported beside coefficient estimates. The estimated coefficients on the time-dependent dummy variables are not reported.
$p < 0.01$***.
H0:a1=1 is a Wald test for the estimated coefficient on the lagged-dependent variable equal to one.

Table 4
System GMM panel estimation regression results treating income as endogenous.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
lenergy(−1)	0.9581*** (46.56)	0.9578*** (46.98)	0.9496*** (43.52)	0.9763*** (57.94)	0.9702*** (79.17)	0.9543*** (61.06)
lgdppcap	0.0602** (2.20)	0.0605** (2.22)	0.0846*** (2.67)	0.0361 (1.32)	0.0364* (1.68)	0.0521*** (2.58)
lcpi	0.0135** (2.03)	0.0134** (2.03)	0.0188** (2.17)	0.0088* (1.65)	0.0072 (1.46)	0.0098 (1.51)
fdigdp		0.0004 (0.27)				
ldbagdp			−0.0058 (−0.42)			
lstmktcap				0.0088** (2.04)		
lstvaltraded					0.0101*** (3.41)	
lstturnover						0.0121** (2.25)
AR(1)	−3.28 (0.00)	−3.28 (0.00)	−3.20 (0.00)	−3.28 (0.00)	−3.28 (0.00)	−3.23 (0.00)
AR(2)	0.94 (0.35)	0.93 (0.35)	1.03 (0.30)	0.92 (0.36)	0.92 (0.36)	0.78 (0.43)
Sargan	135.23 (0.06)	134.70 (0.06)	139.63 (0.03)	127.84 (0.13)	121.99 (0.22)	128.33 (0.12)

$p < 0.01$***, $p < 0.05$**, $p < 0.10$*.
Robust t statistics reported beside estimated coefficients. The regression coefficients are estimated using the Arellano and Bover (1995) and Blundell and Bond (1998) system GMM estimation approach.[a] The estimated coefficients on the time-dependent dummy variables are not reported.
AR(1) and AR(2) are Arellano and Bond (1991) tests for autocorrelation in differences.
Sargan is a test (Arellano and Bond (1991)) for over identification restrictions. p values for these tests shown in parenthesis.

[a] Estimation uses the xtdpdsys command in Stata10. GMM-type instruments for the difference equation include the second, third, and fourth lags of lenergy and lgdppcap. Standard-type instruments for the difference equation include the first difference of lcpi, and the financial development variable and the time dummy variables. GMM-type instruments for the level equation include the lagged first differences of lenergy and lgdppcap.

each positive and statistically significant. Two of these estimated coefficients are statistically significant at the 5% level, while one (stock market value traded) is statistically significant at the 1% level. These results are important in establishing that financial development does impact energy demand in emerging economies in a positive and statistically significant way when financial development is measured using stock market variables. In previous research, stock market development has been found to accelerate economic growth (Levine and Zervos, 1998; Beck and Levine, 2004; Batten and Vo, 2009) and in this paper stock market development is found to increase energy demand.

Neither the estimated coefficient on the FDI variable nor the estimated coefficient on the bank deposit variable is statistically significant at the 10% level. These results indicate that neither FDI nor bank deposits as percentage of GDP have much impact on energy demand in emerging economies.

The lower panel of Table 4 includes some post estimation tests for autocorrelation and instrument validity. AR(1) and AR(2) are Arellano and Bond (1991) tests for first-order and second-order autocorrelation in the first differenced errors. When the regression errors are independent and identically distributed, the first differenced errors are by construction autocorrelated. Autocorrelation in the first differenced errors at orders higher than one suggest that the GMM moment conditions may not be valid. The Sargan test (Arellano and Bond, 1991) is a test for over identifying restrictions (a χ^2-test to determine if the residuals are correlated with the instruments). A rejection from this test indicates that model or instruments may be miss-specified. The test is also not robust to heteroskedasticity and a large amount of heteroskedasticity in the regression equation can cause the test to over reject. For each of the models reported in Table 4, the AR(2) tests show no evidence of autocorrelation at conventional levels of significance. The Sargan tests indicate that none of the models show evidence of miss-specification at the 1% level and only one model (Model 3) shows evidence of miss-specification at the 5% level. These post estimation results indicate that the dynamic panel energy demand model is a reasonably good specification for energy demand in emerging economies.

The results in Table 4 are estimated under the assumption that income may be endogenous but that financial development is not. The possibility that the relationship between energy demand and financial development is endogenous is of less concern because it is highly unlikely that for the countries studied in this paper, and the time period under consideration, energy demand could cause financial development. Never-the-less the issue as to whether or not financial development is or is not endogenous can only be answered through empirical analysis. Table 5 reports results from estimating regression models where income and financial development are each treat as endogenous.

A comparison of the empirical results in Table 5 with those in Table 4 show that for a particular model shown, the empirical estimates are fairly similar. The empirical results from Models 2 and 3 in Table 5 show that the estimated coefficients on FDI and the bank deposits variable are each statistically insignificant.

Table 5
System GMM panel estimation regression results treating income and financial development as endogenous.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
lenergy(−1)	0.9581*** (46.56)	0.9635*** (52.01)	0.9565*** (65.74)	0.9847*** (66.23)	0.9731*** (89.67)	0.9588*** (71.73)
lgdppcap	0.0602** (2.20)	0.0447** (2.21)	0.0595*** (2.92)	0.0297 (1.17)	0.0245 (1.42)	0.0423*** (2.72)
lcpi	0.0135** (2.03)	0.0124** (2.1)	0.0137** (2.00)	0.0085 (1.61)	0.0074* (1.67)	0.0091 (1.41)
fdigdp		0.0007(0.37)				
ldbagdp			0.0084(0.72)			
lstmktcap				0.0111*** (2.65)		
lstvaltraded					0.0129*** (5.43)	
lstturnover						0.0156*** (3.53)
AR(1)	−3.28 (0.00)	−3.29 (0.00)	−3.20 (0.00)	−3.30(0.00)	−3.28(0.00)	−3.26(0.00)
AR(2)	0.94 (0.35)	0.93 (0.35)	1.03 (0.30)	0.92 (0.36)	0.89 (0.38)	0.74 (0.46)
Sargan	135.23 (0.06)	178.31 (0.26)	169.17 (0.44)	190.18 (0.11)	162.25 (0.59)	165.85 (0.51)

$p < 0.01$***, $p < 0.05$**, $p < 0.10$*.
Robust t statistics reported beside estimated coefficients. The regression coefficients are estimated using the Arellano and Bover (1995) and Blundell and Bond (1998) system GMM estimation approach.[a] The estimated coefficients on the time-dependent dummy variables are not reported.
AR(1) and AR(2) are Arellano and Bond (1991) tests for autocorrelation in differences.
Sargan is a test (Arellano and Bond, 1991) for over identification restrictions. p values for these tests shown in parenthesis.

[a] Estimation uses the xtdpdsys command in Stata10. GMM-type instruments for the difference equation include the second, third, and fourth lags of lenergy, lgdppcap and the financial development variable. Standard-type instruments for the difference equation include the first difference of lcpi and the time dummy variables. GMM-type instruments for the level equation include the lagged first differences of lenergy, lgdppcap and the financial development variable.

This is the same as the results found for Models 2 and 3 in Table 4. The estimated coefficients on the stock market variables reported in Table 5 are each positive and statistically significant, as is the case in Table 4.[4]

For each of the models reported in Table 5, the AR(2) tests show no evidence of autocorrelation at conventional levels of significance. The Sargan tests indicate that none of the models show evidence of miss-specification at the 5%. These post estimation results indicate that the dynamic panel energy demand model is a reasonably good specification for energy demand in emerging economies.

6. Policy analysis

The GMM regression results reported in Table 4 can be used to calculate short-run and long-run elasticities (Table 6). Short-run elasticities are obtained directly from the reported results in Table 4. The short-run income elasticity, for example, varies between 0.036 and 0.085 indicating that a 1% increase in real GDP per capita increases per capita energy consumption by a value between 0.036% and 0.085%. The long-run elasticities are obtained by dividing the short-run elasticities by one minus the estimated coefficient on the lagged energy demand variable. For each model, the long-run income elasticity is larger than unity. Across the full suite of models, the long-run income elasticities vary between 1.139 and 1.679 indicating that a 1% increase in real per capita GDP increases per capita energy consumption between 1.139% and 1.679%.

The stock market variables have relatively small short-run elasticities with respect to energy demand, typically between 0.009 and 0.012. The long-run elasticities are much larger (between 0.265 and 0.370). This means, that for the case of stock market capitalization, for example, a one percent increase in stock market capitalization increases energy demand by 0.009% in the short run and 0.370% in the long run. This long-run stock market capitalization elasticity value is about one quarter of the long-run income elasticity (Model 4, Table 6).

Table 6
Energy demand elasticity estimates calculated using the estimates from Table 4.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Short-run elasticities						
income	0.060	0.060	0.085	0.036	0.036	0.052
price	0.014	0.013	0.019	0.009	0.007	0.010
fdigdpn		0.000				
dbagdp			−0.006			
stmktcap				0.009		
stvaltraded					0.010	
stturnover						0.012
Long-run elasticities						
income	1.436	1.434	1.679	1.526	1.223	1.139
price	0.323	0.318	0.373	0.371	0.241	0.214
fdigdpn		0.010				
dbagdp			−0.115			
stmktcap				0.370		
stvaltraded					0.338	
stturnover						0.265

Table 7
Energy demand elasticity estimates calculated using the estimates from Table 5.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Short-run elasticities						
income	0.060	0.045	0.060	0.030	0.024	0.042
price	0.014	0.012	0.014	0.008	0.007	0.009
fdigdpn		0.001				
dbagdp			0.008			
stmktcap				0.011		
stvaltraded					0.013	
stturnover						0.016
Long-run elasticities						
income	1.436	1.223	1.369	1.939	0.910	1.027
price	0.323	0.340	0.314	0.552	0.275	0.222
fdigdpn		0.020				
dbagdp			0.194			
stmktcap				0.725		
stvaltraded					0.480	
stturnover						0.379

Energy demand elasticities calculate form the estimated coefficients in Table 5 are presented in Table 7. Here, short-run income elasticities vary between 0.024 and 0.060 and are fairly similar to those reported in Table 6. The long-run income

[4] At the request of a reviewer, a third set of GMM regressions were run which omitted the income and price variable. The estimated coefficients for the stock market variables were similar in sign, magnitude and statistical significance to those reported in Table 5.

elasticities reported in Table 7 are also similar to those reported in Table 6. The short-run and long-run stock market elasticities reported in Table 7 are slightly larger than the corresponding values in Table 6. Overall, the income, price and stock market variable elasticities reported in Table 7 are similar, in sign and magnitude, to those reported in Table 6.

The results from this paper show that increases in financial development, measured using stock market variables, increases the demand for energy in emerging economies. The long-run stock market variable elasticities tend to be smaller than the long-run income elasticities. Thus while stock market variables do not have as large of an impact on energy consumption as income does, financial development, measured using stock market variables, does have a positive and statistically significant impact on energy consumption even after the effect of income is controlled for. These results have implications for energy demand and greenhouse gas emissions.

The empirical results in this paper show that increases in stock market-related financial development increases the demand for energy in emerging economies. Since stock market development in emerging economies is only likely to increase in the future, this additional increase in energy demand stemming from increased financial development needs to be taken into account when modeling the demand for energy in emerging economies. Energy conservation policies in emerging economies are one area where the results of this paper could have an impact. Energy conservation polices based solely on energy demand and income relationships would tend to underestimate the demand for energy when stock market development is excluded. As a result, energy conservation policies that omit the impacts of stock market development on energy demand would probably fall short of their intended targets.

While the results in this paper do support the view that increase in stock market activity increase the demand for energy, other financial development variables like net FDI and deposit money bank assets as a percentage of GDP were found to not have a statistically significant impact on the demand for energy. These results suggest that omitting these variables from energy policy discussions is probably not too serious of an omission.

While it is often argued that foreign direct investment can stimulate economic growth through technology transfer and diffusion, spillover effects, productivity gains, and the introduction of new processes, and managerial skills the empirical evidence is far from conclusive and there are many empirical studies that fail to find a strong relationship between FDI and economic growth (see for example, the papers surveyed in Batten and Vo, 2009). Batten and Vo (2009), for example, provide empirical support for the hypothesis that the impact of FDI on economic performance depends upon institutional circumstances like educational levels and institutional reforms. The emerging market economies studied in this paper have different educational levels and institutional norms (like the protection of property rights). This may partially explain why the findings of this paper show that net FDI had little impact on the demand for energy. It may also be the case that while foreign direct investment can stimulate economic growth through technology transfer and diffusion, spillover effects, productivity gains, and the introduction of new processes, and managerial skills, these effects are not strong enough to impact energy demand in a statistically meaningful way.

Larger values of deposit money bank assets as a percentage of GDP indicate that more funds are available for loaning out which should stimulate consumption, investment, economic growth and energy demand. Whether the funds actually get loaned out or at what price is not always clear. One way of gauging how easy it is to get credit is to use the World Bank Doing Business Indicators.[5] Each year since 2004 the World Bank scores countries on their ease of doing business. One of the components to the overall score is ease of getting credit. The most recent ranking are for the year 2009 in which 183 countries were ranked. According to the most recent rankings for the countries included in this paper's data set, Malaysia ranks number 1 out of 183 countries for ease of getting credit. South Africa and Israel rank number 2 and number 4 respectively. Brazil, China, India, and Russia rank 87, 61, 30, and 87 respectively. Ranked at 127, The Philippines is the lowest ranked country in this paper's data set. Except for a few countries, the majority of the countries analyzed in this paper rank in the middle of the pack when it comes to ease of getting credit which may partially explain why the estimated coefficient on the bank deposit variable was found to be statistically insignificant.

[5] www.doingbusiness.org.

7. Conclusions

The economic growth literature has emphasized the importance of financial development in helping emerging economies grow and prosper. The energy literature has for the most part, very little to say about the relationship between financial development and energy consumption. This paper has conducted what is believed to be the first published research into the relationship between financial development and energy demand in emerging economies, a topic that is likely to grow in importance as emerging economies continue to develop. The empirical methodology uses recently developed generalized method of moments techniques to control for possible endogeneity between energy demand, income and financial development. The resulting empirical models fit the data well and pass a number of diagnostic tests. The results from this paper show that increases in financial development, measured using stock market variables, like stock market capitalization to GDP, stock market value traded to GDP, and stock market turnover, increases the demand for energy in emerging economies. These results are important for several reasons.

Emerging economies that continue to develop their stock markets will experience an increase in energy demand over and above that which is coming from increases in income. Energy demand projections in emerging economies which do not include financial development as an explanatory variable may underestimate actual energy demand. It is also likely that energy conservation policies may fall short of their intended targets if policy targets do not include the additional impact of financial development on energy demand. Meeting greenhouse gas emissions targets may also be harder to meet if these targets were formulated without taking into account the impact of stock market development on energy demand.

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