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Rabindra Nepal
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Rabindra Nepal[2]

Clem Tisdell[3]

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Tooraj Jamasb[4]

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1 This is a copy of a draft paper completed in early 2015. A revised and extended version of it entitled 'On environmental impacts of market-based responses: Evidence from the European and Central Asian economies' (authors: R. Nepal, T. Jamasb and C.A. Tisdell) will appear this year in *Renewable and Sustainable Energy Reviews*.

2 Business School, Charles Darwin University, Darwin, NT, 0800 Australia. Email: rabindra.nepal@cdu.edu.au

3 School of Economics, The University of Queensland, St. Lucia Campus, Brisbane QLD 4072, Australia Email: c.tisdell@economics.uq.edu.au

4 The Business School, Durham University, Durham, DH1 3LE, UK. Email: tooraj.jamasb@durham.ac.uk

The *Economics, Environment and Ecology* set of working papers addresses issues involving environmental and ecological economics. It was preceded by a similar set of papers on *Biodiversity Conservation* and for a time, there was also a parallel series on *Animal Health Economics*, both of which were related to projects funded by ACIAR, the Australian Centre for International Agricultural Research. Working papers in *Economics, Environment and Ecology* are produced in the School of Economics at The University of Queensland and since 2011, have become associated with the Risk and Sustainable Management Group in this school.

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Economic Reforms and Carbon Dioxide Emissions in European and Central Asian Transition Economies

ABSTRACT

Global warming and other adverse climate change impacts induced by anthropogenic carbon dioxide emissions is a major public policy concern around the world. This paper examines the impacts of market-based economic reforms on per capita CO_2 emissions in the European and Central Asian transition economies where environmental degradation was pervasive prior reforms. A dynamic panel data model is employed for this purpose for 28 countries covering 22 years from 1990-2012. Our results suggest that reforms in competition policy and corporate governance are the significant driver of emissions reductions in the region. Therefore, advances in competition policy and governance reforms are desirable given the available scope to extend these reforms. The Kyoto Protocol had no significant effect in reducing emissions levels while the relationship between economic growth and emissions seems weak based on our results. The results indicate that reducing energy use by increasing energy efficiency and investments in renewable energy are necessary to reduce the carbon emissions level and mitigate the adverse impacts of climate change in the region.

Keywords: transition, CO_2 emissions, reforms, environmental policy, climate change

JEL Classification: Q57, Q54, P27, P28

Economic Reforms and Carbon Dioxide Emissions in European and Central Asian Transition Economies

1. Introduction

The early 1990s marked the end of command-based policies in former member nations of the now defunct Soviet Union. They become transition economies (TECs) in the early 1990s and embarked an era of market-based economic reforms in response to pervasive political, social and economic pressures[1]. Economic liberalization, macroeconomic stabilization, restructuring and privatisation and institutional reforms were the main ingredients of this transformation process (Williamson, 1993). These reforms were termed Type I reforms while Type II reforms included the design and enforcement of laws, regulation and supportive institutions to buttress and facilitate the functioning of the market-based reforms (Svejnar, 2002).

The transition process vividly exposed the broad-scale environmental degradation that took place during the command-based regime in these countries (Soderholm, 2001). High levels of airborne particulates from industrial and household sources; widespread contamination of soil and water from toxic chemicals and nitrates; and a persistent negligence of nuclear safety and waste management issues were some of the common and urgent environmental problems identified in the fifth European Community Environmental Action Programme (EAP) for Central and Eastern Europe in 1993. The legacy of industrial inefficiency, obsolete and polluting technologies coupled with weak environmental management and regulation prior to their economic reforms had exacerbated ecological woes in the region.

The fifth EAP was a powerful forum as the meeting identified the long-term European environmental agenda for the decades to follow. A central principle of the EAP was that the process of economic reforms and restructuring associated with the transition were expected to eliminate the perverse incentives that underlay many of the ecological problems of the centrally planned economies (Hughes and Lovei, 1999). The importance of effective environmental policies; institutions and investments in supporting the market-based reforms improving the environmental performance of developed economies was also recognised. Now, 20 years after

[1] The transition economies, in this study, comprise the countries of Central Europe and Baltic States (CEB), South East Europe (SEE) and Eastern Europe and the Commonwealth of Independent States (CIS) belonging to the Soviet Union (FSU).

the commencement of economic reforms by European and Central Asian TECs, it is possible relying on available empirical data to determine the extent to which their market reforms resulted in environmental experiments such as reduced air pollution. Has the prediction of the fifth EAP been vindicated? The purpose of this paper is to investigate empirically the extent to which this is true for reductions in carbon dioxide (CO_2) emissions by this group of countries.

Improving air quality by reducing the amount of air pollutants such as carbon dioxide (CO_2) in the atmosphere has been an actively pursued global agenda since the 1992 United Nations Framework Convention on Climate Change (UNFCC) came into force. The Kyoto Protocol, which extended the UNFCC, was adopted in Kyoto on 11 December 1997 and entered into force on 16 February 2005 while the first commitment period expired in 2012. All the TECs in the group considered here had agreed to cap and eventually reduce their emissions of CO_2 considering the international importance of combating global warming. However, to what extent international climate change agreements like Kyoto Protocol (a post Kyoto analysis) reduced the CO_2 emissions of these countries remains an important empirical question.

The European and Central Asian (ECA) TECs still contribute about 15 percent of the greenhouse gas emissions (GHGs) even though carbon emissions have fallen substantially since 1990. For example, the transition region is the only major region in the world where per capita carbon emissions fell substantially by about 28 per cent between 1990 and 2008 despite an average increase in real GDP in this region by about 22 per cent over the same period (EBRD, 2011). This fall in CO_2 emissions can be attributed to the combined effects of economic reform and other underlying factors such as economic growth, investments in clean energy, changed composition of energy use, environmental policies and compliance with the EU directives that could potentially affect the trends in total emissions and environmental quality. However, the extent of impacts of economic reforms and other underlying factors on the falling levels of CO_2 emissions in the TECs is unknown in the existing literature. Furthermore, the region still includes some of the most carbon intensive countries in the world such as Russia, Turkmenistan, Uzbekistan, Kazakhstan and Ukraine implying that there is much scope for improvement in environmental quality.

The purpose of this study is to evaluate the impacts of the transition process on environmental quality concentrating on comparisons of changes in CO_2 emissions among fast and slow reformers in the ECA TECs by capturing the combined effects of their economic reforms, growth, environmental interventions and studying trends. The econometric evidences obtained

from this study aims to deliver two major objectives. First, there is a paucity of published econometric studies gauging the impacts of market-oriented economic reforms on environmental quality in TECs. This is particularly so for ECA TECs. This study helps to fill this gap and identifies the main drivers of CO2 reductions in ECA TECs. Secondly, identifying the drivers of CO_2 emissions reductions will guide policymaking on combating climate change in the TECs, as the TECs will have to further reduce emissions over the coming decades to achieve the required scale of global emissions reductions.

The remainder of the study is organized as follows. Section 2 reviews the relevant literature on the relationship between economic reforms, environmental regulations and environmental quality. Section 3 describes the econometric methodology and data used while the results are presented and discussed in section 4 along with relevant policy implications. Section 5 concludes the paper.

2. Review of Relevant Literature

The empirical literature on the relationship between CO_2 emissions and economic growth is large and is beyond the scope of this paper to review extensively. In general, the relationship between several indicators of environmental degradation and income can be typified by an inverted U-shaped relationship. This relationship is referred as the Environmental Kuznets Curve (EKC) and was originally proposed by Seldon and Song (1994) implying that pollution becomes a diminishing problem as per capita income rises large enough. In 1995, Grossman and Krueger (1995) studied the EKC following cross-country studies on urban air pollution (sulphur dioxide emissions and smoke) and several indicators of water pollution as measures of environmental degradation. The EKC, hence, is a hypothesized relationship between indicators of environmental degradation and economic development which shows that the intensity of environmental degradation tend to increase as modern economic growth occurs until average income reaches a certain point over the course of development. Several empirical studies such as Shafik (1994), Hilton and Levinson (1998), Harbaugh, Levinson and Wilson (2002), Dinda (2004) have confirmed this relationship although the functional form and data properties can influence findings about the existence of an EKC curve. Other studies such as Tisdell (2001), Stern (2004, 2014), Perman and Stern (2003) underscore the limitations of EKC and outline the conditions under which the EKC relationship may not exist such as heterogeneity, spurious regressions and spatial dependence.

Another strand of literature focusses on the relationship between economic openness and environmental quality. Economic globalisation and trade openness is viewed as a possible positive force for environmental improvement and as a major factor increasing the likelihood of sustainable development through its likely boost to global investment (Tisdell, 2001). Earlier empirical studies such as by Dean (2002); Copeland and Taylor (2004) and Frankel and Rose (2005) have confirmed a positive relation between trade openness and environmentally quality. The impact of environmental regulation and policy on environmental degradation has also been captured by several studies. Grunewald and Martinez-Zarzoso (2009) found in testing the theory of the EKC while taking account of environmental regulations that Kyoto obligations had a reducing effect on CO_2 emissions in both developed and developing countries. Iwata and Okada (2014) found that the effects of commitment to the Kyoto Protocol significantly reduced the CO_2 emissions among 119 countries from 1990 to 2005. Similarly, Jalil and Habibullah (2013) estimated that Kyoto commitment and Kyoto Clean Development Mechanism produced a statistically significant effect in reducing $C0_2$ emissions in Asia and the Pacific region for the period 1971-2009. Aichele and Felbermayr (2011) conducted the first ex-post empirical evaluation of Kyoto Protocal to analyse the carbon content of bilateral trade. The results showed that Kyoto has led to carbon leakage among countries. Carbon leakage implies that environmental regulation and restrictions in some countries could change relative goods prices and hence shift production of CO_2 intensive goods to countries that are exempt from such restrictions (Copeland and Taylor, 2005). For example, it is possible for higher income countries to reduce their pollution intensities by shipping very polluting industries offshore (such as in China and India) as growing environmental restrictions usually add to the private costs of locating eco-unfriendly businesses in higher income countries.

Governance issues such as corruption and absence of democracy can also result in socially sub-optimal environmental policy and regulation. Lopez and Mitra (2000), Damania, Fredriksson and Mani (2005) and Pelligrini and Gerlagh (2005) show that the existence of corruption has a negative effect n reducing environmental degradation. Moreover, Cole, Elliott and Fredriksson (2006) found that foreign direct investments (FDI) was associated with less stringent environmental policy when the corruption level is very high. Damania, Fredriksson and List (2003) analysed the joint effect of trade openness and corruption on the stringency of environmental policy. Their estimated results showed that trade openness increased the stringency of environmental policy in countries with more corruption (low governance). Halkos and Tzeremes (2013) empirically revealed a high nonlinear relationship between

countries' CO_2 emissions and the incorporated governance measures such as voice and accountability; political stability and absence of violence; government effectiveness; regulatory quality; rule of law and control of corruption. Their findings showed that increasing the quality of countries' different governance factors does not always result to lower carbon dioxide emission levels.

Pellegrini and Gerlagh (2005) found a negative and statistically significant impact of corruption on environmental polices while the presence of democracy produced a limited positive impact. Right-wing governments in OECD countries are found to be associated with less reduction of CO_2 emissions than centre and left-wing governments (Garmann, 2014). In the context of transition economies, environmental problems can also be due to institutional inertia in the economic and political system and are not necessarily only a result of market imperfections (Soderholm, 2001). The stringency of environmental policies set under decentralised regimes also depends on political centralization, measured by the strength of national level political parties (Fredriksson and Wollscheid, 2014).

Zugravu, Millock and Duchene (2008) demonstrated that increases in stringency of environmental policy led to a significant net reduction in CO_2 emissions among the Central and Eastern European countries between 1995 and 2003 even though their output growth increased industrial CO_2 emissions. The results confirmed the importance of institutional factors in reducing pollution in transition countries. Another study by Tamazian and Rao (2010) investigated the linkage between economic development, financial development and institutional quality on environmental degradation in transition countries. The results lend support to the EKC hypothesis while also confirming the importance of both institutional quality and financial development for environmental performance in the region. They pointed out that financial liberalization may be harmful for environmental quality among the transition countries if it is not accompanied by a strong institutional framework. These existing studies do not study the effect of market-based economic reforms on environmental degradation controlling the effects of economic growth, environmental policy, investments in clean energy and energy consumption patterns. This presents a major gap in the literature which this study aims to fill.

3. Methodology and Data

The relationship between market-oriented economic reforms and environmental degradation is

complex, as the implementation of economic reforms does not instantaneously lead to reductions in per capita CO_2 emissions. 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). This necessitates specifying a dynamic panel data model can be expressed as:

$$y_{it} = \rho y_{i,\,t-1} + x'_{it}\beta + \alpha_i + \epsilon_{it}\,; \qquad |\rho| < 1;\ i = 1,\ldots\ldots N \text{ and } t = 1,\ldots\ldots,T \tag{1}$$

where y_{it} is the dependent variable, x_{it} is the { (k – 1) * 1 } vector of strictly exogenous explanatory variables, ρ is the coefficient of the lagged value of the dependent variable, α_i is an unobserved individual effect, $x'_{it}\beta$ represents the matrix of explanatory variables and coefficients and ϵ_{it} is an unobserved white-noise disturbance with constant variance. However, econometric literature establishes that a dynamic panel data model based on fixed-effects or the Least Squares Dummy Variables (LSDV) analysis with a lagged dependent variable generates biased estimates when 'T' is small as is the case here (Roodman, 2006). Kiviet (1995) that produced the lowest Root Mean Square Error (RMSE) for panels of all sizes (Bun and Kiviet, 2003) devised a bias-corrected LSDV estimator applicable only for balanced panel.

These earlier works led to the development of a bias-corrected LSDV estimate (LSDVC) by Bruno (2005) for unbalanced panels as in our case. The approximation terms are all evaluated at the unobserved true parameter values implying no direct use for estimation. Hence, the true parameter values are replaced by estimates from some consistent estimator to make them work (Bruno, 2005). The estimates obtained from a dynamic LSDV are also not meaningful unless they are corrected for bias in small samples. The preferred estimator is then plugged into the bias approximations formulae while the resulting bias approximation estimates β_{i_hat} are deducted to derive the corrected LSDV estimator as

$$LSDVC_i = LSDV - \beta_{i\_hat} \tag{2}$$

where i=1 in STATA by default indicates the accuracy of the bias approximation[2]. To initialize the bias corrections, a consistent estimator needs to o be chosen and could vary could vary, for

[2] The estimation includes one lag by default.

example, between the Arellano-Bond (AB) and the Blundell-Bond (BB) estimators (Bruno, 2005). The AB estimator is a GMM estimator for the first differenced model relying on a greater number of internal instruments (Arellano and Bond, 1991). 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).

An alternative to LSDVC 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, AB and BB estimators by Bruno (2005) for unbalanced panels with small 'N' concludes that LSDVC is superior to 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 based economic reforms on per capita CO_2 emissions in transition countries and report the results for the estimators used to initialize the bias corrections (AB and BB). Equation 3 examines the reform impacts on emissions across the whole sample while equation 4 models the reforms impacts on missions across the specific country groups (SEE, CEB and CIS) of TECs.

$$PCEMS_{it} = \rho PCEMS_{it-1+} \beta_1 PVTI_{it} + \beta_2 OMLRI_{it} + \beta_3 GRI_{it} + \beta_4 CMPI_{it} + \beta_5 EUM + \beta_6 SREN_{it} + \beta_7 ENVMP + \beta_8 PGDP_{it} + \beta_9 PECS_{it} + \epsilon_{it} \quad (3)$$

$$PCEMS_{it} = \rho PCEMS_{it-1+} \beta_1 PVTI_{it} + \beta_2 OMLRI_{it} + \beta_3 GRI_{it} + \beta_4 CMPI_{it} + \beta_5 SREN_{it} + \beta_6 PGDP_{it} + \beta_7 ENVMP + \beta_8 PECS_{it} + \epsilon_{it} \quad (4)$$

We use the revised and updated (in 2012) version of the 'Transition Indicators' developed by the European Bank for Reconstruction and Development (EBRD) as a measure of progress of market-based economic reforms across the TECs. The reform assessments are made in six areas which includes 1) large scale privatization, 2) small scale privatization, 3) governance and enterprise restructuring, 4) price liberalisation, 5) trade and foreign exchange system and 6) competition policy. 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. Progress is measured against the standards of industrialized market economies, while recognizing that there is neither a "pure" market

economy nor a unique end-point for economic transition (EBRD, 2014). For example, a score of 4+ in competition policy reforms imply that there is unrestricted entry to most market and competition policy is effectively enforced representing the standards and performance typical of advanced industrial economies. Likewise, a score of 1 indicate no competition legislation and institutions in place.

We construct the following economic reform indicators from the set of six 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)**: comprising corporate governance and enterprise restructuring reforms.*
- *Overall Market Liberalization Reform Index **(OMLRI)**: composite index based on un-weighted average of reforms in price liberalization and trade and foreign exchange reforms.*
- *Competition Policy Reform Index **(CMPI)**: comprising competition policy reforms.*

Per capita CO_2 emissions are used a measure of environmental degradation in this study[3]. We focus on CO_2 because CO_2 emissions (from fossil fuel use, deforestation, biomass decay and others) are the largest source of GHGs accounting for around 75 percent of the total emissions globally in 2010 (IPCC, 2014). Hence, the contribution of CO_2 emissions to global warming and inducing adverse climate change impacts is internationally recognised implying that reducing CO_2 emissions is an issue of global importance. The data on CO_2 emissions is also rich and publicly available as compared to other measures of environmental degradation. We control for the effect of economic growth on carbon emissions by including per capita Gross Domestic Product (GDP) as an indicator of economic growth in the econometric model. The literature studying the relationships between emissions and growth supports this inclusion (Grossman and Krueger, 1991).

We also account for the effect of energy use by using per capita energy consumption as a control variable. This is important as energy use contributed around 35 percent of CO_2

[3] Carbon dioxide emissions are the economy wide emissions levels as reported in the WDI.

emissions in 2010 (IPCC, 2014). The share of carbon-neutral generation technologies in the generation mix such as renewable energy (SREN) is important in reducing the reliance on emissions intensive generation technologies in the TECs. Furthermore, countries joining the European Union (EUM) have established a common framework for the use of energy from renewables sources aiming to obtain 20 percent of their energy from renewable sources by 2020. We explicitly control for the existence of an environmental policy (ENVMP) by considering the ratification/acceptance of the Kyoto Protocol by the TECs. This is binary variable and captures the different timings of acceptance/and ratification of the Kyoto Protocol by the ECA TECs.

Capturing the extent of emissions reductions effects during the first commitment period of Kyoto Protocol can provide guidance to these countries on the important aspects to be agreed during the future commitment periods of the Protocol. Population growth is an important factors so all comparisons are on per-capita basis. Further, the per capita GDP is adjusted for purchasing power parities (PPP) to remove the price level differences levels across countries for comparison. Table 1 reports the list of variables used in this study.

Table 1: List and description of variables

Type	Variables	Description	Units	Source
Dependent Variables	PCEMS	Per Capita CO_2 Emissions	Metric tons per capita	World Development Indicators (WDI)
Independent Variables	PVTI	Privatisation 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
	CMPI	Competition Policy Reform Index	Scaled from 1 to 4+	EBRD
	PGDP	Per Capita GDP	Constant 2011 international US dollars	WDI
	PECS	Per Capita Energy Consumption	Million Btu per capita	Energy Information Administration (EIA)
	SREN	Share of Renewable Energy Generation	Ratio	EIA
	ENVMP	Environmental Policy	Binary variable	UNFCC

The period of analysis ranges from 1990-2012 (22 years) covering 28 countries (out of 34) in the EBRD areas of operation. The year '1990' marks the dawn of economic transformation in most of the ECA transition countries. Some of the transition countries have already obtained a membership at the EU while some are in the process of being a EU member and have the potential for joining EU. Out of the included 28 countries in our sample, 15 are associated with the EU while 7 out of 9 EU members in the sample belong to the CEB region. Table A1 in Appendix lists the countries included in our analysis[4]. Thus, the data comprises an unbalanced panel including 28 cross-sections with short time series of 22 years that captures the key reform period from 1990-2012.

Table 2 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 (even stalled) process in many transition countries (Nepal, Jamasb and Tisdell, 2014). 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. There is significant scope for advancing competition policy and governance reforms in these countries as the average reform scores are far below the 4+ levels observed in industrialized market economies. The average share of renewable energy installed capacity in the total energy mix is only around 30 percent across the TECs. Table A2 in the Appendix reports the correlation estimates among the variables.

[4] We exclude Turkey, Egypt, Kosovo, Jordan, Tunisia and Morocco from our analysis due to lack of the data although they fall within EBRD areas of operation.

Table 2: Descriptive statistics

Variable	Mean	Standard Deviation	Minimum	Maximum	No. of Observations
PCEMS	5.46	3.37	0.293	15.895	573
PGDP	10294.5	6647.5	1040.23	31057.57	610
SREN	0.294	0.284	0	0.913	590
PECS	3089.017	1456.7	398.25	7137.83	629
PVTI	2.96	0.96	1	4.17	644
GRI	2.05	0.77	1	3.7	644
OMLRI	3.49	0.994	1	4.33	644
CMPI	1.99	0.74	1	3.7	644

The average amount of CO_2 emissions per capita is around five and half tonnes. There are also large disparities both in changes in emissions between 1990 and 2008 such as a reduction of 56 percent in Eastern Europe and the Caucasus to an increase in emissions by 108 percent in Turkmenistan (EBRD, 2011). The region still includes some of the worst performers in the world in terms of carbon intensity (like Uzbekistan, Kazakhstan and Russia), along with countries such as Latvia and Hungary, which are close to the global leaders in carbon performance. Figure 1 shows the evolution of per capita CO_2 emissions across specific groups of TECs. All these groups experienced a significant decline in emissions during the early phase of economic transition. The early phase of economic transition was marked by a decline in real GDP and economic activities in the region. The per capita emissions experienced a decade of decline (especially among the SEE countries) but began to gradually rise after 2000 and continued to do so until the global economic recession trigged by the global financial crisis during 2008-2009. While the level of regional greenhouse gas emissions began rising again after 2000, the rate of its increase has been much lower than economic growth (EBRD, 2011). Since 2010, per capita emissions have been rising across the CEB and CIS country groups. However, the average per capita emissions have fallen in the SEE region as a result of the impact on these economies due to Eurozone crisis of 2011-2013.

Fig 1: Per capita $C0_2$ Emissions in the ECA TECs

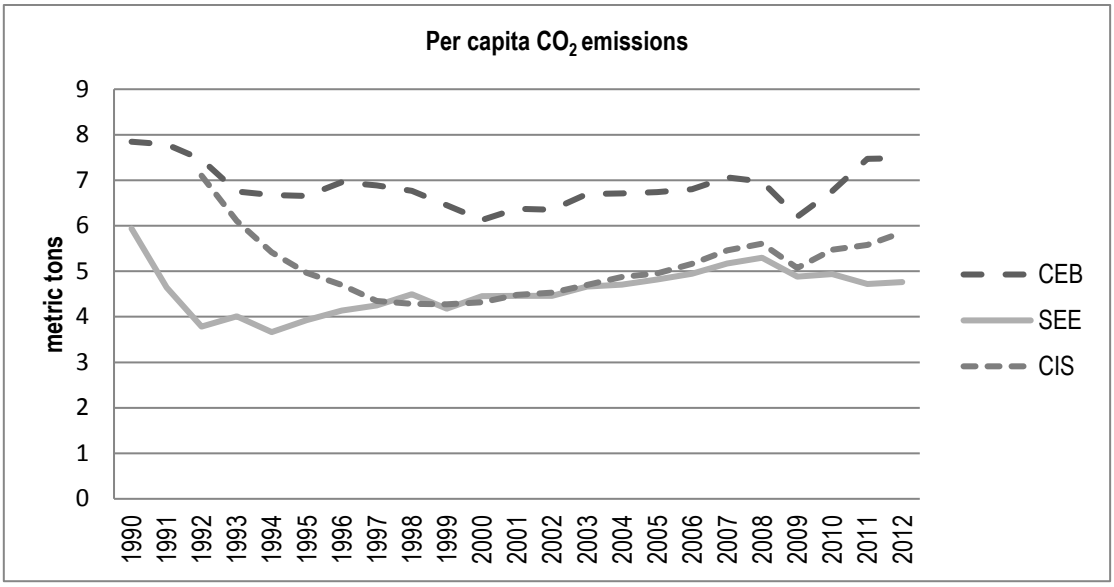
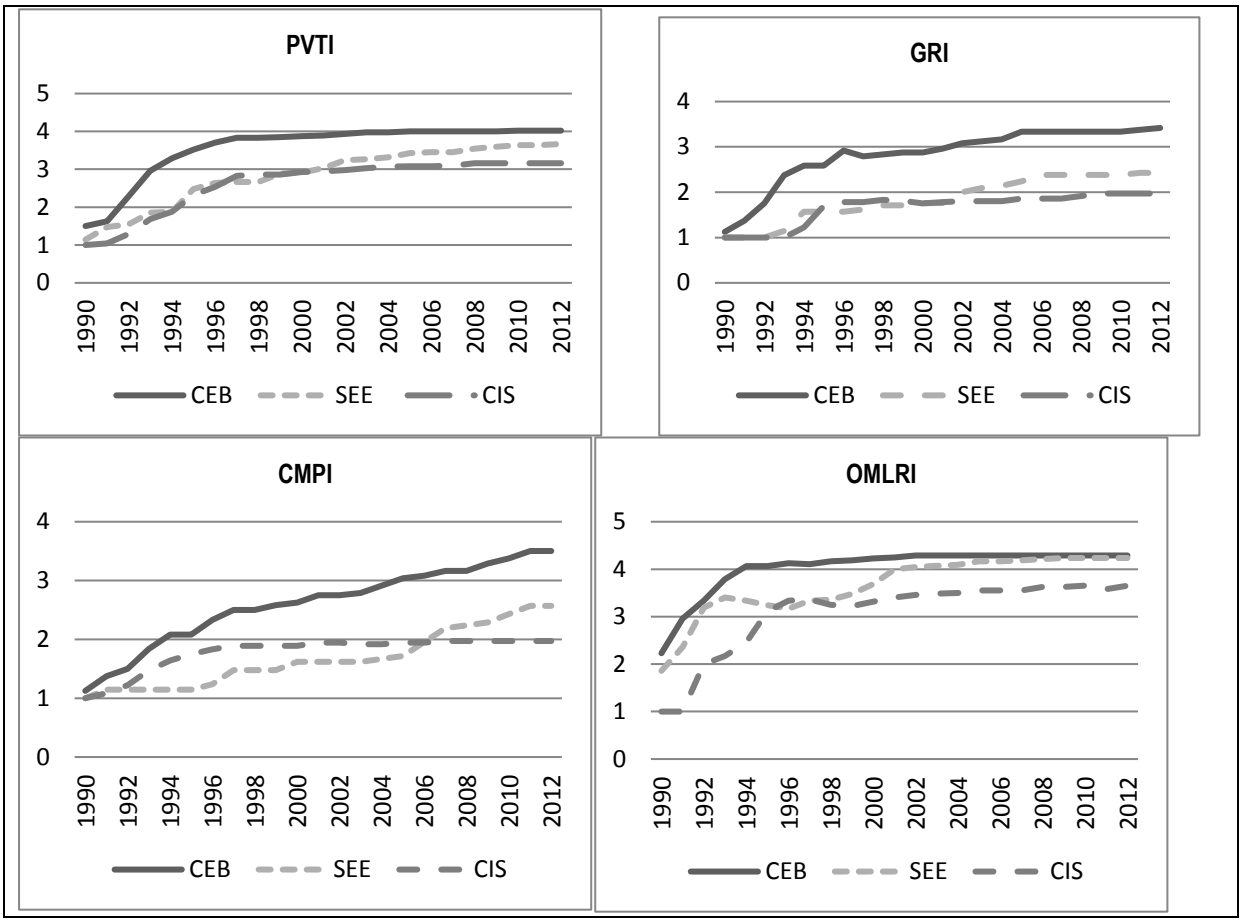


Figure 2 shows the evolution of different market-based economic reforms in the region. Privatization and overall market liberalization reforms seem to have stagnated and stalled in all country groups. Countries belonging to the CIS region have not achieved the reform levels experienced by the CEB and SEE countries. Thus, there is a significant scope for advancing reforms in order to reach the standards of the industrialized market economies across all economic reform measures for the CIS countries. Governance and competition policy reforms seem to be showing an upward trend among the TECs as these reforms have advanced slowly historically in the region. In all cases, the scope for additional market reform has tapered off, even though further scope remains.

Fig 2: Progress of economic reforms across different country groups of TECs



4. Results and Discussions

This section reports the results obtained using the LSDVC methodology in examining the impacts of several market-oriented economic reforms on environmental degradation where we consider per capita CO_2 emissions as its measure. The regression analysis is based on the new LSDVC technique involving a third order bias corrections and is initialised by the AB and BB estimators. The standard errors are bootstrapped and obtained from 1000 iterations[5]. The AB tests of autocorrelation and BB test of over identifying restrictions was also performed for the econometric estimations[6].

[5]Bootstrap is an established method for measuring the accuracy of the sample estimates and generates an estimate of the sampling distribution of almost any statistic using simple methods.

[6]The results can be provided upon request as we do not report them in the paper. We also performed an OLS and FE (i.e. LSDV) estimations and compared the results to determine the nature of bias of the estimates. In all cases, we observed bias as OLS and FE does not take endogeneity into account.

Table 3 shows the results of the regression analysis based on Equation 3 for the whole sample. The carbon emissions, being a cumulative air pollutant, imply that previous level of per capita emissions significantly affect the current per capita emissions. Reforms in governance and enterprise restructuring contributed to a decline in the emissions levels. However, we find that a combination of price liberalisation, trade openness and foreign exchange liberalisation led to rising per capita emissions levels in these countries. Reforms in competition policy, on the other hand, significantly reduced the per capita emissions levels. Per capita carbon emissions have been reduced significantly by the EU members since joining the EU compared to those not in the EU. The share of renewable energy capacity in the generation mix is insignificant in driving the per capita emissions below. The Kyoto Protocol had also no effect on reducing the per capita CO_2 emissions in these countries since their accepting and ratifying the Protocol. Our results show that an increase in per capita GDP by 1 US dollar led to about 60 grams increase in per capita emissions confirming a positive relationship between economic growth and environmental degradation across the whole groups of the ECA TECs. The impact of energy consumption on per capita emissions is also significant.

Table 3: LSDVC regressions results for the whole sample

LSDVC Dynamic Regression (Bootstrapped SE)	**Arellano-Bond (AB)**	**Blundell-Bond (BB)**
PCEMS. L1	0.643***	0.643***
	(0.028)	(0.028)
GRI	-0.175*	-0.178*
	(0.110)	(0.124)
OMLRI	0.153*	0.153*
	(0.084)	(0.084)
CMPI	-0.236***	-0.269***
	(0.085)	(0.096)
PVTI	0.089	0.115
	(0.084)	(0.096)
PGDP	0.00061***	0.00063***
	(0.00014)	(0.00016)
PECS	0.00042***	0.00041***
	(0.00009)	(0.0001)
EUM	-0.403***	-0.439***
	(0.113)	(0.128)
SREN	0.602	0.745
	(0.090)	(0.081)
ENVMP	-0.080	-0.856
	(0.066)	(0.075)

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

However, any generalizations of the above results need to be treated with caution due to the variability in country specific characteristics. The impact of market-based reforms on environmental degradation is likely to depend on initial conditions while cross-country results are likely to hide significant heterogeneity which may lead to the wrong policy discussions and conclusions. Hence, table 4 shows the impacts of market-based reforms and other underlying factors on the per capita CO_2 emissions for specific groups of the TECs estimated using equation 4. No significant link is observed between economic growth and environmental degradation among the SEE and CEB countries apart from the positive link in the CIS countries. Per capita energy consumption is also driving the emissions level in the CIS and CEB countries. Advances in competition policy reforms significantly reduced per capita emissions among the CEB and SEE countries while economic openness through overall market liberalisation increased per capita emissions in the SEE countries. Governance reforms also produced reductions in emissions levels in the CEB and SEE countries. The share of renewable energy installed capacity in the generation mix only reduced per capita emissions in the CEB countries. Countries belonging to the CEB benefited from joining Kyoto Protocol as per capita emissions reduced since the ratification. These results suggest that the impact of market-based reforms on environmental degradation is likely to depend on initial conditions while cross-country results are likely to hide significant heterogeneity which may lead to the wrong policy discussions conclusions.

Table 4: LSDVC regressions results for the specific groups

Country Groups	CIS		CEB		SEE	
LSDVC Dynamic Regression (Bootstrapped SE)	Arellano-Bond (AB)	Blundell-Bond (BB)	Arellano-Bond (AB)	Blundell-Bond (BB)	Arellano-Bond (AB	Blundell-Bond (BB)
PCEMS. L1	0.658*** (0.038)	0.690*** (0.038)	0.357*** (0.073)	0.454*** (0.075)	0.669*** (0.062)	0.688*** (0.064)
GRI	-0.016 (0.169)	-0.007 (0.196)	-0.019* (0.181)	-0.211 (0.239)	-0.277 (0.254)	-0.271* (0.283)
OMLRI	-0.008 (0.110)	-0.004 (0.127)	-0.397 (0.341)	-0.358 (0.442)	0.317** (0.133)	0.292** (0.151)
CMPI	-0.034 (0.140)	-0.034 (0.164)	-0.050** (0.021)	0.001 (0.199)	-0.43** (0.174)	-0.43** (0.201)
PVTI	0.169 (0.143)	0.197 (0.167)	-0.077 (0.131)	-0.007 (0.176)	0.145 (0.169)	0.153 (0.193)
PGDP	0.000069*** (0.000016)	0.000076*** (0.000159)	-0.00003 (0.00024)	-0.00002 (0.027)	0.0007 (0.00006)	0.00008 (0.00007)
PECS	0.00042*** (0.00013)	0.00042*** (0.00015)	0.00094*** (0.00018)	0.00083*** (0.00023)	0.00025 (0.00002)	0.00022 (0.0002)
SREN	-0.588 (2.413)	0.783 (2.893)	-2.16* (0.236)	-1.41 (0.635)	-0.712 (0.091)	-0.365 (0.461)
ENVMP	-0.0495 (0.0922)	-0.641 (0.109)	-2.566* (0.133)	-0.273 (0.181)	-0.042 (0.197)	-0.0627 (0.225)

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

Overall, the above results overall suggests a weak positive relationship between economic growth and per capita CO_2 emissions (environment-growth nexus) in the TECs beyond basic industrialisation as suggested in earlier findings by Grubb, Muller and Butler (2011). Majority of the TECs that implemented reforms experienced resurgent economic growth without growth in per capita emissions levels. The decline in per capita emissions associated with the initial transition process has not symmetrically reversed over-time. The energy-environment nexus seems to be valid only for the CIS and CEB countries. More than 50 percent of energy consumed in these countries is derived from carbon intensive thermal sources although the share of renewable energy is increasing among the CEB countries (Nepal and Jamasb, 2012). Most of the countries in the CEB region are also governed by the European Directive (2009/28/EC) of the European Commission that established a common framework for the promotion and production of energy from renewable sources. Adhering to the Kyoto Protocol has not delivered the anticipated benefits given its insignificant impact in reducing per capita emissions in the TECs. Elsewhere, pollution intensive countries like the US also did not ratify the Protocol stating that the Protocol did not include the "meaningful" participation of all

developing as well as industrialized countries. Canada also dropped out of the Protocol in 2011. While the Kyoto Protocol is now expired, the need for stronger international climate change agreements involving the ECA TECs is desirable in the future in mitigating the adverse impacts of global climate change.

Our results indicate the advances in competition policy reforms seem to be the biggest driver of per capita emissions reductions in the ECA TECs[7]. Advocating externality pricing (through measures like the Emissions Trading Scheme and tradable green certificates) seem to have helped in reducing carbon emissions (Wilsher, 2009). Based on this result, creating robust competition legislation and institutions can drive the future reductions in per capita emissions while these is also a significant scope for advancing competition on policy reforms across all country groups in the TECs. Advancing competition policy reforms are also important as some market-based policy measures require substantial institutional capacity for effective implementation (EBRD, 2008). For example, tradable green certificates are an attractive market‑friendly instrument, but they also require substantial institutional capacity and long development periods to deliver the anticipated environmental benefits. Good governance is an element of institutional capacity required to sustain the market-based reforms. Strengthening reforms in corporate governance and enterprise restructuring in the economy through sound accounting principles, corruption control and enterprise level transparency will also help achieve reductions in per capita emission in the TECs.

Our results showed only limited impact of trade openness (coupled with price and foreign exchange liberalisation) in reducing per capita emissions levels. Economic openness is expected to contribute to sustainable development significantly as it facilitates better transfer of clean technology and knowledge skills that are required to improve the industrialisation process (Hansen, 1990). However, economic openness may not necessarily result in sustainable development if only the 'weak conditions' are satisfied which entails accumulating man-made capital so as to substitute natural capital without adversely affecting economic production. ‘Strong conditions’ probably need to be satisfied to achieve significant sustainable development from economic openness as environmental stocks have an essential and irreplaceable economic role to play (Tisdell, 2001).

[7] It probably did not happen in China’s case but that has yet to be fully explored. In China’s case, the reforms might have had a positive effect but economic growth and other factors might have had a negative effect on CO_2 emissions outweighing the pollution-reducing effects of the market reforms.

In many transition economies, market reforms done were sufficient to reduce CO_2 emissions per capita but as these reforms became more pronounced, their marginal impact is less, they tapered-off. Therefore, after the passage of some time further reductions in CO_2 per capital would become more dependent on policies specifically targeted at reducing CO_2 emissions. That is after a time, further reductions in CO_2 emissions would depend on interventions, e.g. tradable permits, taxes on emissions, subsidies for reducing emission, for instance, for some forms of renewable energy. The marginal effect of pure market reforms on CO_2 emissions is probably declining. Further significant reductions may require increased targeting.

The insignificance of economic reforms on per capita emissions also portray that reform implementation may not always be translated into reform performance or outcome unless implemented properly. This implies that the effect of economic reforms on environmental performance is non-linear and complex. In many transition countries, reforms may have only advanced in paper but not in practice. Hence, only effective implementation of reform measures can achieve the desired outcomes of reforms. Nonetheless, our model may not capture all the qualitative dimensions and steps involved in the reform process considering that not all aspects of reform outcomes are readily quantifiable in physical and monetary units. The model also does not capture the effect of the lagged reform variables on environmental degradation, as their effects can be distributed over-time. The relevant distributed lag can be different for different economic reform variables.

5. Conclusions

This paper examined the impacts of market-based economic reforms on environmental performance in the TECs since the inception of the fifth EAP in 1993. One of the core beliefs of the EAP that the process of economic reforms and restructuring associated in the transition were expected to eliminate the perverse incentives which contributed to vast environmental degradation in these command-based economies. A dynamic panel data model based on the LSDVC technique was employed to gauge the impacts of economic reforms on per capita CO_2 emissions, as a measure of environmental performance, across the TECs. We also consider other underlying factors such as energy consumption, economic growth, environmental policy and the scale of renewable energy in the generation mix that can potentially explain the per capita CO_2 emissions patterns in the transition region.

The results from the LSDVC analysis suggest that the objectives of the fifth EAP have been

partially met after more than two decades of market-based economic reforms in the transition countries. Reforms in competition policy and governance seem to have contributed to significant decline in per capita emissions levels in these countries. Hence, these exists scope to advance these reforms and achieve further reductions in per capita CO_2 emissions levels. This is because the transition countries still remain much more carbon intensive on average than either advanced economies or emerging market economies like China. Moreover, the carbon performance of the leading countries in the region such as Hungary, Latvia and Lithuania demonstrates that a strong carbon performance is feasible with adequate reforms and good policies.

The Kyoto Protocol produced no direct effect in reducing emissions levels in the TECs although other market-based arrangements such as emissions trading scheme and tradable green certificates seem to reduce CO_2 emissions. Our results also suggest that further investments in renewable generation capacities are needed in the TECs to produce any significant carbon reduction impacts. Likewise, reducing energy consumption by promoting energy efficiency is desirable to curb the per capita emissions. These measures are necessary as the carbon performance of the EBRD region as a whole remains mixed indicating that the polluting legacy of central planning is still pervasive.

Hence, the main conclusions from this study is that at least for several years after beginning their economic reforms, the main contributors to reduced CO_2 emissions per capita in the ECA TECs were their economic (market) reforms. The Kyoto Protocol did not come into effect until 2005. So for most of the period considered, Kyoto Protocol was not a factor influencing CO_2 emissions. It seems likely that it was not specific policies to reduce CO_2 emissions but the increased economic efficiencies resulting from the market reforms that were the most important factor in reducing CO_2 emissions per capita in ECATECs. In fact, after Kyoto came into operation we observe no major decline in CO_2 emissions per head. There is, however, some slight decline in these emissions by SEE probably due to the European recession.

Future research may focus on the interaction of the market-based reforms and their effect on per capita CO_2 emissions. Adequate attention also needs to be paid to the importance of time lags in the adjustment of economic systems to various market-based reforms. Alternative measures of environmental degradation also needs be considered in the future analysis depending on the availability of data.

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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	Mongolia
*EU members, ** EU candidates and *** Potential EU candidates			

Table A1: Countries included in the study

	PGDP	SREN	PECS	PVTI	GRI	OMLRI	CMPI
PGDP	1.0	-0.34	0.64	0.5	0.6	0.4	0.6
SREN		1.0	0.45	0.4	-0.37	0.45	-0.38
PECS			1.0	0.43	0.46	0.44	-0.47
PVTI				1.0	0.63	0.64	0.62
GRI					1.0	0.63	0.52
OMLRI						1.0	0.6
CMPI							1.0

Table A2: Correlation matrix

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