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Transition to markets and the environment: Effects of the change in the composition of manufacturing output

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ABSTRACT. The paper measures the changes in environmental quality that occurred in the early years of economic transition for 12 former centrally planned economies using the information on 13 pollution effluents in the manufacturing sector and the energy intensity of the value added. For the manufacturing sector, the change in the pollution is separated into scale and composition effects. Pollution decreases substantially in most countries because of large decreases in aggregate manufacturing activity. The composition effect is more diverse depending on the effluent type and country. We examine the reduced form relationship between composition effects coupled with the energy intensity rate of change and the extent of policy reforms. The results indicate a strong relationship between environmental improvement and price liberalization, trade and foreign exchange reforms, enterprise restructuring, and privatization reforms. In addition, the amplification of the environmental regulatory regime causes a shift towards a less-polluting allocation of resources.

1. Introduction

Early anecdotal reports on the status of the environment in the former Centrally Planned Economies (CPE), released immediately after the collapse of communism, portrayed an appalling picture of extensive environmental degradation which resulted from the absence of adequate

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environmental policies and a systematic neglect of environmental issues. Although this catastrophic portrayal appeared somewhat exaggerated (Pearce and Warford, 1993), little systematic evidence on the status of the environment in the former CPE and no international comparisons with the rest of the world have been presented so far. In this context, an interesting question arises: What happened to the status of the environment in the CPE in the early years of transition? An attempt to provide an answer is presented in this paper. The empirical question addressed is whether the transition from a centrally planned to a market driven economy exacerbates environmental degradation, or is it the case that environmental improvements complement economic transition.

The literature on explicit linkages between the environment and the socio-economic transition from central planning to markets tends to be 'conjectural' or based on scarce and incomplete evidence (Pearce and Warford, 1993; Scalan, 1992; DeBardeleben, 1991; OECD, 1995; Buydos, 1990; and Zylicz, 1997). In an attempt to try to predict the environmental consequences of a country's transition from a centrally planned to a market driven economy, one can start with a standard categorization of pollution as an externality. This particular type of market failure can be mainly attributed to the absence of clearly specified property rights over different environmental media. Since centrally planned economies were characterized by a complete absence of markets, one can think about the transition from a centrally planned to a market economy as a movement from a domain of more (complete) market failure to a domain of less market failure. Therefore, in theory at least, the transition from more market failure to less market failure is consistent with an overall improvement in environmental quality.

The above conclusion would most likely hold in the very long run. However, in the short and medium run, the consequences of transition are far from being obvious. This is especially true since even in the most developed and mature market systems, the environmental media are certainly the last ones where property rights would be established and market failures alleviated. Based on the existing literature on growth, trade, and environment, several more operational hypotheses pertaining to the transition and post-transition periods can be developed.

First, one can conjecture that the environment in the economies in transition would get cleaned up quickly because of rising energy prices, and penalizing energy-intensive activities (Hughes, 1991). Secondly, one can also argue that the abundance of skilled labor in these countries may result in a new allocation of resources towards cleaner specialization induced by international market discipline, as shown to be the case for Mexico (Beghin *et al.*, 1995; Grossman and Krueger, 1993). These optimistic views may be invalidated by the fact that many transition economies have lax environmental regulations and are 'abundant' in environmental endowment (Rauscher, 1995). If this is true, then one could potentially observe worsening pollution due to an increased specialization in pollution-intensive industrial activities.

Some of these questions can be addressed by looking into the relationship between the pollution intensity of the economy and measures of

openness. The literature on this question presents controversial evidence. Lucas *et al.* (1992) found that intensities for outward-oriented and fast-growing economies were decreasing rapidly in the 1980s, and, further, that a negative relationship could be established between an index of openness and pollution intensity of value added. This finding suggests that outward orientation is environmentally less damaging than the inward orientation. However, Rock (1996) found little econometric evidence to support the relationship between outward orientation and environmental improvement.

The scope of this paper is largely determined by the availability of the empirical data. Since no reliable statistics exist to monitor trends in pollution emissions in former CPE (Zylicz, 1997), in constructing the data set for the purpose of inter-temporal and inter-country comparison, we had to rely on approximations. First, our goal is to quantify the changes in environmental quality that occurred in the early years of transition by measuring the changes in the composition of manufacturing output in the direction of cleaner or dirtier industries. Second, controlling for the overall decline in economic activity which happens to be a necessary byproduct of the transition process, we want to see whether changes in the composition of output can be explained by the relevant institutional changes, i.e., primarily by the degree of the completeness of transition reforms, but also by the changes in environmental regulatory regimes. The paper investigates these issues for a representative subset of the Central and Eastern Europe (CEE) countries and Newly Independent States (NIS).

We find that pollution sharply decreased in most CEE/NIS because of a near collapse of output. The new manufacturing specialization varies a lot by country and no clear general pattern on transition and pollution can be easily identified. Further, we find that policy reforms affecting price liberalization, trade and the foreign exchange system, as well as reforms in the area of enterprise restructuring and privatization had a beneficial effect on the composition of manufacturing output steering it towards less-polluting sectors and in reducing the energy consumption per dollar of value added. With available data capturing the degree of environmental policy reforms, we find that the amplification of the environmental regulatory regime caused a shift towards a less-polluting allocation of resources.

2. Market and environmental policy reforms in former CPE

The data for measuring the degree and completeness of the market reforms in the former CPE used in this study comes from the EBRD (1995)[1] which summarizes the progress of transition in four major areas: enterprises, markets and trade, financial institutions, and the role of the state. As of October 1994, the countries that had made the most significant progress in establishing a market economy were Czech Republic, Slovak Republic, Hungary, Poland, Baltic States, Slovenia, and Croatia. Most of these countries had already liberalized foreign trade and domestic prices, privatized small-scale businesses, and had started to deal with banking reform, enterprise restructuring, and large-scale privatization. The intermediate group

[1] Alternative set of transition progress scores are available from the World Bank (1996).

of countries consists of Romania, Bulgaria, and several NIS such as Kyrgyzstan and Russia. Russia, in particular, was already making rapid progress in privatization in all sectors, except in agriculture. The remainder of the former CPE had made much less progress with market-oriented reform and were finding it difficult to liberalize trade, embark upon enterprise restructuring, and even, in some cases, to achieve small-scale privatization.

The EBRD data were organized into three groups of transition indicators: *enterprises*, *markets and trade*, and *financial institutions*, with each group consisting of several elements. For each of the transition elements, each country is assigned a number between 1 and 4, indicating the degree of the completeness of the market reform in the respective category, with 4 being the highest degree of reform. There are no numerical scores given for the category *the role of the state.* Within the *enterprises* category, three aspects of market reform were analyzed: (a) *large-scale privatization*, (b) *small-scale privatization*, and (c) *enterprise restructuring.* In the category of *markets and trade* two aspects of market reform were analyzed: (a) *price liberalization and competition* and (b) *trade and foreign exchange system.* Finally, in the category of *financial institutions* the degree of market reform was assessed through the analysis of the *banking reform.* The transition indicators classification system is reproduced in table 1.

The aggregate scores for the three groups of transition indicators were obtained by summing up individual elements' scores. Since there are six individual transition elements (3 in the enterprises, 2 in the markets and trade, and 1 in the financial institutions category), the maximal achievable score for each country is 24. The ranking of countries according to the total market transition score is presented in table 2. The progress in transition is positively rank-correlated with per capita GNP calculated at purchasing power parity (PPP) with two notable exemptions such as Croatia and the Baltic States where progress in the market reforms is well ahead of their wealth ranks, and Belarus and Ukraine whose cumulative transition scores rank well below their per capita GNPs.

Aside from the changes in the political-economic environment brought about by the transition from central plan to market, the change in the environmental regulatory regime may have significantly influenced the changes in environmental quality. Unlike with the assessment of the overall degree of market reform in former CPE, the comparable assessment of the degree of environmental policy reforms across former CPE is not available.[2] To approximate changes in environmental regulatory regimes we use a measure of *revealed* regulatory effort exerted by policy makers to address environmental problems. Environmental protection in CEE/NIS is mostly financed by the extra-budgetary 'environmental funds' (Zylicz, 1997). They have emerged as the major resource for environmental reform. Because the main sources of revenues for environmental funds are pollution fines, pollution emissions charges, waste disposal fees, and

[2] For the individual countries' experiences with environmental reform and recovery problems see for example Bluffstone and Larson eds. in ref. (1997) and Kaderjak and Powell eds. in ref. (1997).

Table 1. *Classification system for transition indicators*

Transition indicator	*Score*	*Description of the category*
ENTERPRISES		
Large-scale privatization	4	More than 50 per cent of the state-owned enterprise assets are privatized in a scheme that reflects support for corporate governance.
	3	More than 25 per cent of large-scale state-owned enterprise assets are privatized or in the process of being sold but with major unresolved issues regarding corporate governance.
	2	Advanced comprehensive scheme is almost ready to be implemented and some sales have already been completed.
	1	Little done.
Small-scale privatization	4	Comprehensive and well-designed program implemented.
	3	Nearly comprehensive program implemented, but design or lack of central supervision leaves important issues unresolved.
	2	Substantial share privatized.
	1	Little done.
Enterprise restructuring	4	Restructuring program which substantially improves corporate governance in operation, strong financial discipline at the enterprise level, large-scale conglomerates broken up.
	3	Structures created (e.g., through privatization combined with tight credit and subsidy policies and/or enforcement of bankruptcy legislation) to promote corporate governance, or strong action taken to break up conglomerates.
	2	Moderately tight credit and subsidy policy, weak enforcement of bankruptcy legislation and little action to break up large conglomerates.
	1	Lax credit and subsidy policies weakening financial discipline at the enterprise level and few other reforms to promote corporate governance.

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Table 1. *Continued*

Transition indicator	*Score*	*Description of the category*
MARKETS AND TRADE		
Price liberalization and competition	4	Comprehensive price liberalization and price competition and anti-trust legislation in place.
	3	Comprehensive price liberalization and price competition.
	2	Price controls remain for several important product categories.
	1	Most prices remain formally controlled by the government.
Trade and foreign exchange system	4	Few import or export quotas, insignificant direct involvement in exports and imports by ministries and state-owned former trading monopolies, almost full current account convertibility at unified exchange rate, no major non-uniformity of customs duties.
	3	Few import quotas, almost full current account convertibility at unified exchange rate.
	2	Few import quotas, almost full current account convertibility in principle but with a foreign exchange regime which is not fully transparent (possibly with multiple exchange rates).
	1	Widespread import controls or very limited legitimate access to foreign exchange.
FINANCIAL INSTITUTIONS		
Banking Reform	4	Well-functioning banking competition and prudential supervision.
	3	Substantial progress on bank recapitalization, bank auditing, and establishment of a functioning prudential supervisory system, significant presence of private banks, full interest rate liberalization with little preferential access to cheap refinancing.
	2	Interest rates significantly influencing the allocation of credit.
	1	Little progress beyond establishment of a two-tier system has been done.

Source: Transition Report Update, EBRD, April 1995 (pp. 69–70).

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Table 2. *Progress in transition and environmental reform in CEE/NIS*

	PCGNP	*Transition scores***				*Environmental funds*	
	*(ppp US $) 1994**	*Enterprises*	*Markets and trade*	*Banking*	*TOTAL*	*1993*** mil. 1987 US$*	*% of GDP*
Czech Rep.	7910	11	7	3	21	84.119	0.2773
Slovak Rep.	6660	10	7	3	20	27.516	0.1885
Hungary	6310	10	7	3	20	21.777	0.0953
Poland	5380	10	7	3	20	156.053	0.2650
Estonia	3785	10	7	3	20		
Slovenia	9234	9	7	3	19		
Croatia	3828	9	7	3	19		
Lithuania	3240	9	7	2	18		
Latvia	5170	7	7	3	17		
Kyrgyzstan	1710	9	6	2	17		
Macedonia		8	7	2	17		
Russia	5260	8	6	2	16	55.031	0.0157
Romania	2920	7	7	2	16	0	0.0000
Bulgaria	4230	6	7	2	15	1.808	0.0084
Albania		6	7	2	15		
Moldova	2215	6	5	2	13	0.0126	0.0003
Uzbekistan	2390	6	5	1	12	0.016	0.0001
Armenia	2170	5	5	1	11		
Belarus	5010	6	3	1	10	0.46	0.0023
Kazakhstan	2830	5	4	1	10	2.913	0.0166
Tajikistan	1160	5	4	1	10		
Ukraine	3330	4	3	1	8	0.786	0.0010
Azerbaijan	1720	3	4	1	8	0.057	0.0019
Georgia	1160	4	3	1	8		
Turkmenistan		3	3	1	7		

Sources: * Transition report 1996, EBRD, p. 122. The numbers for Croatia, Estonia, Moldova, and Slovenia are for 1993. ** Transition report update, EBRD, April 1995, p. 69. *** Zylicz, 1997; and OECD, 1995. The numbers for Azerbaijan, Kazakhstan, Romania, and Belarus are for 1994.

energy taxes, the size of the fund reflects the recent regulatory effort as well as the actual implementation, monitoring, and enforcement of environmental policies. Since environmental funds did not exist under central planning, their size can be used as a gauge of the environmental policy reform paralleling the market transition processes. Looking at table 2, we see that in 1993/4 the size of those funds range from 156 million in constant 1987 dollars or 0.265 per cent of the GDP in Poland to only about $16 thousand or 0.0001 per cent of the GDP in Uzbekistan.

3. Measures of environmental quality

In order to carry out the empirical analysis, cross-country time series data on pollution emissions are needed. As mentioned earlier, no reliable statistics to monitor trends in pollution emissions in former CPE exist (Zylicz, 1997). The only available environmental indicator that satisfies our criteria

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are the data on energy use.[3] In order to get a broader picture about the status of the environment in those countries we had to rely on constructed measures. Notably, the changes in a country's environmental quality are approximated by the changes in the composition of manufacturing output. This is accomplished by using pollution intensities estimates[4] and the data on the composition of the manufacturing output for the sample of 12 countries. The intensities are expressed in pounds of pollutant per million dollars of output at 1987 prices. Thirteen types of pollutants are grouped into four subsets (total toxic chemicals released in air, water, and soil; bioaccumulative metals in air, water, and soil; air pollutants (nitrogen oxides, sulfur oxides, volatile organic compounds, suspended particulates, carbon monoxide); and water pollution (biological oxygen demand, and total suspended solids).

Countries included in the data set and the time period coverage are as follows: Armenia (1990–3), Azerbaijan (1991–4), Bulgaria (1990–4), Hungary (1990–3), Kyrgyzstan (1990–4), Latvia (1990–3), FYR Macedonia (1990–4), Poland (1990–3), Russia (1991–4), Slovakia (1991–3), Slovenia (1990–4), and Ukraine (1990–4). Countries were chosen according to the availability and continuity of disaggregated manufacturing data for the period 1990–4.[5] Other industries' data, such as mining and quarrying; and electricity, gas and steam, was too fragmented to be used.

The implemented analytical approach rests upon two assumptions. First, technologies are fixed across countries meaning that former CPE are all using the same technical/technological processes equal to what the US industry was using in 1987. Second, technologies are also fixed in time meaning that the analysis is not capable of capturing any environment-saving technological progress, which may have occurred during the analyzed period. During the central planning era and in the early years of economic transition, CEE/NIS were probably using inferior technology compared to what the United States were using in 1987 and, hence, our early data (1990–1) would tend to underestimate the pollution concentrations. However, as transition progressed, the influx of foreign capital brought about the installation of brand new technologies most of them with superior pollution abatement specifications than the 1987 US vintage. Hence our end-of-the-period data (1993–4) would tend to overestimate pollution concentrations. As a result, for countries which moved towards a cleaner specialization in manufacturing, we underestimate the decrease

[3] Data used in this study represent the total consumption of energy in metric tons of oil equivalent and comes from United Nations (1995, 1997).

[4] The estimates of pollution intensities of aggregate gross output and by sectoral activities come from a data base called the *Industrial Pollution Projection System* (Hettige *et al.*, 1995). The data base provides estimates of sectoral pollution intensities for industrial activity at the three-digit ISIC disaggregation level for 13 effluent types.

[5] The data on the composition of manufacturing output are three-digit ISIC sectoral data collected from UNIDO (1996, 1997). As of 1997, UNIDO has switched its data base to ISIC—Revision 3 for some countries whereas retained the older ISIC—Revision 2 for the remaining countries rendering the construction of longer time series virtually impossible.

in pollution, whereas for countries which moved towards dirtier specialization in manufacturing, we overestimate the increase in emissions by assuming a constant 1987 US technology. Therefore, our approach has a systematic 'pessimistic' bias.

Following this approach, any measurable changes in environmental quality are the results of either the change in the country's aggregate output or the change in the sectoral composition of output, as shown in the following simple derivation. Let $E(t) = \sum_i e_i(t)$ denote the aggregate pollution in a given economy in period t expressed as the sum of pollution emissions of individual sectors, and let $X(t) = \sum_i x_i(t)$ denote the aggregate output. Aggregate pollution is expressed as

$$E(t) = \sum_i \left(\frac{e_i(t) x_i(t) X(t)}{x_i(t) X(t)} \right), \tag{1}$$

where, for the purposes of this exercise, the term (e_i/x_i) is assumed to be constant (therefore t has been dropped) representing the sector pollution intensities based on 1987 US technology. Differentiating (1) with respect to time, one obtains

$$\frac{dE}{dt} = \sum_i \frac{e_i}{x_i} \left(\frac{d\left(\frac{x_i(t)}{X(t)}\right)}{dt} X(t) + \frac{x_i(t)}{X(t)} \frac{dX(t)}{dt} \right). \tag{2}$$

Introducing $S_i(t) = \frac{x_i(t)}{X(t)}$ to denote the share of the ith sector's output in the aggregate output, and $\dot{S}_i = \frac{dS_i(t)}{dt}$ and $\dot{X} = \frac{dX(t)}{dt}$ to denote the respective time derivatives, expression (2) can be rewritten as

$$\frac{dE}{dt} = \sum_i e_i \left(\frac{\dot{S}_i}{S_i} + \frac{\dot{X}}{X} \right). \tag{3}$$

After some straightforward manipulation of terms, (3) can be rewritten as follows

$$\frac{\dot{E}}{E} = \sum_i \left(\frac{e_i}{E} \frac{\dot{S}_i}{S_i} \right) + \frac{\dot{X}}{X}, \tag{4}$$

where $\frac{\dot{E}}{E}$ denotes the rate of change in total pollution for the period under consideration, $\frac{e_i}{E}$ is the share of the ith sector pollution in total pollution, $\frac{\dot{S}_i}{S_i}$ is the rate of change in output share of sector i, and $\frac{\dot{X}}{X}$ is the rate of

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change in total output.

It follows from (4) that the rate of change in total pollution has two parts: the composition effect and the scale effect. The composition effect reflects the change in pollution resulting from producing different goods (the product of the pollution share of sector i and the corresponding rate of change in output share, summed across all sectors). The scale effect represents the expansion or contraction of pollution directly proportional to aggregate manufacturing activity holding composition constant (the rate of change in aggregate output). The composition effect also reflects the change in average pollution intensity of aggregate manufacturing output. Equation (4) forms the basis for the empirical analysis of the environmental quality changes in the remainder of this section.

All output data, originally reported in current values of local currencies, were first converted into constant 1987 US dollars,[6] and then pollution intensities coefficients were used to convert sectoral outputs into pollution emissions. The results for the average annual rate of change in pollution composition and scale effects for 13 pollutants and 12 countries are presented in table 3. Positive numbers indicate the environmental deterioration in the composition of manufacturing output (a movement towards more polluting industries), and negative numbers indicate the improvement in environmental quality (a shift towards cleaner sectors). Referring to the analytical formula in (4) indicates that adding up the composition effect and scale effect produces the rate of change in the aggregate pollution. However, the results show that independently computed rate of change in pollution differs from the sum of composition and scale effects. The differences are quite small and stem from the use of discrete time approximations of the continuous time derivatives.[7]

The last column in table 3 represents the average annual rate of change of the GDP energy intensities, where the indicator was derived by dividing the total consumption of energy in metric tons of oil equivalent by the total GDP expressed in constant 1987 US dollars. As of 1994, CEE/NIS exhibited far larger energy intensities per dollar of GDP than the OECD countries. The absolute numbers (not presented in this paper) show that for the analyzed group of countries the energy intensity varies from as low as 387 grams of oil equivalent per 1987 dollar of GDP in Slovenia and as high as 4 kilogram of oil equivalent for Azerbaijan. From 1990 to 1994, energy intensity of GDP

[6] For all countries in the data set, nominal exchange rates were obtained by dividing the respective GDP in current US$ by the GDP in current local currency. The real exchange rates were obtained by dividing the yearly nominal exchange rates by the corresponding US consumer price index based on 1987 = 100. The GDP and the US CPI data were obtained from the World Bank (1997).

[7] The scale and composition effects from equation (4) are approximated by the geometric rate of change: $\frac{\dot{X}}{X} = s\sqrt{\frac{X_{t+s}}{X_t}} - 1 = \exp\frac{1}{s}(\log X_{t+s} - \log X_t) - 1$, where t denotes the first year and $t + s$ the final year of the period under consideration. For details on how to construct and decompose indices, see Boyd, Hanson, and Sterner (1988).

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Table 3. *Pollution indicators: Average annual rates of change*

	*SCALE EFFECT**	*COMPOSITION EFFECTS**													*Energy*** *intensity*
		BOD	*TSS*	*Toxic air*	*Toxic solid*	*Toxic water*	*SO_2*	*N_2O*	*CO*	*VOC*	*Particul.*	*Bio air*	*Bio land*	*Bio water*	
Armenia (1990–93)	−0.4555	−0.0125	0.1401	0.0082	−0.0264	−0.0101	−0.0993	−0.0299	−0.0674	0.0039	−0.0499	−0.1242	−0.1586	−0.0138	−0.0446
Azerbaijan (1991–94)	−0.4420	−0.0069	−0.1158	0.0219	0.0968	0.0312	0.1315	0.2011	0.0938	0.2280	0.0908	−0.0816	−0.0983	0.0418	0.1550
Bulgaria (1990–94)	−0.2668	0.0682	0.1992	0.1205	0.1729	0.1837	0.1985	0.1805	0.1916	0.1377	0.1578	0.1971	0.2035	0.19582	−0.0039
Hungary (1990–92)	−0.0802	−0.0296	−0.1602	−0.0371	−0.0831	−0.1113	−0.0553	−0.0105	−0.0269	0.0333	−0.0290	−0.1704	0.1903	−0.1154	−0.0182
Kyrgyzstan (1990–94)	−0.3209	0.1519	0.3197	0.1288	0.2275	0.1109	0.2372	0.1221	0.2581	0.0706	0.1337	0.3031	0.3086	0.1990	−0.0929
Latvia (1990–93)	−0.3573	0.0943	0.4593	0.0642	0.1423	0.1183	0.1259	0.1052	0.1714	0.1458	0.0838	0.3397	0.3286	0.2571	−0.0446
Macedonia (1990–94)	−0.1342	0.1055	−0.1953	−0.0215	−0.0659	−0.0357	0.1067	−0.0712	−0.1453	−0.0446	0.0757	0.1708	−0.1550	−0.1339	−0.0141
Poland (1990–93)	−0.0127	0.0037	−0.1108	−0.0247	−0.0426	−0.0608	−0.0176	0.0135	−0.0373	0.0563	−0.0215	−0.1022	−0.1062	−0.0780	−0.0138
Russia (1991–94)	−0.2449	−0.1419	0.1100	−0.1712	−0.1404	−0.2068	−0.0068	−0.0624	0.0316	0.0867	0.0003	0.0247	0.0013	−0.0808	0.0383
Slovakia (1991–93)	−0.1463	−0.0003	0.1069	0.0200	0.0332	0.0165	0.0365	0.0277	0.0656	0.0279	0.0277	0.0842	0.0747	0.0837	−0.0755
Slovenia (1990–94)	−0.0580	0.0704	−0.0058	0.0323	0.0418	0.1431	−0.0355	0.0639	−0.0163	0.0474	0.0018	−0.0869	−0.1011	0.0625	−0.0560
Ukraine (1990–94)	−0.1521	0.0203	0.1770	0.0764	0.1209	0.1111	0.1266	0.1222	−0.1523	0.0969	0.1173	0.1568	0.1497	0.1602	0.0490

Notes: * The scale and composition effects for 13 pollutants are calculated for the time period indicated following the country name. ** The average rate of change in energy intensity reflects the period 1990–4 for Bulgaria, Hungary, and Poland, and 1992–4 for all other countries.

decreases for nine countries in our sample, illustrating the rationalization brought about by higher energy prices in the transition period.

The obtained results seem to point towards several common tendencies emerging in transition economies. First, in most countries manufacturing output had collapsed or substantially decreased in early transition, and eventually leveled in later years, thereby reducing pollution levels by a corresponding massive scale effect. The scale effect virtually dominates composition effects in all countries for all pollutants. Second, various composition effect patterns, observed across pollutants and countries, suggest diverse patterns of specialization induced by the transition. In many countries, resources have been moved away from heavy manufacturing industries, such as iron and steel and towards lighter industries, such as food, beverage, and tobacco products. We find such instances in Armenia, Hungary, Kyrgystan, Latvia, and Poland. These compositional changes towards lighter industries have been accompanied by increases in biological oxygen demand (BOD) and volatile organic compounds (VOC) emissions, but decreases in bio-accumulative emissions released in soil and air. In addition, several countries have expanded their energy and petroleum-refining activities (for example, Bulgaria, Azerbaijan, Latvia, Hungary, and Kyrgystan), inducing more toxic pollution.

The composition effect results reveal two clusters of countries with no country remaining at the status quo: those with dirtier and those with cleaner manufacturing composition. The first group comprises Azerbaijan, Bulgaria, Kyrgystan, Latvia, Slovakia, and Ukraine. For these countries, the compositional changes of manufacturing output were environmentally harmful with respect to at least ten pollutants, and sometimes for all pollutants (see composition effects in table 3). In these countries the emphasis on chemicals, metallic industries, and plastics seems to have survived transition or has even increased. The second group, consisting of Armenia, Hungary, Macedonia, Poland, Russia, and to a lesser extent Slovenia, shows consistent environmental improvements in the composition of manufacturing output with respect to most pollution emission types, except for VOC and BOD.

4. Composition effect and transition reforms

Based on the results obtained in the previous section, we investigate whether changes in pollution that have occurred in the early 1990s can be explained by relevant institutional changes, notably by the degree of completeness of transition reforms and the changes in environmental regulation. To isolate the impact of the overall decline in economic activity, which is a common characteristic of all countries in the region during that period, we select the composition effect, i.e., the rate of change in pollution attributable only to the change in the composition of manufacturing output, as a dependent variable in the regression model. For the same reason, we use the rate of change in energy intensity, i.e., the rate of change in energy consumption per dollar of GDP, as a dependent variable in the model. The data on 13 pollution intensities rates are stacked vertically together with the data on energy intensity rates to form a column vector of 14 pollution indicators for 12 countries.

The empirical method involves regressing the column vector of composition effects *cum* energy intensity rates on relevant transition and policy reform indicators. Defining $\mathbf{Z}_j$ to be the observable variables measuring the degree of the completeness of transition reforms and F_j to measure the changes in the environmental regulatory regime affecting the change in the pollution emissions of pollutant i in country j, the empirical model can be expressed as

$$y_{ij} = y(\mathbf{Z}_j, \mathrm{F}_j) = u_{ij}, \tag{5}$$

where y_{ij} is either the composition effect defined as $\sum_i \left(\frac{e_i}{E} \frac{\dot{S}_i}{S_i} \right)$ from equation (4) or the energy intensity rate, and u_{ij} is the random error with zero mean representing measurement error as well as unmeasured and unmeasurable factors influencing the composition of output and energy intensity.

The strength of the transition reforms is measured by the scores for various transition elements from table 2. The maximum theoretical score for enterprise restructuring and privatization is 12, whereas the highest observed score in our sample of 12 countries is actually 10. The highest possible score for price liberalization and trade and foreign exchange system reform is 8 whereas the highest observed score is 7. For banking reform, the maximum attainable score is 4 and the highest observed score is 3. However, in regression analysis, rather than using cardinal scores, we use six categorical variables (dummies). In the category of enterprise reform the first dummy variable 'Enterprise(7,8)' has the value of one if the score equals 7 or 8, and zero elsewhere, and the second dummy variable 'Enterprise(9,10)' has the value of one if the score equals 9 or 10, and zero in all other cases. The definitions of other dummy variables for markets and trade and banking reforms are recognizable from the self-explanatory variable labels in table 4. The change in the environmental regulatory regime is approximated by the size of environmental funds expressed as a percentage of a country's GDP from table 2. For those countries in our sample of 12 for which the OECD (1995) has not reported the existence of environmental funds (Armenia, Kyrgyzstan, Latvia, Macedonia, Slovenia), we assumed that they were zero.

Two specifications of the model are presented in table 4: one with transition reform indicators only, and the other with transition reform and environmental policy regime indicators. The results look fairly similar, with the second specification providing a slightly better overall fit (adjusted R^2 of 26 per cent compared to adjusted R^2 of 21 per cent).[8] The results suggest the existence of a robust and negative link between enterprise and market reforms and pollution. In both specifications, pollution

[8] We tested both models for the presence of heteroskedasticity by performing a battery of Goldfeld–Quandt tests for all possible splits of the data set. Only 11 of the 153 computed Goldfeld–Quant test values were larger than the corresponding critical F-value in the first model, and only 12 out of 151 in the second model, indicating that heteroskedasticity is not a serious problem.

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Table 4. *Pollution and institutional reform model estimation results*

Variable	*Estimate*	*Standard error*	*t-statistics*
Model 1: Specification with transition reform indicators			
N	168		
Adjusted R^2	0.2073		
Constant	0.08664	0.02055	4.126
Enterprise(7,8)	−0.23809	0.04110	−5.793
Enterprise(9,10)	−0.26551	0.04836	−5.490
Markets(5,6)	−0.12124	0.03559	−3.407
Markets(7,8)	−0.27942	0.05192	−5.382
Bank(2)	0.35015	0.05584	6.270
Bank(3)	0.47469	0.08220	5.775
Model 2: Specification with transition reform and environmental policy regime indicators			
N	168		
Adjusted R^2	0.2576		
Constant	0.08729	0.01989	4.389
Enterprise(7,8)	−0.24187	0.03979	−6.079
Enterprise(9,10)	−0.23409	0.04768	−4.910
Markets(5,6)	−0.12189	0.03444	−3.539
Markets(7,8)	−0.26599	0.05040	−5.278
Bank(2)	0.33985	0.05412	6.279
Bank(3)	0.48552	0.07960	6.099
Funds	−0.44904	0.1301	−3.452

intensity decreases monotonically with the degree of completeness of the market reforms as indicated by the larger magnitude of the coefficient of Markets (7,8) than the coefficient of Markets (5,6). The composition component of pollution appears to respond negatively to price liberalization and trade and foreign exchange system reforms in a sense that advancing reform shifts resources towards less-polluting manufacturing sectors. The same is true for energy intensity in a sense that more advanced reforms stimulate the reduction in the energy consumption per dollar of GDP.

The estimated link between enterprise reforms and pollution intensity is monotone and negative in the specification with no environmental reform variable in the model. As far as the first 13 pollutants are concerned, the suggestion is that the progress in enterprise restructuring and privatization shifts the resources towards less-polluting manufacturing sectors. In the area of energy utilization the result says that the degree of completeness of enterprise reforms reduces the energy intensity per dollar of value added created. However, when we account for the change in environmental regimes, we observe an initial decrease in pollution intensity associated with enterprise reforms, but with no additional environmental improvement with further enterprise reforms. Hence, while the initial improvement appears well established, it is questionable if further completion of enterprise reforms brings any additional environmental improvement.

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The response of pollution intensity to the environmental funds variable is robust and negative in both specifications, strongly suggesting that a shift away from pollution-intensive activities is induced by environmental reforms. Hence, we found evidence supporting the conjecture that environmental 'abundance' (lax environmental regimes) is associated with specialization in pollution-intensive industries.

A surprising result is a positive and robust relationship found between the banking reform variable and pollution intensities. We could not find any obvious rationalization for this result. Several countries, which have lowered the pollution intensity of manufacturing, also have been lagging on the banking reform front; such is the case for Armenia and Macedonia. The converse is however also true. For instance, Slovakia and Latvia have extensively reformed their banking institutions as of 1994, while also specializing in more pollution-intensive manufacturing. The heterogeneous sequencing of reforms in the countries included in our sample may explain this finding and certainly warrants further investigation when data on other countries become available. We have also estimated several alternative specifications with only two banking reform levels (one dummy variable) and also without banking reform variables. In both instances, the explanatory power of the model decreases, but qualitative results remain unchanged.

Finally, we investigated sensitivity of our results to the inclusion or exclusion of the energy intensities in the data. Regression results are invariant to the inclusion or exclusion of the energy intensities as a 14th pollution indicator.

5. Conclusions

Using relatively simple techniques we investigated the character of the change in the pollution emissions of 13 pollutants plus energy intensity of value added in 12 CEE/NIS countries which have embarked on the path of economic transition from the centrally planned towards market driven economic systems. We found that pollution emissions associated with aggregate manufacturing production have substantially decreased because of the near collapse of manufacturing in many of the former CPE. However, it was more difficult to identify patterns of changes in emissions due to the new composition of manufacturing activities. A diversity of patterns emerge with some cleaner composition for some effluent types and some countries, but also with dirtier composition for other pollutants and countries. Despite these heterogeneous patterns, we were able to identify two recognizable clusters of countries, one expressing the tendency towards cleaner manufacturing, and the other moving towards dirtier sectors based on heavy manufacturing.

From our econometric exercise we found strong evidence that the majority of the transition reforms, such as increased openness and enterprise restructuring and privatization has influenced the allocation of resources towards cleaner manufacturing sectors. The same can be said about the changes in energy intensity per dollar of value added. Most of the former CPE experienced a major change in the price of energy caused by realignment of domestic prices to world prices, as evidenced by

decreasing energy intensity of aggregate income. Because of a tighter budget constraint at the enterprise level, enterprise restructuring and privatization reforms reinforce the response to price signals and induce greater allocative efficiency with an indirect environmental improvement. Both of these results provide support to the early conjecture of Hughes (1991) on rapid environmental improvement in CPE following the collapse of the communist system.

In summary, our findings can be interpreted as being consistent with Lucas *et al.* (1992). In the case of the former CPE, the partial effect of outward orientation achieved with reforms affecting market incentives and border measures is beneficial to the environment. We also find empirical support for the conjecture that more stringent environmental regimes produce further shifts away from pollution-intensive activities suggesting increased environmental benefits from the coordination of environmental protection and market reforms.

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