Market-Related Reforms and Energy Efficiency in Transition Countries: Empirical Evidence

Rabindra Nepal *

School of Economics, University of Queensland

Tooraj Jamasb **

Durham University Business School, Durham

Clement Allan Tisdell ***

School of Economics, University of Queensland

Abstract

Energy efficiency improvement is a desirable response to growing climate change and security of energy supply concerns. This paper studies the impacts of a varied set of macro-level market-oriented reforms as well as structural change on economy wide measure of energy efficiency across a group of transition countries. These countries experienced a rapid marketization process, which, since the early 1990s, transformed their economies from central planning towards market-driven models. We use a bias corrected fixed-effect analysis technique to estimate this effect for the 1990-2010 period. The results suggest that reforms aimed at market liberalisation, financial sector and most infrastructure industries drove energy efficiency improvements. We find significant differences in improvements in energy efficiency between transitional Central European and Baltic States, South East Europe ones, and the Commonwealth of Independent States. The reasons for these differences are also discussed.

Keywords: market reforms, energy efficiency, transition countries, institutions

JEL Classification: P28, Q54, C33

* *Corresponding author*. Energy Economics and Management Group, School of Economics, University of Queensland, Colin Clark Building 652, St. Lucia, QLD 4072, Australia, Email: r.nepal@uq.edu.au, Phone: +61 7 33460798.

** Durham University Business School, Durham, DH1 3LB, UK. Email: tooraj.jamasb@durham.ac.uk, Phone: +44 (0) 191 3345463.

*** School of Economics, University of Queensland, Email: c.tisdell@economics.uq.edu.au, Phone: +61733656570

Acknowledgements: We would like to thank the editor and two anonymous reviewers for their helpful comments in revising the paper. The usual disclaimer applies.

1. Introduction and Purpose

Systematic institutional changes in the early 1990s in former communist countries marked the end of central planning and paved the way for economy-wide market reforms as part of deep political, social and economic transformation. Twenty-nine countries of the Central and Eastern Europe and the Former Soviet Union (FSU) underwent these changes. Economic liberalization, macroeconomic stabilization, restructuring and privatisation and institutional reforms were the main ingredients of their transformation process (Williamson, 1993). These reforms were termed Type I reforms while Type II reforms included the design and enforcement of laws, regulation and proper institutions to support and nurture the functioning of the market-driven reforms (Svejnar, 2002).

The overall structural economic changes in these countries implied that their energy sectors also experienced marketization. However, the empirical evidence on the impacts of their macro-level economic reforms on energy efficiency, gauged by a macro-measure of energy efficiency, remains to be examined. Macro-energy efficiency is defined as the ratio of total energy consumed to GDP (see, e.g., Jaffe et al., 2004; Metcalf, 2008; Sue Wing, 2008; Gillingham et al., 2009)[1]. Several authors argue that energy intensity is a suitable indicator of macro-level energy efficiency and that its accuracy can increase by controlling for a range of economic, technological and behavioural factors (Filippini and Hunt, 2012). This examination is relevant considering that improving energy efficiency remains among the most intensely discussed and widely implemented targets in current energy and environmental policy (Brennan, 2013).

[1] Nevertheless, other measures of energy efficiency can be appropriate in different circumstances (Turner, 2013).

Existing studies suggest that market-oriented macroeconomic and sectoral reforms should promote energy efficiency due to the adoption of commercial policies and practises and increased openness to private investment (Anderson, 1995). Improvement in energy efficiency also coincides with the aim of improving overall economic productivity and competitiveness. Several economists argue that, a combination of privatization, regulatory reform and liberalisation should enhance economic efficiency and improve service standards in all economic sectors (Megginson and Netter, 2001). Efficient use of energy can bring energy costs down and free up resources that can be mobilized elsewhere more productively.

Reliance on markets, both, as a resource-allocating agency and as an incentive mechanism can optimize energy allocation. Markets motivate consumers to reduce waste and adopt the most cost-reflective energy-saving equipment and appliances (Fan et al., 2007). Energy is also an intermediate input factor in production. Thus, effective market signals in the form of cost-reflective energy prices provide producers with incentives to decrease energy consumption by switching to substitutes when energy prices rise while market-driven reforms also subject the users to international energy prices. It can also induce energy saving technologies and innovations, which can lead to energy price decreases in the long-run (Popp, 2002)[2].

From a policymaking perspective, energy and economic efficiency can be considered to be complementary, though not always coincident as goals (Sutherland, 1991). In addition, liberalised policies should be aimed at making markets work better by eliminating market imperfections, mitigating market power through competition

[2] However, downward pressure on prices may induce a direct 'rebound effect' by promoting higher energy use and thereby energy inefficiency contradicting the actual motives of liberalised market driven reforms. Also, an increase in per capita real income due to market-based structural reforms may lead to higher consumption of energy through income effect and i.e. the indirect rebound effect.

policies, and internalizing environmental externalities such as climate change impacts using flexible market-based mechanisms (Joskow, 2001). Therefore, energy efficiency improvement is strongly linked with various policies aimed at strengthening the effectiveness of market economy and correcting the market failures (Labandeira and Linares, 2010).

The purpose of this paper is to examine, by means of a panel data econometrics, the impacts of different market-oriented economic reforms on energy intensities using the macro-measure of energy efficiency during the two decades of market driven reforms in the transition economies (TECs hereafter). This examination is important given that existing empirical evidence, although debatable, indicates that energy intensities in transition countries declined because of more efficient energy use rather than because of underlying structural changes (or structural mix) in the economy (Zhang, 2013). On the other hand, capturing the impacts of induced and semi-autonomous technical change on energy intensities using econometric models is very complex (Conrad, 2000). Furthermore, energy efficiency promotion is a leading global policy response to the growing concerns on greenhouse gas emissions, energy security, costly renewable generation and transmission expansion (Brennan, 2013). Hence, the lessons drawn from the massive market-driven economic transformation process across the TECs could provide a helpful guide to policymakers undertaking energy efficiency reforms in other emerging economies such as China.

The remainder of this paper is organized as follows. Section 2 provides an overview on the evolution of energy intensity in transition countries and the literature analysing the impacts of reforms on energy efficiency. Section 3 presents the data and methodology while Section 4 illustrates the results. Section 5 discusses the findings. Finally, Section 6 concludes.

2. Evolution of Energy Efficiency and Relevant Literature

The energy consumed per unit of GDP in the transition economies was historically estimated to be four to eight times that of the OECD countries and the United States (Gray, 1995). The legacy of central planning in the absence of effective market signals, use of energy inefficient technologies, available excess capacity in generation, excessive reliance on energy-intensive industries in many countries and the inefficiency in energy use (encouraged by low electricity prices) contributed to high energy-intensity in the region. Furthermore, the distorted energy prices and soft budget constraints for industry, such as being debt-free, led to high-energy use in the TECs.

The state-owned firms were operationally and technically energy inefficient and had under-invested in energy efficiency before the start of the transition process. Despite this, the energy intensities of many TECs declined at the start of the transition process, mainly due to declining GDP, although the extent of this decline varied greatly across countries (Cornilie and Fankhauser, 2004). Structural changes such as the closure of dirty and inefficient plants as a result of privatisation coupled with the initial economic decline after political independence also contributed to this fall (Raiser et al., 2000).

The energy intensities of less efficient countries have improved rapidly and the cross-country variance in energy productivity have narrowed over time coinciding with the adoption of reforms (Zhang, 2013). Initially, the CIS countries were the most energy intensive of the groups of transition countries (see Figure 1) but have reduced their energy intensity by about one-third since 1994 (EBRD, 2008). However, these countries compared to Western Europe still use three times more energy to produce a unit of GDP in terms of purchasing power parities (PPP) (Markandya et al., 2006). Countries such as Uzbekistan and Turkmenistan have a high energy intensity of GDP indicating that they have the greatest potential to reduce their energy-efficiency gap whereas countries like Latvia, Lithuania, and Hungary have similar levels of energy intensities to those of the EU-15, OECD and the US in 2008.

A number of studies have studied the impacts of market-oriented economic reforms on energy efficiency in the international context. Seabright et al. (1996), for example, argued that the promotion of open and competitive markets, removal of subsidies on energy prices and market based-energy conservation programs in many countries contributed to improvements in energy efficiency. China, being one of the rapidly growing economies, has gathered considerable attention among researchers on this subject. Sinton and Fridley (2000) concluded that energy efficiency improved in China since 1996 as a result of the shift from state-owned to collective, private and foreign invested ownership. Fisher-Vanden (2003) also argued that the implementation of market reforms can facilitate the shift towards less energy intensive production in the Chinese context using a dynamic computable general equilibrium analysis (CGE). Similarly, Fan et al. (2007) concluded that accelerated marketization contributed substantially to energy efficiency improvements in China by estimating the change in energy own-price elasticity, as well as the elasticity of substitutions between energy and non-energy resources (capital and labour) in China during the periods 1979-1992 and 1993-2003.

In the regional context, three studies are of notable importance. Cornilie and Frankhauser (2004) study the evolution of energy intensities in the transition countries by decomposing the energy data and using panel data model based on random effects to identify the main factors driving improvements in energy intensity. The study concludes that energy prices and progress in enterprise restructuring are the two most significant drivers for efficient energy use. Similarly, a study by Markandya et al. (2006) investigates the relationship between twelve countries of Eastern Europe and the European Union (EU) members to examine convergence in energy intensities across them. A two-way fixed effects model is used to study the convergence in income and energy intensity between the advanced (EU 15) and the transition countries. While some evidence of convergence in energy intensity exists among the EU members and the transition countries; the findings suggest that the rate of convergence in energy intensities varies across countries. Zhang (2013) provide strong evidence of convergence of energy intensities where less energy efficient countries improved more rapidly and attributed this fall to a more efficient use rather than structural change in the transition countries. Hence, all three studies, confirm to the notion that the transition towards market-driven economic reforms contributed to a fall in energy intensities among the transition countries.

However, there is a significant potential among the CIS countries to further reduce their energy intensities and eventually converge at a similar levels with the SEE and CEB countries in terms of per capita energy consumed per unit of GDP. On the other hand, the extent to which market-oriented economic reforms contributed to the declining average energy intensities across the transition region since reforms began remains to be examined.

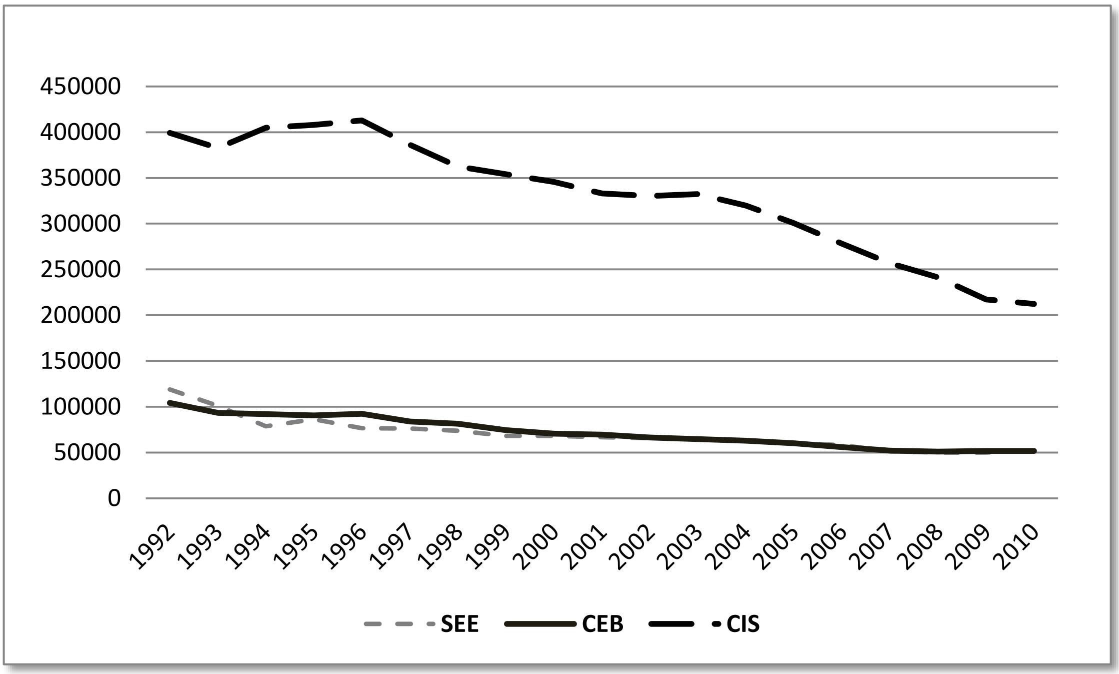

Figure 1: Total primary energy consumption per unit of GDP (Btu per dollar in 2005 US$)

Source: Energy Information Administration (EIA)

3. Methodology and Data

This paper uses the 'Transition Indicators' developed by the European Bank for Reconstruction and Development (EBRD) to investigate the apparent impacts of macro-level reform on macro-measure of energy efficiency in the transition countries since the start of the transition period. These indicators assess the progress of market-based reforms in transition economies. The degree to which reforms are made are assessed for nine areas encompassing 1) small scale privatization, 2) large scale privatization, 3) governance and enterprise restructuring, 4) price liberalisation, 5) trade and foreign exchange system, 6) competition policy, 7) banking reform and interest rate liberalisation, 8) securities markets and non-bank financial institutions and 9) infrastructure includes electric power, railways, telecommunication, roads, water and waste water. The measurement scale for these indicators ranges continuously from 1 to 4+, where 1 represents little or no change from a rigid centrally planned economy while 4+ represents the standards of an industrialized market economy. For example, a score of 4+ in the power sector reforms would imply that electricity tariffs are fully cost-reflective and provide adequate incentives for efficiency improvements, the presence of large-scale private sector involvement in the unbundled and well-regulated sector and fully liberalised sector with well-functioning arrangements for network access and full competition in generation (EBRD, 2001; 2008).

We construct six composite economic reform indicators (from the set of available nine indicators) to summarize and reflect the different types of market-driven economic reforms in the transition countries[3]:

- *Privatisation Reform Index* ***(PRI)***: composite index based on un-weighted average of small-scale privatisation and large scale privatisation reforms.
- *Governance Reform Index* ***(GRI)***: composite index based on un-weighted average of competition policy and corporate governance and enterprise restructuring reforms.
- *Overall Market Liberalization Index* ***(OMLRI)***: composite index based on un-weighted average of reforms in price liberalization and trade and foreign exchange reforms.
- *Other Infrastructure Reform Index* ***(OINFRI)***: composite index based on un-weighted average of reform scores in roads, water and wastewater and telecommunication.

[3] Hence, we consider all nine reform indicators in the model. We created 6 composite indexes from the 9 indicators.

- *Financial Reform Index* ***(FRI)***: composite index based on un-weighted average of banking reform and interest rate liberalization and securities markets and non-bank financial institutions.
- *Electric Power Index* ***(EPRI)***: electricity sector reform index alone.

The reform index for the power sector is included as a separate reform variable from other infrastructural reforms. This is because the power sector reforms were critical in determining the pace and direction of overall economic reforms in these transition countries. The transformation of the power sector was one of the prominent components of the transition process because of the economic and technical characteristics of the sector. The sector primarily involved large sunk investments operated by regulated monopolies with significant links with national income and output (Nepal and Jamasb, 2012). We also control for the size of the manufacturing sector as a measure of structural change. This is because manufacturing was the cornerstone of the centrally planned economies as countries lurched towards rapid industrialisation based on heavy industries to foster economic growth (Zhang, 2013). Figure A in the Appendix plots the manufacturing share of GDP for the transition countries considered here.

The data on energy intensities were obtained from the U.S. Energy Information Administration (EIA). Furthermore, the energy intensity estimates are adjusted for purchasing power parities (PPP) to remove the price level differences between countries. LEI denote the logarithmic transformed energy efficiency estimate, which captures the underlying distribution of the residuals used in our model. The shares of manufacturing sector in the economy (percentage of GDP) was used as a proxy measure for structural change and was obtained from the United Nations (UN) database. Table B in the Appendix reports the list of variables used in this study.

The period of analysis ranges from 1990 to 2010 (20 years) and covering 27 countries. The year '1990' marks the dawn of economic transformation in most of the transition countries. Some transition countries had already obtained membership in the EU in 1990 while some were in the process of becoming EU members or had the potential for joining EU. Out of the 27 countries in our sample, 15 are associated with the EU while 7 out of the 9 EU members in the sample belong to the CEB region. Turkey and Montenegro[4] are excluded from the sample of countries studied due to the lack of data. We also exclude China from our study, since China does not belong to the sample of transition economies as defined in the study.

The data comprises an unbalanced panel including 27 cross-sections with short time series of 20 years that captures the key reform period. We use the fixed effects (FE) estimator to account for unobserved heterogeneity given that the countries included in our sample are not identical to each other. Furthermore, the data used in this study does not represent a random sample as 'N' is limited but represents a finite sample allowing the use of FE estimator. However, the relationship between overall market-oriented economic reforms and energy efficiency is complex because the implementation of economic reforms does not instantaneously lead to improvements in energy efficiency. The behaviour of the dependent variable can depend upon the past values of itself along with a set of independent and control variables (Bruno, 2005). Thus a dynamic specification of the panel model is:

[4] Montenegro became an independent state on 3 June 2006.

$$y_{it} = \beta_0 + \rho y_{it-1} + X_{it}\beta + \alpha_i + \epsilon_{it} \quad (1)$$

where 'ρ' is the coefficient of the lagged value of the dependent variable while '$X_{it}\beta$' represents the matrix of explanatory variables and coefficients. In addition, it is well established in econometric literature that a dynamic LSDV model with a lagged dependent variable generates biased estimates when 'T' is small as is the case here (Roodman, 2009). The estimates obtained from a dynamic LSDV are not meaningful unless they are corrected for bias in small samples. Kiviet (1995) devised a bias-corrected LSDV estimator applicable only for balanced panels, which is believed to have the lowest Root Mean Square Error (RMSE) for panels of all sizes (Bun and Kiviet, 2003).

Based on these previous works, a version of bias-corrected LSDV estimate (LSDVC) developed by Bruno (2005) is used given two fundamental assumptions: a) it has a strictly exogenous selection rule and b) the error term 'ϵ_{it}' is classified as 'an unobserved white noise disturbance'. The approximation terms are of no direct use for estimation as they are all evaluated at the unobserved true parameter values. Hence, the true parameter values are replaced by estimates from some consistent estimator to make them work (Bruno, 2005). The preferred estimator is then plugged into the bias approximations formulae while the resulting bias approximation estimates β_{i_hat} are subtracted to derive the corrected LSDV estimator as

$$LSDVC_i = LSDV - \beta_{i\_hat} \quad (2)$$

where i=1 in STATA by default indicates the accuracy of the bias approximation[5]. The consistent estimator to be chosen to initialize the bias corrections could vary, for example, between the Anderson-Hsiao (AH) and the Arellano-Bond (AB) estimators (Bruno, 2005). The AH estimator by transforming the data into first differences precludes the fixed effects and uses the second lags of the dependent variable (either differenced or in levels) as an instrument for the one-time differenced lagged dependent variable (Anderson and Hsiao, 1982). The AB estimator is a GMM estimator for the first differenced model relying on a greater number of internal instruments (Arellano and Bond, 1991).

An alternative to dynamic LSDV panel estimates would be to use other consistent Instrumental Variable (IV) and Generalized Methods of Moments (GMM) estimators (Roodman, 2009). However, the relative performance evaluation of LSDVC in comparison to LSDV, AH and BB estimators by Bruno (2005) for unbalanced panels with small 'N' concludes that the STATA computed LSDVC version outperforms all other estimators in terms of root mean square errors (RMSE) and bias. We thus use the LSDVC model to examine the impact of several market-driven economic reforms on energy efficiency in transition countries and report the results for the estimators used to initialize the bias corrections (AH and AB). The use of EBRD indexes based on scores of individual components as regressors also conforms to the exogenous selection rule as a requirement for performing LSDVC. Equation 3 examines the reform impacts on energy across the whole sample controlling for EU membership by introducing a

[5] Using 'xtlsdvc' command in STATA, the estimator first produces uncorrected LSDV estimates which then approximates the sample bias of the estimator using Kiviet's higher order asymptotic expansion techniques (Bruno, 2005). The estimation includes one lag by default.

dummy variable EUM while equation 4 models the reforms impacts on energy efficiency across the specific country groups (SEE, CEB and CIS).

$$\mathbf{LEI_{it} = \beta_0 + \rho LEI_{it-1} + \beta_1 PRI_{it} + \beta_2 OINFRI_{it} + \beta_3 GRI_{it} + \beta_4 FRI_{it} + \beta_5 OMLRI_{it} + \beta_6 EPRI_{it} + \beta_7 EUM + \beta_8 SC + \epsilon it} \quad (3)$$

$$\mathbf{LEI_{it} = \beta_0 + \rho LEI_{it-1} + \beta_1 PRI_{it} + \beta_2 OINFRI_{it} + \beta_3 GRI_{it} + \beta_4 FRI_{it} + \beta_5 OMLRI_{it} + \beta_6 EPRI_{it} + \beta_7 SC + \epsilon_{it}} \quad (4)$$

We do not explicitly capture the impacts of technological progress on energy intensities in our model. This is because there is strong evidence that much technical progress in the energy sector is induced and not autonomous which mostly depends on government R&D, corporate technology investment, learning by doing and scale economy effects in response to market conditions (Grubb and Kohler, 2000). New investments would imply that new technology is embodied in new equipment and especially in relation to economic activity and for some new consumer durables that involves the use of durable equipment. Induced technical change, in modelling terms, imply that technical change is reflected and dependent on other parameters within the model. As such, incorporating induced technical change in economic models, by making them endogenous to the model, is very complex as the modelling inherently becomes non-linear with path dependencies (Kohler et al., 2006)[6].

Table 1 shows the descriptive statistics for the dependent and independent variables for the group of TCs covered in this article. In general, the results indicate that many transition countries have not fully met the economic reform standards of industrialised economies in all sectors. Thus, market-based economic transformation is an on-going process in many transition countries. It can be inferred that complete economic

[6] There might be semi-autonomous technical change arising from cross-country spillovers. However, this is hard to capture in an econometric model.

liberalization (opening up trade, liberalising foreign exchange and price liberalization) has been on high agenda of reforms across the transition countries though the extent of progress varies considerably between them.

Variable	Mean	Standard Deviation	Minimum	Maximum	No. of Observations
LEI	4.15	0.27	3.67	4.87	563
SC	19.88	8.54	4.2	73.7	567
PRI	2.94	0.98	1	4.17	567
OINFRI	2.08	0.84	1	3.89	567
GRI	2.05	0.73	1	3.67	567
OMLRI	3.49	1.01	1	4.33	567
FRI	2.18	0.86	1	4	567
EPRI	2.29	0.97	1	4	567

Table 1: Descriptive statistics (up to two decimal places)

Privatisation (both large scale and small scale), which is often perceived as a cornerstone of market-driven economic transformation process, has advanced ahead as compared to reforms in the financial sector and in the electric power sector on average. Likewise, the governance reform (including competition policy and corporate governance and enterprise restructuring reforms), also, a proxy measure for institutional reforms seems to have progressed the least. The low governance scores, to some extent, also explain the widespread corruption that these countries faced during the yesteryears (EBRD, 2008).

Figure 2 shows the overall progress of market-driven reforms among the 9 EU countries included in our sample. It is evident that privatisation and reforms in overall market liberalisation stalled after 2000 among the EU members while stagnation in reforms has occurred for all other sectors since 2005. The average reform score across all sectors is also above 3 in 2010 indicating that the standards of the industrialised economy have not been reached. The overall market liberalisation reforms progressed the most while the governance reforms progressed the least. The indices for reforms in the electric power sector and the financial sector have converged since 2006 among the EU members in transition.

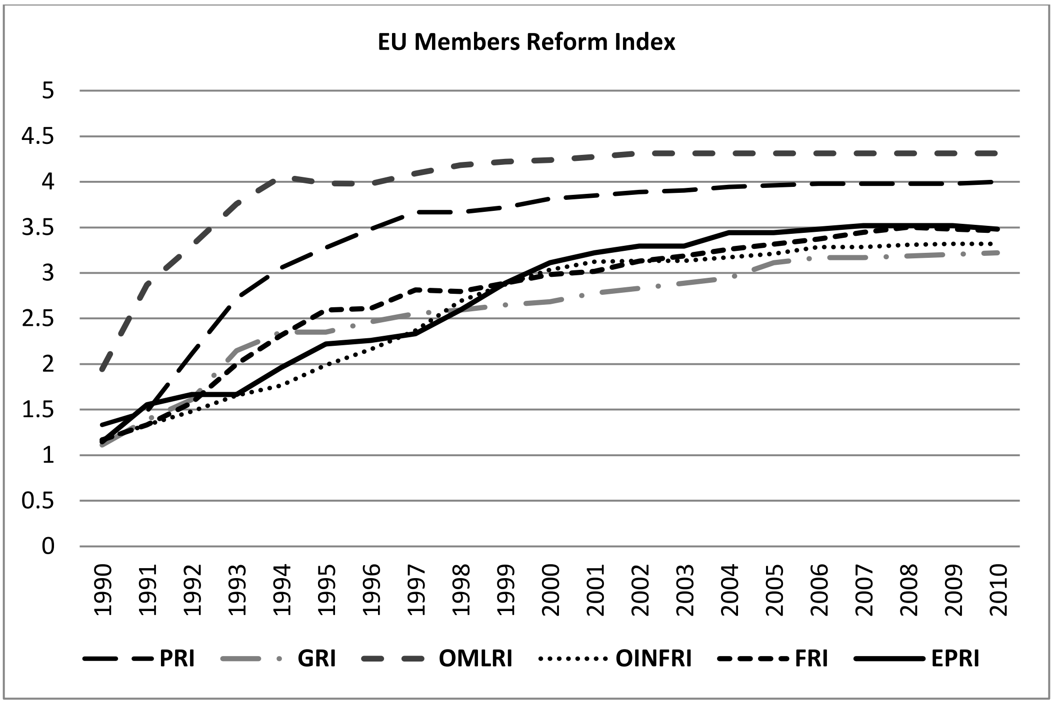

Figure 2: Reform progress among the SEE and CEB EU members

(vertical axis denotes indexes)

Similarly, Figure 3 shows the progress of reforms in all transition countries (considered here) by specific country groups. The privatisation programmes and overall market liberalisation seem to have stagnated in the CEB countries after 2000. Likewise, reforms in the electric power sector and financial sector stagnated after 2004. Since 2008, the overall market reforms have converged between the CEB and SEE countries while reforms in governance and other infrastructure sectors are on-going among CEB countries. The prospect of joining the EU and thereby benefitting from regional integration encouraged and accelerated market reforms in the CEB and SEE regions and increased their economic openness.

The SEE countries are still experiencing reforms in the financial, governance and the infrastructure sectors while reforms in other sectors seem to have stagnated. The SEE countries have some catching up to do in relation to the CEB countries apart from the reforms in overall market liberalisation. The CIS countries, on the other hand, lag behind both CEB and SEE countries in all aspects of reforms while governance reforms and reforms in other infrastructures seem to be the least pursued. However, these countries exhibited higher reform progress across all dimensions as compared to the SEE countries during the early phase of their transition. This indicates that the CIS countries mostly embraced a shock therapy approach to reforms in the early transition period and later resorted to a more gradual approach.

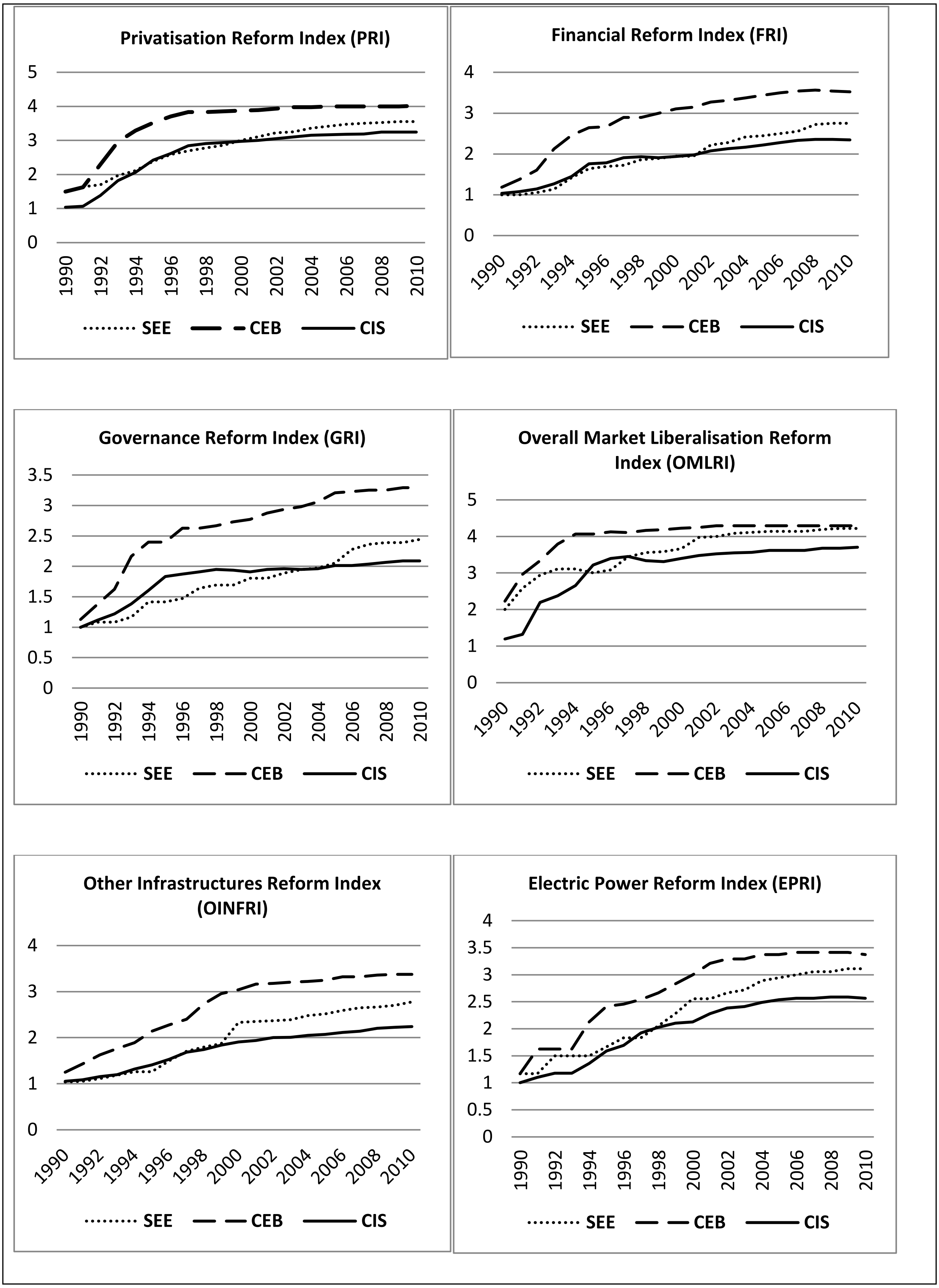

Figure 3: Reform progress in the TECs

4. Results

The results for the whole sample from Table 2 indicate that overall market liberalisation and reform in other infrastructure sectors as well as in the financial sector were positively associated with energy efficiency improvements in the transition countries considered. Greater price liberalisation by phasing out state procurement at non-market prices; no explicit price control; increased openness in trade and foreign exchange by removing all quantitative and administrative trade restrictions and reducing direct involvement of state in international trade seems to have improved energy efficiency in these countries. Market-driven reforms in energy intensive infrastructures (excluding the electricity sector) also led to energy efficiency improvements by greater reliance on the market process and signals, eliminating subsidies and adopting larger degree of decentralisation and commercialisation. Structural change in the economy, as captured by the share of manufacturing sector, had no effect on energy efficiency as a whole.

LSDVC Dynamic Regression (Bootstrapped SE)	**Anderson-Hsiao (AH)**	**Arellano-Bond (AB)**
LEI. L1	0.273*** (0.034)	0.261*** (0.026)
GRI	0.125*** (0.053)	0.125*** (0.041)
OMLRI	-0.119*** (0.020)	-0.118*** (0.017)
OINFRI	-0.195***	-0.194***

	(0.033)	(0.025)
EPRI	0.059** (0.021)	0.058*** (0.014)
FRI	-0.087** (0.041)	-0.087*** (0.032)
PRI	0.043* (0.034)	0.043** (0.022)
SC	-0.052 (0.035)	-0.054 (0.041)
EUM (dummy variable for EU membership)	-0.073*** (0.036)	-0.070*** (0.024)

Table 2: Impacts of economic reforms on energy efficiency (whole sample)

*, **, *** denote significance at 10, 5 and 1% respectively. Numbers in ( ) reports the SE

Similarly, the availability of substantial market liquidity and capitalisation coupled with well functioning and effectively regulated but competitive bank and non-banking financial institutions under financial sector reforms drove energy efficiency improvements in these countries. This result implies that liquidity constraints arising from capital market failures can deter energy efficiency improvements, as energy efficient investments cannot be financed. Hence, easing the liquidity constraints by increasing access to credit can drive the energy efficiency process as experienced in the transition countries.

Table 3 shows the impacts of reforms on energy efficiency for specific groups of the TECs. Member countries of the EU are more energy efficient than the non-EU members within the TECs. The EU countries are already nearing the advanced stages of reforms with the average reform scores being above 3 in all sectors at the end of 2010. The EU countries are further expected to undertake the energy efficiency improvements with the adoption of the Energy Efficiency Directive 2012/27/EU in October 2012.

Country Groups	**SEE**		**CEB**		**CIS**	
LSDVC Dynamic Regression (Bootstrapped SE)	**Anderson-Hsiao (AH)**	**Arellano-Bond (AB)**	**Anderson-Hsiao (AH)**	**Arellano-Bond (AB)**	**Anderson-Hsiao (AH)**	**Arellano-Bond (AB)**
LEI. L1	-0.211 (0.210)	0.020 (0.123)	-0.467*** (0.038)	-0.478*** (0.036)	0.146 (0.086)	0.193 (0.066)
GRI	0.192 (0.123)	0.179 (0.137)	0.156*** (0.014)	0.156*** (0.014)	0.114 (0.103)	0.133* (0.051)
OMLRI	-0.139** (0.061)	-0.156*** (0.029)	-0.188*** (0.041)	-0.185*** (0.042)	-0.141*** (0.050)	-0.139*** (0.017)
OINFRI	-0.139* (0.077)	-0.154** (0.074)	-0.056** (0.021)	-0.052** (0.022)	-0.249** (0.102)	-0.253*** (0.039)
EPRI	0.038 (0.103)	0.088 (0.049)	-0.017 (0.016)	-0.015 (0.016)	0.079 (0.056)	0.074*** (0.040)

FRI	0.209 (0.126)	0.227 (0.144)	-0.076*** (0.028)	-0.075*** (0.017)	-0.093* (0.113)	-0.089** (0.049)
PRI	-0.126* (0.074)	-0.122*** (0.043)	0.128*** (0.036)	0.127*** (0.036)	0.109* (0.052)	0.105*** (0.023)
SC	-0.306 (0.034)	-0.320 (0.056)	-0.336 (0.024)	-0.337* (0.026)	-0.247 (0.035)	-0.338 (0.029)

Table 3: Impacts of economic reforms on energy efficiency (specific groups)

*, **, *** denote significance at 10, 5 and 1% respectively. Numbers in ( ) reports the SE

However, initially, privatisation, governance reforms and reforms in the electricity sector were associated with increased energy intensities among the TECs as indicated by our results. Privatisation was popularly pursued among the TECs, often as shock therapy measures, and occurred without appropriate institutional and legal framework implying inadequate governance mechanisms. The privatization efforts were also criticized due to poor selling processes and occurred under the 'velvet gloves' such as widespread corruption, lack of rules and transparency and lack of planning of the process (Stiglitz, 1999). Raising proceeds through the sale of state assets and reducing state deficit was the primary aim of mass privatisation in these countries rather than improving economic efficiency. Hence, privatisation did not coincide with improvements in energy efficiency. The governance reforms remain the least pursued reform on average among the TECs and were not significant enough to improve energy efficiency across these countries.

Likewise, the progress of reforms in the electricity sector had an adverse effect on energy efficiency possibly because electricity prices continue to be subsidised and are not necessarily cost-reflective in many transition and developing countries[7]. The electricity industry also remains vertically integrated in some of these countries. Hence, any progress of reforms in the electricity sector has not driven energy efficiency improvements. However, the impact of electricity sector reform progress on electricity intensities of these countries may shed a better light on the role of electricity sector reform progress among the TECs[8]. The results also show a weak evidence of structural change driving energy efficiency improvements only among the CEB countries while producing no significant impact for other countries.

Similarly, reforms financial sector reforms are associated with the largest improvements in energy efficiency among the CIS countries. On the other hand, governance reforms negatively reflected to the energy efficiency of the CEB and CIS countries. This indicates that governance reforms remain weak even among the EU countries as a result of which the effect on energy efficiency is adverse. This finding is consistent with the view that the implementation and enforcement of economic reforms were weak as the state's legal and judicial capacities were limited and constrained during the transition process (Stiglitz, 1999). Likewise, the reform progress in the electric power sector in the CIS also generated adverse impacts on energy efficiency.

The results show the mixed impacts of privatisation on energy efficiency among the TECs. Privatisation improved energy efficiency among the SEE countries indicating that higher economic efficiency could have been a major aim of privatisation in this region. This result supports the earlier general theoretical and empirical findings that market-

[7] Figure 2 and Table 2 also support this argument.
[8] Nonetheless, a substantial fraction of energy use goes toward electricity generation indicating that energy intensity can be a proxy for electricity intensity in these countries. This implies that electricity reforms generate a similar impact on electricity intensity though this needs to be examined.

based instruments and policies, such as private ownership, can significantly improve the energy efficiency by improvements in economic efficiency and efficient resource allocation (Vickers and Yarrow, 1988) and, in particular, China (Sinton and Fridley, 2000; Fan et al., 2007). This underlines the importance of reducing excessive price support through government subsidies in improving energy efficiency in the SEE countries and imposing hard-budget constraints among firms in transition post-1990.. In contrast, privatisation had an adverse effect on energy efficiency improvements among the CEB and CIS countries.

5. Discussion

Our results send out two key messages to policymakers. Firstly, energy efficiency improvements may be achieved by pursuing policies designed to correct energy market failures and capital market failures through market pricing, reliance on market principles such as commercialisation and decentralisation and access to finance and loan programs. Secondly, energy efficiency improvement requires coordinated progress across all relevant sectors of the economy and the role of market driven reforms in other infrastructures apart from the energy sector should not be overlooked.

The results from the econometric modelling in our study indicate that market related-reforms are the primary influencers of energy efficiency for two major reasons[9]. This accords with that structural change has had an insignificant influence on energy intensities of transition countries, which our analysis confirms. Nonetheless, we cannot

[9] Earlier study by Cornillie and Fankhauser (2004) also asumme that market related-reforms are the primary influencers of energy efficiency.

dismiss the possibility of some semi-autonomous changes in energy efficiency that is not captured by econometric modelling.

Investments in new equipment both by producers and consumers would be associated with increased energy efficiency, as it tends to embody energy-saving technologies. Reforms in the financial sector imply that reforms might have led to increased international investments opportunities such as foreign investment inflow leading to increasing use of new technologies embodied in the new energy saving equipment. Cultural ties and geographical affinity may all play a role because they influence investment and economic growth although there is no clear consensus on the directions of the causality. For example, the CEB states potentially outpaced the SEE and CIS states in terms of higher economic growth and gross investments although the CEB states were already relatively ‘advanced’, had traditional links with the strongest EU nations, and benefitted quickly from investment and trade links with these countries. However, examining the energy efficient impacts of these factors require further explorations, which will also allow determining the extent to which more effective market reforms promoted energy intensities decline in transition countries.

Nonetheless, the econometric model used in this paper builds on the notion that induced technological progress is endogenous to any underlying reform process because economic policies and institutional reforms reflect current know-how and political forces (Easterly and Levine, 2002). This implies that market-related reforms simulate the technological progress by providing cost-reflective price signals in the long run because the adjustment of economies to market reforms takes time. For example, most fixed capital and many consumer durables embody given technologies that can only be altered by investment in new capital. The limited substitutability between capital and labour in the short-term should not be ignored. Adjustment in the stock of capital durable equipment takes time. Taking into account the theory of Salter (1966), about embodied technologies, alterations in the composition of the stock of durable equipment takes time, and time is needed to adopt new vintages of equipment which are developed to reflect changes in energy prices, Therefore, important lags occur in the changes in energy efficiency in response to price changes. Our model does not adequately account for these time lags. It would be desirable in future research to allow for these specifically.

The lack of a complete data set also prevented us from incorporating relevant aspects such as behavioural changes related to energy conservation. This can be important because the reduction in physical energy used to produce an energy service (without any reduction in the price of that service) can depend on decisions to reduce the use of energy a given service rather than the technological change. Similarly, our model may not capture all the qualitative dimensions and steps involved in the reform process considering that all aspects of reform outcomes are readily quantifiable in physical and monetary units. Our model also does not capture the effect of the lagged reform variables on energy efficiency, as their effects can be distributed over-time. The relevant distributed lag can be different for different reform variables.

6. Conclusions

This paper provided an empirical contribution to the scarce literature examining the impacts of market-driven reforms on declining energy intensities among the transition countries. A bias corrected fixed effect panel data technique (LSDVC) was used for this purpose. The transition countries have experienced market-oriented economic reforms in all sectors of their economies since the start of the transition period (early 1990s).

The results from the LSDVC analysis suggest that market-driven reforms in overall market liberalisation, financial sector and other critical infrastructures (or network industries) were associated with the energy efficiency improvement during the twenty years of transition process (from 1990-2010). Countries joining the EU as a member also experienced improvements in energy efficiency while privatisation reforms generated a mixed effect on energy efficiency improvements. The SEE countries improved energy efficiency from privatisation reforms while the CEB and CIS countries initially (but not subsequently) experienced adverse impacts. The results indicate that market-driven policies aimed at correcting market failures in the infrastructure sector and capital market failures can help in promoting energy efficiency in developing and transition countries.

Future research may focus on the interaction of the macro-level reforms and the effect of their interaction terms on energy efficiency. It is also important to pay attention to time lags in the adjustment of economic systems to market reforms. The efficacy of market-driven electricity sector reforms, which is now a global phenomenon, can be directly examined by analysing its impact on the electricity intensities of the transition countries. Alternative measures of energy efficiency needs be considered in the future analysis. Future research should also focus on addressing the effectiveness of market-driven polices aimed at correcting market failures in innovation and adoption of energy-saving techniques, information problems, and potential behavioural failures affecting in improvements in energy efficiency in transition countries.

References

1. Anderson, D. (1995). Energy Efficiency and the Economists: The Case for a Policy Based on Economic Principles, *Annual Review of Energy and the Environment*, Vol. 20(1), pp. 495-511.
2. Anderson, T.W. and Hsiao, C. (1982). Formulation and Estimation of Dynamic Models Using Panel Data, *Journal of Econometrics*, Vol. 18(1), pp. 47-82.
3. Arellano, M., and S. Bond (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations, *Review of Economic Studies*, Vol. 58, pp. 277-297.
4. Brennan, T. (2013). Energy Efficiency Policy Puzzles, *The Energy Journal*, Vol. 34(2), pp. 1-25.
5. Bruno, G.S.F. (2005). Estimation and Inference in Dynamic Unbalanced Panel data Models with a Small Number of Individuals, *The Stata Journal*, Vol. 5(4), pp. 473-500.
6. Bun, J.G. and Kiviet, J.F. (2003). On the Diminishing Returns of Higher Order Terms in Asymptotic Expansions of Bias. *Economics Letters*, Vol. 79, 145-152.
7. Conrad, K. (2000). An Econometric Model of Production with Endogenous Improvement in Energy Efficiency, 1970-1995, *Applied Economics*, Vol. 32 (9), pp. 1153-1160.
8. Cornillie, J. and Fankhauser, S. (2004). The Energy Intensity of Transition Countries, *Energy Economics*, Vol. 26(3), pp. 283-295.
9. Druckmann, A., Chitnis, M., Sorrell, S. and Jackson, T. (2011). Missing Carbon Reductions? Exploring Rebound and Backfire Effects in UK Households, *Energy Policy*, Vol. 39, pp. 3572-3581.

10. Easterly, W. and Levine, R. (2003). Tropics, Germs, and Crops: How Endowments Influence Economic Development, *Journal of Monetary Economics*, Vol. 50 (1), pp. 3-39.
11. EBRD (2001). Energy in Transition, Transition Report 2001, European Bank for Reconstruction and Development, London.
12. EBRD (2008). Securing Sustainable Energy in Transition Economies, Transition Report, European Bank for Reconstruction and Development, April, London.
13. Fan, Y., Liao, H. and Wei, Y-M (2007). Can Market Oriented Economic Reforms Contribute to Energy Efficiency Improvement? Evidence from China, *Energy Policy*, Vol. 35(4), pp. 2287-2295.
14. Filippini, M. and Hunt, L.C. (2012). US Residential Energy Demand and Energy Efficiency: A Stochastic Demand Frontier Approach, *Energy Economics*, Vol. 34(5), pp. 1484-1491.
15. Fisher-Vanden, K. (2003). The Effects of Market Reforms on Structural Change: Implications for Energy Use and Carbon Emissions in China, *The Energy Journal*, Vol. 24(3), pp. 27-62.
16. Gillingham, K., Newell, R.G. and Palmer, K. (2009). Energy Efficiency Economics and Policy, RFF Discussion Paper 09-19, Resources for the Future, Washington, DC.
17. Gray, D. (1995). Reforming the Energy Sector in Transition Economies, World Bank Discussion Papers, No. 296, Washington, DC.
18. Grubb, M.J. and Kohler, J. (2000). Induced Technical Change: Evidence and Implications for Energy-Environmental Modelling and Policy, Cambridge Working Papers in Economics 0031, University of Cambridge.
19. Jaffe, A.B., Newell, R.G., and Stavins, R.N. (2004). Economics of Energy Efficiency, *Encyclopedia of Energy*, Vol. 2, pp. 79-90.

20. Jamasb, T., Mota, R., Newberry, D. and Pollitt, M. (2004). Electricity Sector reform in Developing Countries: A Survey of Empirical Evidence on Determinants and Performance, Cambridge Working Papers in Economics, CWPE 0439.

21. Kiviet, J.F. (1995). On Bias, Inconsistency and Efficiency of Various Estimators in Dynamic Panel Data Models, *Journal of Econometrics*, Vol. 68, 53-78.

22. Kohler, J., Grubb, M., Popp, D. and Edenhofer, O. (2006). The Transition to Endogenous Technical Change in Climate-Economy Models: A Technical Overview to the Innovation Modelling Comparison Project, *The Energy Journal*, Special Issue, pp.57-108.

23. Kraakman, R.H., Black, B. and Tarassova, A. (2000). Russian Privatization and Corporate Governance: What Went Wrong, *Stanford Law Review*, Vol. 52, pp. 1731-1808.

24. Linares, P. and Labandeira, X. (2010). Energy Efficiency: Economics and Policy, *Journal of Economic Surveys*, Vol. 24(3), pp. 573-592.

25. Markandya, A., Pedroso-Galinato, S. and Streimikiene, D. (2006). Energy Intensity in Transition Economies: Is There Convergence towards the EU Average?, *Energy Economics*, Vol. 28(1), pp. 121-145.

26. Megginson, W.L. and Netter, J.M. (2001). From State to Market: A Survey on Empirical Studies of Privatization, *Journal of Economic Literature*, Vol. 39(2), pp. 321-389.

27. Metcalf, G. (2008). An Empirical Analysis of Energy Intensity and its Determinants at the State Level, *The Energy Journal*, Vol. 29, pp. 1-26.

28. Nepal, R. and Jamasb, T. (2012). Reforming the Power Sector in Transition: Do Institutions Matter? *Energy Economics,* Vol. 34(5), September, pp. 1675-1682.

29. Popp, D. (2002). Induced Innovation and Energy Prices, *American Economic Review*, Vol. 92 (1), pp. 160-180.

30. Raiser, M., Schaffer, M., and Schuchhardt, J. (2003). Benchmarking Structural Change In Transition, European Bank for Reconstruction and Development, EBRB, London, February.

31. Rodrik, D. (1996). Understanding Economic Policy Reform, *Journal of Economic Literature*, Vol. 34(1), pp. 9-41.

32. Roodman, D. (2009). How to do xtabond2: An Introduction to Difference and System GMM in Stata, *Stata Journal*, Vol. 9(1), pp. 86-136.

33. Salter, W.E.G. (1966). Productivity and Technical Change, Cambridge: Cambridge University Press (second edition).

34. Seabright, J; Smith, S.G. and Vierbicher, H.L. (1996). Market Conditions Affecting Energy Efficiency Investments, Energy Conversion Engineering Conference, Proceedings of the 31st Intersociety, Vol. 3.

35. Sinton, J.E. and Fridley, D.G. (2000). What Goes Up: Recent Trends in China's Energy Consumption, *Energy Policy*, Vol. 28(10), pp. 671-687.

36. Sobel, R.S. and Coyne, C.J. (2011). Co-integrating Institutions: The Time Series Properties of Country Institutional Measures, Journal of Law and Economics, Vol. 54 (1), pp. 111-134.

37. Stiglitz, J.E. (1999). Whither Reform? Ten Years of the Transition, *Voprosy Economiki*, Vol. 7, Institute of Economics, Russia.

38. Sue Wing, I. (2008). Explaining the Declining Energy Intensity of the U.S. Economy, *Resource and Energy Economics*, Vol. 30, pp. 21-49.

39. Sustersic, J. (2009). Endogenous Gradualism and the Slovenian Puzzle, *China Economic Review,* Vol. 20 (2), pp. 265-274.

40. Sutherland, R.J. (1991). Market Barriers to Energy-Efficiency Investments, *The Energy Journal*, Vol. 12(3), pp. 15-34.

41. Svejnar, J. (2002). Transition Economies: Performance and Challenge, *The Journal of Economic Perspectives*, Vol. 16 (I), pp. 3-28.

42. Turner, K. (2013). Rebound Effects from Increased Energy Efficiency: A Time to Pause and Reflect, *The Energy Journal*, Vol. 34 (4), pp. 25-42.

43. Vickers, J. and Yarrow, G. (1988). *Privatisation: An Economic Analysis*, London: MIT Press.

44. Williamson, J. (1993). Development and the Washington Consensus, *World Development,* Vol. 21(8), 1239-1336.

45. Zhang, F. (2013). The Energy Transition of the Transition Economies: An Empirical Analysis, *Energy Economics*, Vol. 40, November, pp. 679-686.

Appendix

Central Eastern Europe and Baltic States (CEB)	South Eastern Europe (SEE)	Commonwealth of Independent States (CIS)	Others
Croatia**, Estonia*, Hungary*, Latvia*, Lithuania, Poland*, Slovak Republic* and Slovenia*	Albania***, Bosnia and Herzegovina***, Bulgaria*, FYR Macedonia** , Serbia, Romania* and Montenegro***	Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan	Turkey** and Mongolia
*EU members, ** EU candidates and *** Potential EU candidates			

Table A: List of transition countries

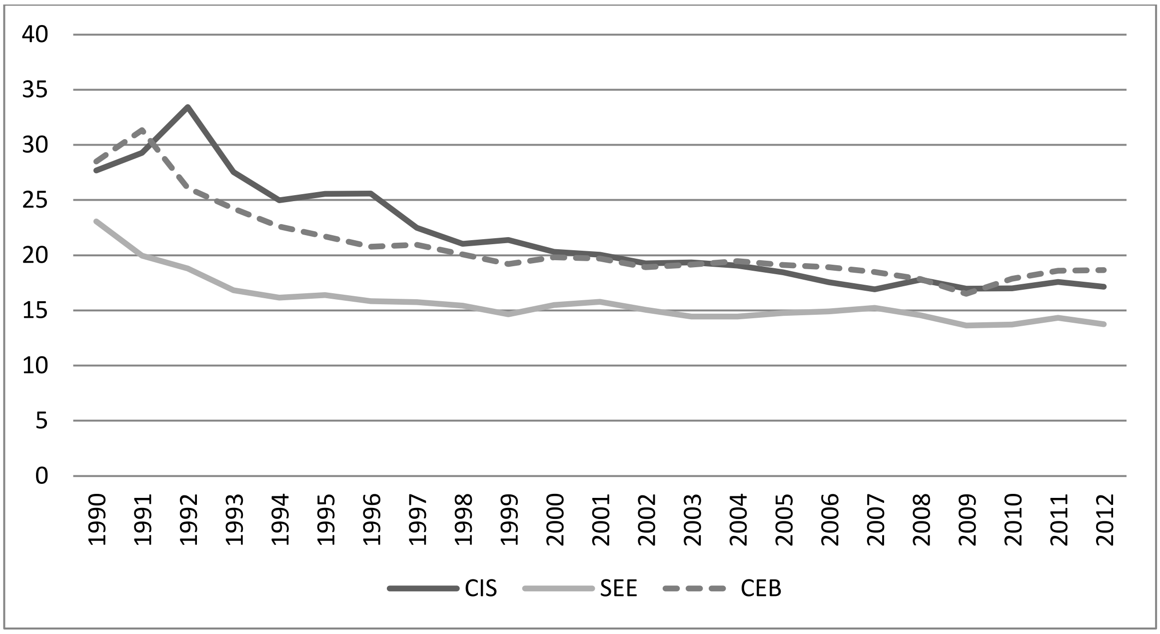

Figure A: Shares of Manufacturing Sector as a percentage of total GDP
Source: UN

Type	Variables	Description	Units	Source
Dependent Variables	LEI	Energy Intensity (log transformed)	Energy Use per $1000 GDP (PPP adjusted)	EIA
Control Variable	SC	Structural Change	Percentage Share of GDP	UN
Independent Variables	EPRI	Electric Power Reform Index	Scaled from 1 to 4+	EBRD
	PRI	Privatisation Reform Index	Scaled from 1 to 4+	EBRD
	OINFRI	Other infrastructure Reform Index	Scaled from 1 to 4+	EBRD
	FRI	Financial Reform Index	Scaled from 1 to 4+	EBRD
	GRI	Governance Reform Index	Scaled from 1 to 4+	EBRD
	OMLRI	Overall Market Liberalization Reform Index	Scaled from 1 to 4+	EBRD

Table B: List of variables