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Keywords market reforms, energy efficiency, transition countries, institutions

JEL Classification P28, Q54, C33

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Economic theory suggests that market-based policies and reforms should promote energy efficiency in developing and transition countries. This paper, therefore, analyses the impacts of a varied set of market-oriented macro-level reforms on macro level energy efficiency across the transition countries. Since the early 1990s, these economies experienced a rapid marketization process which transformed them from central planning towards more market driven economies. The results from the relatively new bias corrected fixed-effect analysis (LSDVC) technique suggest that between 1990 and 2010, reforms in overall market liberalisation, financial sector and infrastructure industries, excluding the power sector, drove the energy efficiency improvements in these countries. Also, privatisation programmes only improved energy efficiency in the SEE countries. Thus, the empirical evidence support market driven energy efficiency policies aimed at addressing the market failures in the network industries and capital markets. We conclude that these results can help explain the energy efficiency policy puzzles in developing and transition countries where energy efficiency improvement can be a leading policy response to growing climate change and security of supply concerns.

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1. Introduction

Since the early 1990s, the 'Washington Consensus' became a standard reference point for economic reforms for many crisis-ridden developing countries (Williamson, 1993). The solution packages included policy measures that were heavily based on economic liberalisation and market reforms. Privatization, deregulation, financial reform, trade liberalisation and reduced role of the state in the economy were some of the major underlying concepts of these market-oriented economic reforms (Rodrik, 1996). Many transition and developing economies adopted a market-oriented approach to economic reforms since then.

The transition countries comprising twenty-nine countries of Central and Eastern Europe and the Former Soviet Union (FSU), in particular, embarked on a programme of market-based macroeconomic reforms starting the early 1990s. The overall structural changes in the economy implied that the energy sector also experienced marketization across these countries. For example, many advanced economies including the OECD countries and over 70 developing and transition countries had introduced some market-oriented reform steps in the electricity sector by the end of 1990s (Jamasb et al., 2005; Nepal and Jamasb, 2012a). While the transition countries are still pursuing liberalised market-based economic reforms at different stages; the empirical evidence on the impacts of the economic reforms in the economy and energy efficiency remains to be examined. This is especially relevant as promoting energy efficiency has become a leading policy response to the growing concerns on greenhouse gas emissions, energy security, costly renewable generation and transmission expansion around the world (Brennan, 2013).

Theory suggests 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). It is believed that a combination of privatization, regulatory reform and liberalisation enhances economic efficiency and improves service standards in all economic sectors (Megginson and Netter, 2001). Improvement in energy efficiency also coincides with the aim of improving overall economic productivity and competitiveness. Efficient use of energy can bring energy costs down and free up resources that can be mobilized elsewhere

more productively. Hence, the reliance on market, both, as a resource allocating agency and as an incentive mechanism can optimize energy allocation. It also incentivises consumers to reduce waste and adopt the most cost-reflective energy saving equipment and appliances (Fan et al., 2007). Furthermore, energy is largely an intermediate input factor in production and as a necessary final consumption good. Thus, effective market signals in the form of cost-reflective energy prices imply that producers 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 (Jorgenson and Wilcoxen, 1993; Popp, 2002, Brenan 2010; 2011).

However, downward pressure on prices may induce a 'rebound effect' by promoting higher energy use and thereby energy inefficiency contradicting the actual motives of liberalised market driven reforms. A direct rebound effect occurs when increased competition resulting from market reforms lowers the cost of energy consumption, and hence increases the consumption of energy because of the substitution effect (Saunders, 1992). 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 is known as the indirect rebound effect (Turner, 2011).

From a policymaking perspective, energy and economic efficiency can be considered to be complementary, though not always coincident goals, under many circumstances (Sutherland, 1991; Brennan, 2013). In addition, liberalised energy policies should be aimed at making markets work better by eliminating market imperfections, mitigating market power through competition policies, and internalizing environmental externalities such as climate change impacts using flexible market-based mechanisms (Joskow, 2001). Hence, it is argued that energy efficiency improvement is strongly linked with various policies aimed at strengthening the effectiveness of a market economy and correcting the market failures (Meyers, 1998; Gillingham et al., 2009; Labandeira and Linares, 2010).

The purpose of this paper is to analyse the impacts of different market-oriented economic reforms on energy efficiency during the two decades of market driven reforms among the transition economies (TECs hereafter) using panel data

econometrics. The TECs being highly energy intensive and energy inefficient prior reforms initiated economic transformation from central planning towards market since the early 1990s allowing us to capture the effects of market-based economic transformation on energy efficiency after more than two decades of reforms. Hence, the lessons drawn from the massive market driven economic transformation process across the TECs can provide a helpful guide to policymakers undertaking energy efficiency programmes in other developing countries.

The remainder of the paper is organized as follows. Section 2 provides an overview of reforms in the transition countries with discussion on the evolution of energy intensity in these countries since reforms. Section 3 presents the conceptual, theoretical and empirical literatures on energy efficiency while reviewing studies that analyses the effects of liberalised market reforms on energy efficiency. Section 4 presents the data and methodology while section 5 discusses the results with model limitations. Finally, Section 6 concludes.

2. The Transition Economies: An Overview

The systemic change of early 1990s marked the end of central planning and paved the way for economy wide market reforms as part of deep political, social and economic transformation in the TECs. Economic liberalization, macroeconomic stabilization, restructuring and privatisation and institutional reforms were the main ingredients of the transformation process. These reforms were also termed as 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). Thus, market reforms incorporated aspects such as the expansion of competitive markets in all sectors of the economy, wide spread private ownership, adoption of appropriate institutions, laws and policies to facilitate market functioning and efficiency, setting standards for good corporate governance and business conduct (EBRD, 2000). Table 1 classifies the transition countries in terms of the European Bank for Reconstruction and Development (EBRD) areas of operation. The countries are divided into three distinct groups Central Eastern Europe and Baltic States (CEB), South Eastern Europe (SEE), and Commonwealth of Independent States (CIS.

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 1: Countries included in the study
Source: EBRD (2001)

The pace and order of the reforms varied across the countries reflecting the constraints on the governments' willingness, ability and resources to transform and adapt to changes. Some countries such as Lithuania, Russia and Slovak Republic opted for instant large scale privatisation as a 'shock therapy' approach towards economic reforms. The absence of appropriate legal framework and institutions often resulted in significant economic and social costs in these countries (Kraakman et al., 2000). In contrast, Belarus and the Caspian countries such as Turkmenistan and Kazakhstan have exhibited greater reluctance towards economic reforms and have not started with the initial reform process of liberalization, small scale privatization and the creation of an economic environment supportive of private sector.

Hence, there is significant heterogeneity and divergence in overall reform progress among the different groups of transition countries after two decades of reforms. The CEB countries have progressed in significantly reforming their economic institutions and power sector as compared to the SEE and CIS countries. However, it is not clear whether the reforming countries have gained more from reforms than the non-reformers. For example, countries such as Albania, Bosnia and Herzegovina, Georgia and Tajikistan already have low levels of energy intensity and carbon emissions intensity despite less reform in the power sector and economic institutions. However, these countries are endowed with large hydroelectric resources and their industries are less energy intensive.

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, 2012b). However, a fundamental characteristic common across all TECs was that these countries were highly energy intensive implying high energy inefficiency. 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 of energy use spurred by low power 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 also led to high energy use in the TECs (Schaffer, 1998).

Historically, the energy consumed per unit of GDP in the transition economies was estimated at four to eight times that of the OECD countries and the United States (Gray, 1995). However, the energy intensities of the TECs have declined since the start of the transition process although the extent of this decline varies greatly across countries (Cornilie and Frankhauser, 2004). Figure 1 shows the evolution of energy intensity across the SEE, CEB and CIS regions since the start of the market-oriented economic reforms. The CIS countries remain highly energy intensive while the energy intensities among the SEE and CEB countries have fully converged since 2000. However, it can be inferred that national energy intensities across all CIS, SEE and CEB regions have declined since the start of the transformation process. The closure of dirty and inefficient plants coupled with the initial economic decline after political independence might have contributed to this fall. Moreover, the extent to which market-oriented economic reforms contributed to the decline in average energy intensities across the transition region since reforms began remains to be examined.

The CIS countries being the most energy intensive have reduced their energy intensity by about one-third since 1994 (EBRD, 2008). However, these countries still use three times more energy as compared to Western Europe to produce a unit of GDP in terms of purchasing power parities (PPP) (Markandya et al., 2006). Countries such as Uzbekistan and Turkmenistan have high energy intensity of GDP indicating the greatest potentials

to reduce the energy-efficiency gap among them while countries like Latvia, Lithuania, and Hungary have similar levels of energy intensities as compared to EU-15, OECD and the US in 2008. Hence, there is a significant potential in the TECs to be more energy efficient and eventually converge at a similar levels with the OECD countries in terms of per capita electricity consumption.

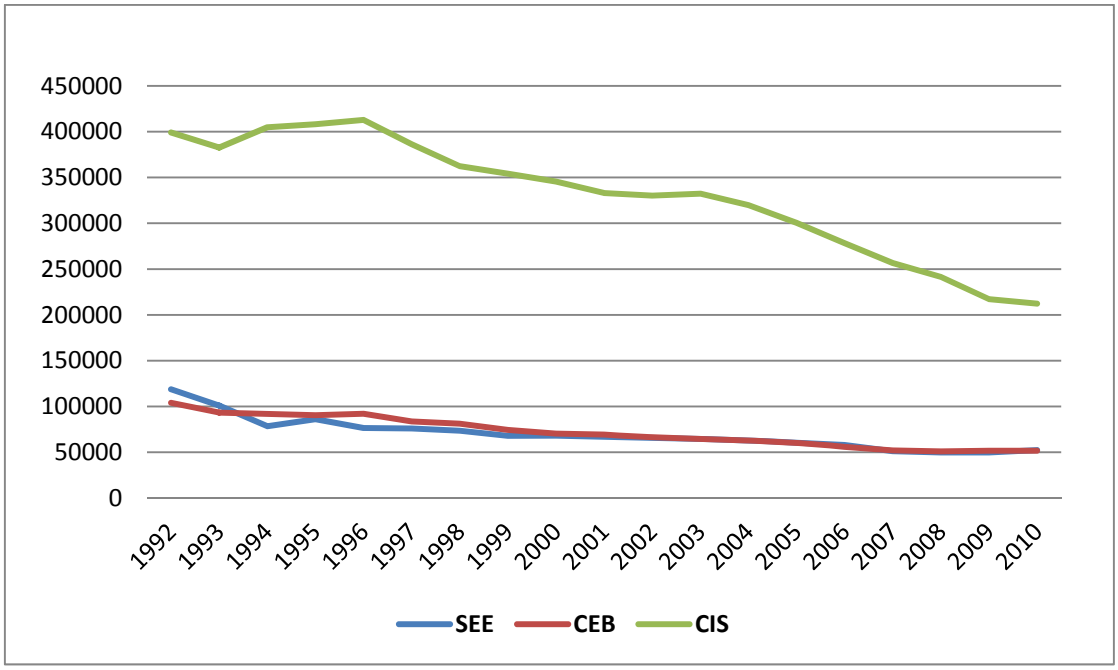

Figure 1: Total primary energy consumption per unit of GDP (Btu per 2005 $US)
Source: Energy Information Administration (EIA)

3. Review of the Literature

Energy Efficiency is among the most intensely discussed and widely implemented targets in energy and environment policy (Brennan, 2013). It generally implies the utilization of energy in the most cost-effective manner such that the output to input ratio is maximised where the level of service is the output, and energy consumed is the input. However, the definitions and understanding of energy efficiency can vary. For example, it is defined as a ratio of energy consumption to GDP at aggregate macro level while it refers to mean energy services provided per unit of energy input at a disaggregated product level (Jaffe et al., 2004). Hence, energy efficiency can be thought as one of a bundle of product characteristics, alongside product cost and other

attributes at the individual product level (Gillingham et al., 2009). The macro level measurement of energy efficiency implies the level of Gross Domestic Product (GDP) of an economy per unit of energy consumed (Metcalf, 2008). Therefore, energy intensity can be used as a proxy or indicator of macro level energy efficiency while its accuracy can be increased by controlling for a range of economic and other technological and behavioural factors (Filippini and Hunt, 2011; 2012).

As such, energy efficiency can be (often contentiously) associated with economic efficiency and the underlying economic changes brought about by changes in economic policies (Hausman and Joskow, 1982; Min et al., 2011; Brennan, 2013). Eyre (1998) states that market-based reforms can affect energy efficiency through the effects of price changes from increased competition, re-regulation of natural monopolies such as electricity networks, the loss of existing regulatory supported mechanisms for energy efficiency and new opportunities for energy efficiency improvement from liberalisation of supply. Sutherland (1991), in general, 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. However, the barriers to energy efficiency remain in the form of imperfect and asymmetric information to energy consumers, bounded rationality and tariff structure and regulation which do not reflect social marginal costs due to neglecting negative externalities, imperfections in the capital markets, significant transactions costs or hidden costs (Sanstad and Howarth, 1994; Eyre, 1998).

The end of a supply monopoly due to a wider adoption of liberalised market reforms can create difficulties in properly mandating demand-side management programmes (Schipper and Grubb, 2000). Most importantly, the success of market-oriented economic reforms can depend on the development of market-based institutional framework to support reforms (Pollitt, 2009). The existence of suitable institutional environment (e.g. rules of the game, which can be explicit, formal or implicit, informal) and institutional arrangements, (so called governance structures) are crucial for the reinforcement of market-based reforms to produce the desired outcomes (North, 1971; Williamson, 1996). Thus, similar approaches to economic reforms can lead to different outcomes depending upon the existing levels of formal and informal institutions created in each country (Sobel and Coyne, 2011). The evolution of energy intensity is also of

greater importance from a policymaking perspective for two fundamental reasons. It allows policymakers to comprehend how energy demand responses to changes in economic system and structure and it contributes to the active policy debate within the transition counties on the link between total energy use growth and GDP growth (Markandya et al., 2006). It also allows the policymakers to identify the measures to reduce the energy-efficiency gap. The energy-efficiency gap exists due to differences in the actual and optimal energy use (Jaffe and Stavins, 1994).

However, only a few studies have empirically discussed the impacts of market reforms on energy efficiency in the international and regional context. Sinton and Fridley (2000) showed 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) documented 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). Fan et al. (2007) showed 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 substitution between energy and non-energy (capital and labour) in China during the periods 1979-1992 and 1993-2003. Their study concludes that raising energy prices can significantly contribute to energy conservation in China.

In the context of transition countries, two studies are of notable importance. Cornilie and Frankhauser (2004) studied the evolution of energy intensities in these countries from 1992 to 1998 by decomposing the energy intensity data and using panel data model based on random effects to identify the main factors driving improvements in energy intensity. The study concluded that energy prices and progress in enterprise restructuring are the two most significant drivers for efficient energy use. Another study by Markandya et al. (2006) examined convergence in energy intensity among twelve countries of Eastern Europe and the European Union (EU) members using forecasted energy intensities values from 2000 till 2020. A two way fixed effects model was 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 suggested that the rate of convergence in energy intensities varies across these countries. Hence, both studies, to some extent, conform to the notion that the transition towards a more market driven economic reforms contributed to a fall in energy intensities among the transition countries.

However, the empirical results from these studies can be complemented by accounting for the bias arising from using static fixed effect analysis in a small dataset. This is because it is well established in econometric literature that an individual-specific fixed effect model engenders biased estimates in the absence of a large and comprehensive datasets as a static fixed effect model is typically designed for dataset with large 'N' and small 'T' (Cameron and Trivedi, 2009). Thus, there is a need to correct for such bias in the estimates when the sample size is small. It is also likely that individual country specific and relatively time-invariant characteristics that are unobservable and non-measurable such as culture, legal origin, geographical location and history and are fixed over time are likely to be correlated with the various economic reforms and thereby contradicting the use of random effects. Likewise, the limited number of cross-sections 'N' used in earlier studies implies that the data represents a finite sample and not a random sample. Moreover, dynamic models can capture the effects of economic reforms on outcomes which are not instantaneous but rather lagged. Hence, this paper uses a bias-corrected fixed effect (LSDVC) analysis to study the impacts of various market reforms on energy efficiency from 1990 to 2010 in transition countries.

Furthermore, the quantitative evidence on the linkage between market-oriented economic reforms and energy efficiency also remains relatively unexplored in the economics literature. Such analyses are important for policymakers considering the policies puzzles surrounding energy efficiency in the light of climate change and security of supply concerns towards economic development[1]. This paper, thus, aims to contribute towards the relatively scarce literature and aims to bridge the knowledge gap by examining the drivers of energy efficiency improvement in the transition countries covering two decades of overall market-oriented reform process in the transition countries since 1990.

[1] See Brennan (2013) for energy efficiency policy puzzles.

4. Data and Methodology

This paper uses the 'Transition Indicators' developed by the European Bank for Reconstruction and Development (EBRD) to investigate the drivers of energy efficiency in the transition countries since the start of the transition period. The indicators assess the progress of market based reforms in transition economies. The reform assessments are made in 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 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).

Cornilie and Frankhauser (2004) have used the EBRD index. However, the reforms aspects analysed were limited to a shorter timeframe as compared to those used in this paper. They also use the reform indices as available in the EBRD report. In contrast, the present paper constructs the following economic reform indicators from the set of nine indicators to summarize and reflect the different types of market driven economic reforms in the transition countries:

- *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 waste water and telecommunication.
- *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)***: electric power reform index alone.

The reform in the railway sector is excluded due to many missing observations while the reform progress in the power sector is considered as a separate reform variable from other infrastructural reforms. This is because the economic importance of the sector to the national economy meant that the power sector reforms were critical in determining the pace and direction of overall economic reforms in the transition countries (Nepal and Jamasb, 2012b). Similarly, the paper uses energy intensity (ratio of total energy consumption and GDP) as a measure of energy efficiency (EI) across the transition countries. The data on energy intensities were obtained from the U.S. Energy Information Administration (EIA). Further, the energy intensity estimates are adjusted for purchasing power parities (PPP) to remove the price level differences levels across countries for comparison. The logarithmic transformed energy efficiency estimate is denoted by LEI. The log transformation captures the underlying distribution of the residuals used in our model. Table 2 reports the list of variables used in this study.

The period of analysis ranges from 1990-2010 (20 years) covering 27 countries as the year '1990' marks the dawn of economic transformation in most of the transition countries. Some of the transition countries have already obtained a membership at the EU while some are in the process of being an EU member and have the potential for joining EU. Table 1 shows the status of the countries included in the sample in terms of EU accession. As shown in the table, 15 out of 27 countries included in our sample are associated with the EU while 7 out of 9 EU members in the sample belong to the CEB region. Turkey and Montenegro[2] are excluded from the sample of countries studied due to data unavailability on the predictor and criterion variables respectively.

[2]Montenegro became an independent state from 3 June 2006.

Type	Variables	Description	Units	Source
Dependent Variables	LEI	Energy Intensity (log transformed)	Energy Use per $1000 GDP (PPP adjusted)	EIA
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 2: List and description of variables

The data thus comprises an unbalanced panel including 27 cross-sections or countries (N) with short time series (T) of 20 years that captures the key reform period from 1990-2010. Each cross-section represents a diverse set of countries with its own economic, political, cultural system and history allowing the possibility for individual country-specific characteristics to influence the behaviour of other. As such, panel data econometric methods consisting fixed effects (FE) and random effects (RE) estimators can account for unobserved heterogeneity as established in econometric literature. The FE and RE estimators differ in their assumptions about the unobserved heterogeneity and a Hausman test is appropriate when applying RE and FE (Hausman and White, 2008). We use the FE estimator to account for unobserved heterogeneity given that the countries included in our sample are not identical to each other. This also fundamentally violates the assumption of RE model. Further, 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[3].

[3] A static FE model can be specified as $y_{it} = \beta_0 + X_{it}\beta + \alpha_i + \varepsilon_{it}$ which can be estimated using commands 'xtreg' or 'xtregar' for AR (1) estimates in STATA.

However, the relationship between overall market-oriented economic reforms and energy efficiency is complex as the implementation of economic reforms does not instantaneously lead to improved 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 can be expressed as

$$y_{it} = \beta_{0+} \rho y_{it-1} + X_{it}\beta + \alpha_i + \varepsilon_{it} \quad (1)$$

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, 2006). 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 understood 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) has been developed by Bruno (2005) which can be applied under 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[4]. 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)[5].

An alternative to dynamic LSDV panel estimates would be to use other consistent Instrumental Variable (IV) and Generalized Methods of Moments (GMM) estimators (Roodman, 2006). 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 individual components score as regressors also conforms to the exogenous selection rule as a requirement for performing LSDVC while the technique in itself is relatively new and largely unused[6]. Equation 3 examines the reform impacts on energy across the whole sample controlling for EU membership by introducing a dummy variable EUM while equation 4 models the reforms impacts on energy efficiency across the specific country groups (SEE, CEB and CIS).

[4]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 also includes one lag by default.
[5]Another estimator that could be used is the Blundell-Bond (BB) estimator. The BB estimator assumes that the first differences of the instrumental variables are uncorrelated with fixed effects and augments the AB estimator by allowing for introducing more instruments and improve efficiency of the estimates (Blundell and Bond, 1998).
[6]Recent applications of LSDVC includes Sen and Jamasb (2012) and Nepal and Jamasb (2012b). The former study is an analysis of determinants and impacts of electricity reforms across the Indian states while the latter study examines the impacts of overall economic reforms in the power sector among the transition countries.

$$LEI_{it} = \beta_{0+} \rho LEI_{it-1+} \beta_1 PRI_{it} + \beta_2 OINFRI_{it} + \beta_3 GRI_{it} + \beta_4 FRI_{it} + \beta_5 OMLRI_{it} + \beta_6 EPRI_{it} + \beta_7 EUM + \varepsilon it \quad (3)$$

$$LEI_{it} = \beta_{0+} \rho LEI_{it-1+} \beta_1 PRI_{it} + \beta_2 OINFRI_{it} + \beta_3 GRI_{it} + \beta_4 FRI_{it} + \beta_5 OMLRI_{it} + \beta_6 EPRI_{it} + \varepsilon_{it} \quad (4)$$

Table 3 shows the descriptive statistics for the dependent and independent variables. 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 liberalizing the economy as a whole (which involves opening up trade, liberalising foreign exchange and price liberalization in the economy) has been on high agenda of reforms across the transition countries though the extent of progress varies considerably across them.

Variable	Mean	Standard Deviation	Minimum	Maximum	No. of Observations
LEI	4.15	0.27	3.67	4.87	563
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 3: Descriptive statistics of the variables (up to two decimal places)

However, overall price liberalization in the economy has not been necessarily applied to the power sector as all groups of countries considered are still a distance away from cost-reflective pricing of electricity as suggested by the mean reform score[7](EBRD, 2008). Likewise, the governance reform (including competition policy and corporate governance and enterprise restructuring reforms) which is also a proxy measure for institutional reforms seem to have progressed the least. The low governance scores, to some extent, also explain the widespread corruption that these countries faced during

[7]A score of 4 and above would imply that the existence of cost-reflective electricity tariffs.

the yesteryears (EBRD, 2001). 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.

Figure 2 shows the overall progress of market driven reforms among the 9 EU countries included in our sample. Seven of these countries belong to the CEB region while two of them belong to the SEE region. It is evident that Privatisation and reforms in overall market liberalisation stalled after 2000 among the EU members while stagnation in reforms 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 reforms in the electric power sector and financial sector reforms have converged since 2006 among the EU members.

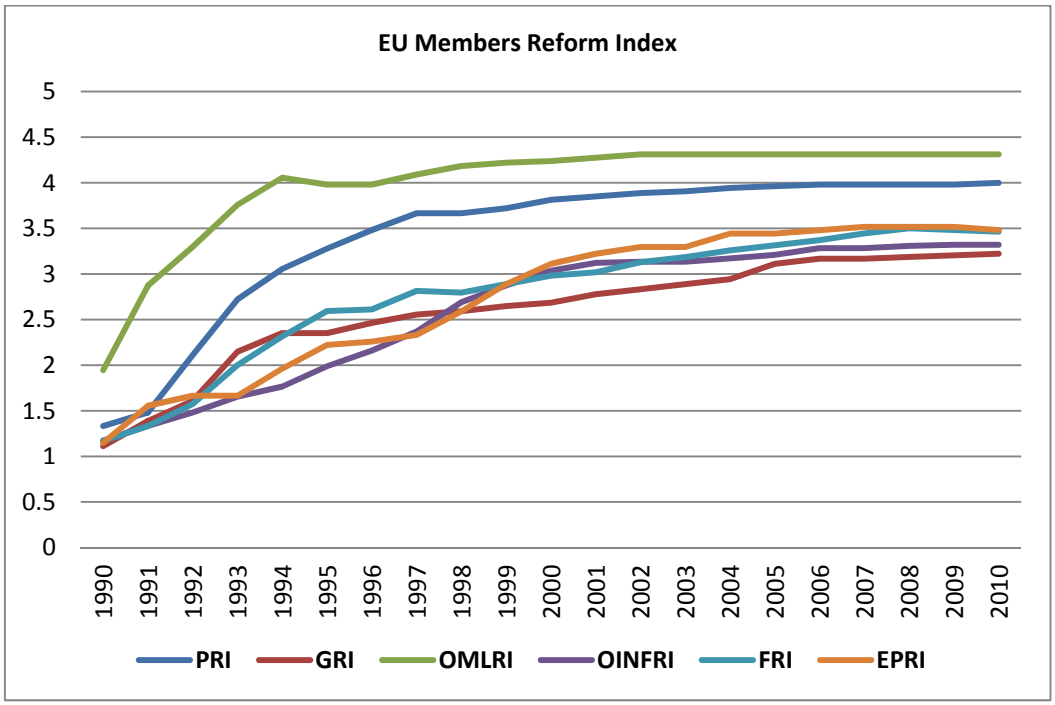

Figure 2: Reform progress among the SEE and CEB EU members (vertical axis denotes indexes)

Similarly, Figure 3 shows the reform progress in all transition countries by specific country groups. The CEB countries lead the reform progress in all sectors while the SEE and CIS countries follow respectively. 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 incentives to join the EU and the underlying motives to benefit from regional integration encouraged and accelerated the market reforms and increased economic openness in the CEB and SEE region.

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 exhibit higher reform progress across all dimensions as compared to the SEE countries during the early phase of transition. This indicates that the CIS countries embraced the shock therapy approach to reforms in the early transition period and later resorted to a more gradual approach. Hence, reforms seem to have progressed again since 2000 after an early upward surge and decline.

Figure 3: Reform progress in the TECs

5. Results and Discussions

This section reports the results estimation obtained using the methodology described in Section 4 to examine the impacts of several market-oriented economic reforms on energy efficiency in the transition countries since the start of the transition period. The regression analysis is based on the relatively new LSDVC technique which allows for third order bias corrections and is initialised by the AH and AB estimators. The standard errors are bootstrapped and obtained from 1000 iterations[8]. The AB tests of autocorrelation and BB test of over identifying restrictions was also performed for the econometric estimations[9].

Table 4 shows the results of the regression analysis based on Equation 3 for the whole sample. The results show that overall market liberalisation and reform in other infrastructure sectors as well as in the financial sector contributed to energy efficiency improvements in transition countries. 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 improved energy efficiency in these countries.

These results are also in line with the earlier findings by Cornillie and Frankhauser (2004) that energy price liberalisation drove the efficient energy use in transition 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.

[8]Bootstrap is a method for measuring the accuracy of sample estimates (see Efron and Tibshirani, 1994) and generates an estimate of the sampling distribution of almost any statistic using simple methods (Varian, 2005).

[9]The results can be provided upon request. Likewise, we also performed an OLS and FE (i.e. LSDV) estimations and compared the results to determine the nature of bias for each hypothesis. In all cases, we observed bias as OLS and FE does not take endogeneity into account.

LSDVC Dynamic Regression (Bootstrapped SE)	Anderson-Hsiao (AH)	Arellano-Bond (AB)
LEI. L1	0.270***	0.262***
	(0.043)	(0.033)
GRI	0.123***	0.123***
	(0.043)	(0.029)
OMLRI	-0.117***	-0.116***
	(0.023)	(0.016)
OINFRI	-0.191***	-0.190***
	(0.035)	(0.024)
EPRI	0.057**	0.056***
	(0.022)	(0.015)
FRI	-0.088**	-0.088***
	(0.044)	(0.030)
PRI	0.046*	0.046**
	(0.031)	(0.021)
EUM	-0.077***	-0.074***
	(0.029)	(0.019)

Table 4: 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. Hence, our results confirms the earlier theoretical arguments by Blumstein et al. (1980), Blumstein and Harris (1993) and Ray (1998) 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 the access to credit can drive the energy efficiency process as experienced in the transition countries.

Likewise, the results also show that the 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 reform score 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.

However, privatisation, governance reforms and reforms in the electricity sector increased the 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 wide-spread corruption, lack of rules and transparency and lack of planning of the process (Stiglitz, 1999; Kraakman et al., 2000[10]). 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 as observed in Table 3. Hence, the progress in governance reforms is not significant enough to improve energy efficiency across these countries.

Likewise, progress of reforms in the electricity sector generated 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 (Kennedy, 2003; Erdogdu, 2011)[11]. 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 can shed a better light on the role of electricity sector reform progress among the TECs[12].

Table 5 shows the impacts of reforms on energy efficiency for specific groups of the TECs. As in Table 4, overall market reforms, other infrastructure and financial sector drove energy efficiency improvements across the TECs except for SEE countries where financial sector reforms had no impact on energy efficiency. Reforms in overall market liberalisation had the greatest impact on energy efficiency of the CEB countries while

[10] See Kraakman et al. (2000) for dirty privatisation.
[11] Figure 2 and Table 2 also supports this argument.
[12] 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 needs to be examined.

reforms in other infrastructures largely affected the energy efficiency of the CIS countries.

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	-0.213 (0.220)	0.020 (0.120)	-0.464*** (0.058)	-0.477*** (0.056)	0.142 (0.092)	0.197 (0.064)
GRI	0.190 (0.127)	0.159 (0.137)	0.144*** (0.026)	0.144*** (0.026)	0.112 (0.139)	0.104* (0.054)
OMLRI	-0.136** (0.071)	-0.157*** (0.029)	-0.183*** (0.043)	-0.184*** (0.042)	-0.137*** (0.050)	-0.138*** (0.016)
OINFRI	-0.132* (0.087)	-0.164** (0.070)	-0.050** (0.021)	-0.049** (0.020)	-0.244** (0.102)	-0.251*** (0.037)
EPRI	0.018 (0.111)	0.038 (0.039)	-0.019 (0.016)	-0.018 (0.016)	0.073 (0.056)	0.076*** (0.020)
FRI	0.202 (0.123)	0.217 (0.159)	-0.078*** (0.028)	-0.077*** (0.027)	-0.091* (0.111)	-0.079** (0.043)
PRI	-0.123* (0.084)	-0.120*** (0.040)	0.121*** (0.026)	0.122*** (0.026)	0.104* (0.062)	0.106*** (0.023)

Table 5: Impacts of economic reforms on energy efficiency (specific groups)

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

Similarly, reforms in the financial sector led to the highest improvements in energy efficiency among the CIS countries. On the other hand, governance reforms negatively affected 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 impact on energy efficiency.

However, 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 theoretical and empirical findings that market-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; Farinelli et al., 2005; Sinton and Fridley, 2000). The state-owned firms were operationally and technically energy inefficient and had under-invested in energy efficiency before the start of the transition process (Hall et al., 2005). Privatisation could have spurred efficient use of energy and the adoption of energy efficient technologies across different economic sectors in the process of minimizing costs and maximising profit in the SEE region. Privatization also led to the collapse of some large energy intensive firms and industries among the TECs (Raiser et al., 2003). In addition, the result reflects the importance of hard-budget constraints among firms in transition post 1990 and the importance of reducing the excessive price support through government subsidies in improving energy efficiency in the SEE countries.

However, the results show that privatisation had an adverse effect on energy efficiency improvements among the CEB and CIS countries indicating that improving economic efficiency (and thereby energy efficiency) was not a major aim of the privatisation process. In addition, privatisation in the CIS countries was marked by widespread corruption and political chicanery (Birdsall and Nellis, 2003).

Results Summary and Limitations

The progress of market driven reforms is characterised by distinct heterogeneity across the TECs. Reforms have progressed the least in the CIS countries primarily reflecting the legacy of central planning. As such, the collapse of central planning was not a choice of any country or government but rather a consequence of dysfunctional political and economic system of early years. Hence, this translated into slow willingness and commitment towards implementing market-based reforms in the CIS countries. This also indicates that there still exists a potential for progress in economic reforms in the CIS countries. On the contrary, the motives to join the EU accelerated reforms in the CEB

and CIS countries after which the process stalled. However, governance reforms and reforms in other infrastructures can still be pursued in these countries.

The varying progress of reforms generated varying magnitude of impacts on energy efficiency. The results show that market and liberalisation reforms, reforms in other infrastructure sectors and reforms in the financial sector are crucial drivers of energy efficiency in transition countries. These results send out two messages to policymakers. Firstly, energy efficiency improvements can be achieved by pursuing polices designed to correct energy market failures and capital market failures through market pricing, reliance on market principals 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.

Similarly, electricity sector reforms and governance reforms generated adverse impacts on energy efficiency. These results send a clear signal to policymakers that reform implementation may not always translated into reform performance or outcome unless implemented properly. This implies that the effect of reforms on energy efficiency performance is a non-linear and complex relationship. Likewise, privatisation generated a mixed impact on energy efficiency improvements. This provides a lesson that only effective implementation of reform measures can achieve the desired outcomes of reforms.

However, our research may have a number of limitations that are worth mentioning like any other research examining the determinants and impact of reforms. The issue of endogeneity can be raised as in other studies on electricity and economic reforms (Erdogdu, 2011). Nonetheless, we believe that the econometric methodology used in this study controls for endogeneity problems to a large extent. Similarly, our model may not capture and reflect all the qualitative dimensions and steps involved in the reforms process. This is because not all aspects of reform outcomes are readily quantifiable in physical and monetary units (Jamasb et al., 2004). The lack of a complete data also prevented us to incorporate relevant aspects such as technological innovations and

changes in energy regulatory practices and study their impacts. Finally, the reform indicators are qualitative in nature and reflect the judgment of EBRD's Office of Chief Economist. However, these scores are updated on a timely basis and thereby a good proxy of reform progress in these countries.

6. Conclusions

The aim of this paper was to provide an empirical contribution to the scarce literature examining the impacts of market driven reforms on energy efficiency. Hence, the paper empirically analysed whether market-driven economic reforms matter in addressing energy efficiency in an attempt to solve the energy efficiency policy puzzles. A bias corrected fixed effect analysis (LSDVC) was used to examine the impact of overall market driven economic reforms on energy efficiency in the transition countries. The transition countries experienced market-oriented economic reforms in all sectors of the economy 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) drove 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 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. Hence, these results provide valuable lessons to policy makers around the world.

However, further research can be pursued to aid policymaking and solving the energy efficiency policy puzzles as climate change, and security of supply concerns continue to pose significant threats for sustainable development in developing and transition countries. Future research may focus on the interaction of the macro-level reforms and the effect of these interaction terms on energy efficiency. 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. Similarly, future research can focus on addressing the effectiveness of market driven polices aimed at correcting the innovation market failures, information problems and potential behavioural failures relevant to energy efficiency improvements in transition countries.

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