CARBON LEAKAGE WITHIN THE EU: A STUDY ON THE IMPACT OF THE ENVIRONMENTAL POLICY ON THE COMPETITIVENESS OF THE POLLUTION INTENSIVE SECTORS

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Abstract

In this paper we investigate the relation between the environmental policy and the competitiveness of the polluting sectors in the international market. We propose several alternative indicators to assess the stringency of environmental policy. A standard gravity framework is used for measuring the impacts of the environmental policy on the volume of trade in the pollution intensive sectors. The model estimation is conducted in two samples – a general and a secondary sample including only bilateral trade flows between the EU member-states. We find a strong correlation between the amount of trade and strictness of environmental policy both in the importing and exporting countries. Results provide a basis for assessing the economic impacts of the Kyoto protocol and the European emissions-trading scheme.

Key words: Environmental policy, International trade patterns, Competition

1. Introduction

The start of the first commitment period of the Kyoto Protocol brings forward the questions of the economic consequences of the greenhouse gases mitigation. The main principle in Kyoto Protocol of "common but differentiated responsibilities" divides the participants in two groups:

1) **Annex B states**[3], including 36 industrialized countries which have to abate their emissions to the assigned in the Protocol amount.
2) **Non-Annex B countries** without quantitative emission reduction targets.

There are well reasoned concerns that the differentiated commitments of the two sets of countries will cause change in the patterns of the international trade[4]. The national divergences of the environmental costs may result in loss of competitiveness on the international markets in the pollution intensive sectors for the Annex B countries and increase of the production, respectively the emissions in the non-Annex B countries. Such a situation when one country increases its competitive advantages and volume of production, due to comparatively lax environmental policy is called "Emissions leakage" or in the case of greenhouse gas emissions – "Carbon leakage". The sectors that may be affected by the shift of the competitive advantages include: electricity, iron and steel, paper and pulp, cement, glass, ceramics, chemical production and many others.

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[3] By the name of the second annex of the Kyoto Protocol, containing a list of countries and the corresponding commitments for reduction of greenhouse gases emissions.
[4] **Barrett, S.** Environment and statecraft. The strategy of environmental treaty-making. Oxford University press, New York, 2005. p. 383.

Carbon leakage phenomenon hinders the international efforts to prevent the global warming and reduces the environmental effectiveness of the Kyoto Protocol. The leakage also decreases the economic efficiency of the Protocol by worsening the trade balances of the industrialized countries in addition of the emissions mitigation costs and it is the main reason for the US withdrawal from the agreement[5].

The Kyoto Protocol is a global initiative that is unprecedented in terms of its scale and scope. The lack of knowledge and experience in the international enforcement of environmental regulation impose the need to investigate the economic consequences of greenhouse gases abatement. In this paper our goal is to assess the impact of Kyoto Protocol on the international trade patterns in the pollution intensive sectors. We hypothesize that carbon leakage is possible not only between the industrialized and developing countries but also among the Annex B countries. In order to verify this hypothesis we develop a set of country-level indicators for measuring the stringency of environmental policy and we integrate it in a model of international trade.

2. Defining Carbon leakage

Emissions leakage is not a new concept although it is a widely discussed issue in the economic theory. The relation between the stringency of environmental policy and the international competitiveness of the affected industries has been explored for the first time from William Baumol[6]. He states that the adoption of stricter environmental standards in one country may produce deterioration on its balance of payments and an increase of domestic unemployment due to decrease of export in polluting sectors. Also a country that fails to undertake an environmental protection program when other countries do so increases its comparative advantage in the production of items that damage its environment; in the absence of offsetting subsidies, this will encourage greater specialization in the production of these polluting outputs.

In the more recent studies emissions leakage is examined in the context of the Heckscher-Ohlin theorem. Countries well endowed with environmental resources are expected to export pollution intensive goods and countries poorly endowed with such resources tend to export "clean" commodities[7]. Very important contribution to the theory is made by Chichilnisky who distinguishes natural and environmental resources[8] - the endowment with environmental resources is determined not by the abundance of natural resources but the availability of these resources for economic activities or in other words by the adopted environmental policy. Countries with relatively lax environmental policy may be expected to export more environmentally intensively produced commodities even if they are poorly endowed with natural resources.

Thereby when a country (or a group of countries) adopts relatively stringent environmental policy it reduces its comparative advantages in the international trade with "dirty" goods, which results in reduction of production and export of the commodity. Emissions leakage occurs when the decrease of export is compensated by an increase of

[5] **Stavins, R., Barrett, S**. Increasing participation and compliance in international climate change agreements. Kennedy School of Government, Harvard University Working Paper, No. RWP02-031, 2002. p.11.

[6] **Baumol, W., Oates, W.** The theory of environmental policy. Prentice-Hall Inc, New Jersey, 1975. pp. 213 – 225.

[7] **Rauscher, M.** International trade, Foreign Investment, and the Environment. Handbook of environmental economics, Volume 3. Economywide and international environmental issues, Edited by Maler, K. and Vincent, J., Elsevier North-Holland, 2005. p. 1408.

[8] **Chichilnisky, G.** North-South Trade and the Global environment. The Economics of International Trade and the Environment, Edited by Batabyal, A., Beladi, H., Lewis Publishers, Boca Raton, 2001. p. 98.

production and respectively – pollution in other jurisdictions with relatively lax environmental standards.

This assertion meets some eminent opposition. Porter and van der Linde[9] state that all pollution is a result of incomplete, inefficient, or ineffective use of the resources and well-designed environmental regulations stimulate innovation which, by enhancing productivity, increases private benefits and international competitiveness of affected companies. On the empirical level studies on the relationship between competitiveness, reflected in changes in the trade patterns, and environmental regulation do not find either a significant adverse effect of more stringent environmental policies on competitiveness, or evidence supporting the Porter Hypothesis[10].

The possible reasons for the inconclusive results of the empirical studies on emissions leakage can be divided in two sets:

- *Measurement difficulties.* They are associated with the lack of objective country-level indicators for assessing the stringency of environmental policy and also with the possibility that leakage effects are too small to be detected by current statistical means[11].
- *Existence of counteracting factors.* These factors include the common variables that influence the volume of international trade and thus affecting leakage, such as: *trade frictions*[12] – shipping and communication costs, tariffs, customs agency fees and other importer country regulations reduce the advantages that the exporter gains from its lax environmental standards; inability of the pollution havens (which are mainly developing countries) to organize production[13] due to corruption, lack of investments and infrastructure.

We consider that the Kyoto Protocol holds the potential to induce severe leakage effect due to the significant divergence in the commitments of the Annex B parties and the developing countries. Also we assert that leakage can occur among the Annex B countries themselves and in particular between the transition economies and the industrialized countries. Our arguments in support of this hypothesis stem from the fact that in the transition economies the actual CO_2 emissions are well below the assigned in the Protocol amount due to the restructuring of the economy and the decrease of industrial output. These countries can actually increase their greenhouse gases emissions regardless of their inclusion in the Annex B of the Kyoto Protocol. Our study is focused on the EU countries because we consider that the lack of trade restrictions amongst members and relatively shorter transport distances (and costs) would induce emissions leakage in larger extent.

3. Modelling the impact of environmental regulation on the patterns of international trade

As we pointed out earlier one of the main obstructions in the econometric studies of emissions leakage is the lack of objective indicators for measuring the strictness of environmental policy. Previous researchers coped with this challenge by using proxy

[9] **Porter, M, van der Linde, C.** Green and competitive ending the stalemate in On competition. Harvard business school publishing, Boston, 1998. pp. 352 – 360.

[10] **Rivera-Batiz, L., Oliva i Armengol, M.** International Trade, Theory, Strategies and Evidence. Oxford University Press, New York, 2003. p. 614.

[11] **Xepapadeas, A.** Economic growth and the environment in Handbook of environmental economics. Volume 3. Economywide and international environmental issues, Edited by Maler, K. and Vincent, J. Elsevier North-Holland, 2005. p. 1260

[12] **Copeland, B., Taylor, M.** Trade and the Environment. Princeton University Press, New Jersey, 2003. p.110.

[13] **Smarzynska, B., Wei, S.** Pollution Havens and Foreign Direct Investment: Dirty Secret or Popular Myth? National Bureau of Economic Research, Working paper No 8465, Cambridge, September 2001. pp. 2-3.

variables or subjective scales. Copeland and Taylor[14] measure the stringency of environmental regulation using sulfur dioxide (SO_2) concentrations in the atmosphere from 290 observation sites in major urban areas. This approach has several weaknesses as concentration data possess large annual variance – up to 9000% in some observation sites; also only 30% to 50% of the SO_2 emissions are from anthropogenic sources and cannot be relied on for assessing the stringency of regulation.

Smarzynska and Wei[15] employ three different variables to capture the strength of environmental protection. The first is based on the degree of participation of one country in different international protection treaties adjusted by the number of environmental NGOs in that country relative to its population size. The second is an index developed by the European Bank for Reconstruction and Development. The third variable contains data for the actual reductions in emissions of several major pollutants for five years period as a proxy for the effectiveness of environmental policy. We find some faults in this approach too. For the first two variables the derived numerical values don't necessarily describe correctly the actual differences in the strictness of regulation and possess subjective features in some extent. Concerning the third variable we may argue that emission reductions are not always induced by change of environmental policy, pollution abatement may also be a result from rise in fuel prices or decrease in industrial output (for example in the transition economies).

Grether, Mathys and de Melo[16] use the difference in the average lead content of gasoline for the exporter and the importer as a proxy for assessing the regulatory gap between the two countries. We consider this indicator to have too small descriptive power for the stringency of environmental policy provided that it concerns only one narrow aspect of regulation. Gasoline lead content also does not provide the necessary cross-sectional variation for an econometrical study of EU members.

Our goal in this paper is to measure the magnitude of carbon leakage or the impact of restrictions on greenhouse gasses emissions over the patterns of international trade. In order to achieve this goal we propose three *alternative* variables for assessing the stringency of environmental regulation and in particular the greenhouse gases emissions standards. The Kyoto Protocol only sets the emission targets for each of the countries in Annex B for the commitment period (2008 -2012). We employ country-level proxy variables to take into account the different approaches that every country may adopt for achieving its targets (direct regulation, Pigouvian taxes, tradable emission permits etc.).

The first indicator (**KPa**) is a dummy variable with value 1 when a country has commitments for emissions abatement under the Kyoto Protocol and zero value if the country's emissions are not capped. This variable divides the selection into two groups – Annex B and non-Annex B countries. We assume that Annex B countries would have more stringent environmental regulations relative to the rest of the world. It may look somehow simplistic but this variable allows us to check for significant leakage effects between the two groups of countries.

However the Annex B countries are not an internally homogenous group. Each of these countries employs different environmental standards and certainly has different emission levels. To include these peculiarities in the model we introduce the second Kyoto variable (**KPb**) which contains data for each country's share of actual emissions in its assigned amount in Annex B of the Kyoto Protocol. We assume that countries with emission levels higher than the Annex B limit (KPb > 1) would have to adopt stricter environmental standards on order to achieve their Kyoto targets. The countries with emission levels below

[14] **Copeland, B., Taylor, M.** Op. Cit. 2003. p. 223.
[15] **Smarzynska, B., Wei, S.** Op. Cit. 2001. pp. 8-9
[16] **Grether, J., Mathys, N., de Melo, J.** A Gravity analysis of the pollution content of trade. Working paper. September 2005. http://www.etsg.org/ETSG2005/papers/mathys.pdf

the assigned amount (for example the transition economies) can maintain lax policy in the 2008-2012 commitment period. The countries without emission targets under the Kyoto Protocol don't have assigned amount, thereby for the non-Annex B countries we accept an artificial value of 0.001 (or 0.1%) to represent the possibility for unrestricted increase of emissions. This variable is has better descriptive power than KPa because of the actual numeric value for each of the countries in the sample and the large cross-selection variance.

The third Kyoto variable (**KPc**) that we propose is called "Carbon intensity of the economy". KPc accounts for the amount of greenhouse gases that are released in the atmosphere for producing one unit of the GDP in the corresponding country. This variable is computed as the annual emissions are divided by the GDP. The stringency of environmental policy is described probably best with the carbon intensity because this indicator accounts for the magnitude of production and not only the volume of emissions.

In modeling the impact of environmental regulation over the patterns of international trade we apply each of the proposed Kyoto variables in separate regression equations in order to asses the leakage effects at different levels. In this study we apply gravity model which is most commonly used model in measuring the effects on trade flows[17]. The gravity model allows us to take into account the different variables relevant to the emissions leakage and the standard determinants of international trade. We use the natural log form of the multiplicative gravity equation which yields the following expression:

$$\begin{aligned} \ln M_{ie} = {} & \beta_0 + \beta_1 \ln GDP_i + \beta_2 \ln GDP_e + \beta_3 \ln IPC_i + \beta_4 \ln IPC_e + \\ & + \beta_5 \ln DIST_{ie} + \beta_6 \ln KP_i + \beta_7 \ln KP_e + \beta_8 BOR + \beta_9 EU + \\ & + \beta_{10} LNG + \varepsilon_{ie} \end{aligned}$$

Where:

M_{ie} – Value of import from pollution intensive sectors in country *i* (importer) from county *e* (exporter).
GDP – Gross Domestic Product of *i* and *e*. This is a proxy variable for the economic size and export (import) potential of the trade partners.
IPC – Income per Capita. A proxy variable for labour costs and level of economic development.
$DIST_{ie}$ – Physical distance between the capitals of the two trade partners. Proxy for the transport, communication, transaction cost and cultural distance[18].
KP – Kyoto variables.
BOR – Dummy variable with value 1 when the trade partners share common border and zero if they don't.
EU – Dummy variable that controls for the trade agreements between the partners. The variable yields value 1 when *both* exporter and importer are members of EU and zero value when one of them is not.
LNG – Dummy variable with zero value when the two countries speak in different languages and 1 when they share common language.
ε_{ie} - Multiplicative error term.

[17] **Anderson, J., van Wincoop, E.** Gravity with Gravitas: a Solution to the Border Puzzle. American Economic Review, No. 1, 2003. pp.170-171.
[18] **Head, K.** Elements of Multinational Strategy. Springer-Verlag, Berlin, 2007, pp. 55-56.

The $\boldsymbol{\beta}$ coefficients represent the influence of the corresponding variable over the trade flow. In the natural log form of the multiplicative function the parameters are interpreted as coefficients of elasticity[19]. In this study we are interested especially in the parameters of the Kyoto variables which account for the impact of greenhouse gasses regulation in the exporter ($\boldsymbol{\beta}_7$) and the importer ($\boldsymbol{\beta}_6$) over the trade flows.

We acquired data for the import of EU member-states in all sectors covered form the Kyoto Protocol excluding electricity (due to weak international competition) and fuel refining (trade is strongly determined by natural and income factors). In the sample are included 55 states – 34 Annex B and 21 non-Annex B countries. The study is conducted on aggregate level covering data for the 2006 year [20]. We use ordinary least squares method for model estimation.

4. Carbon leakage: Results

The model is estimated separately with each of the Kyoto variables thus producing three different regression equations (Table 1). The fourth regression is constructed by using the KPc variable and limiting the sample only to the intra EU trade. The estimates of regression parameters and the significance levels of the t criteria are shown in table1.

The first regression yields significant parameter estimate only for the KPa_i variable. The exponential value of the coefficient[21] (0.373) indicates that the Annex B countries import less pollution intensively produced commodities (with 62.7%) relative to non-Annex B. This finding contradicts the hypothesis that the strictness of environmental regulation in Annex B would induce increase of import in the affected industries. The higher import in the non-Annex B countries can be explained with the differences in the level of economic development and not the in the environmental policy. All of the Annex B countries are highly developed and their industrial potential is greater than the internal demand, on the contrary the developing countries consume more industrial goods than they can produce.

Significant estimates of the parameters in *the second regression* are produced again for the Kyoto variable of the importer country. The value of the KPb_i coefficient (-0.47) indicates that *increase* in the share of greenhouse gasses emissions in the assigned amount with 1% corresponds to *decrease* in value import with 0.47%. This result implies that the lax environmental policy allows the substitution of import in the pollution intensive industries with a local production.

Table 1. Regression results for carbon leakage

Variables	Regression 1		Regression 2		Regression 3		Regression 4	
	β[22]	Sig.[23]	β	Sig.	β	Sig.	β	Sig.
Observations	1291		1291		1291		672	
Constant	9.001	0	7.28	0	8.042	0	4.786	0.004
GDPi	1.102	0	1.06	0	1.008	0	0.897	0
GDPe	1.115	0	1.109	0	1.124	0	0.944	0
IPCi	-0.506	0	-0.336	0	-0.516	0	-0.354	0.002
IPCe	-0.167	0	-0.182	0	-0.068	0.288	0.46	0

[19] The interpretation of the dummy variable coefficient is not straight forward. The exponential function of the dummy coefficient shows the degree of deviation from the normal level as a percentage.

[20] Data sources: Eurostat (for economic statistics: international trade; GDP and population) and United Nation Frame Convention on Climate Change (for emissions data).

[21] The KPa indicator is a dummy variable and cannot be interpreted as a elasticity coefficient.

[22] Estimates of regression parameters.

[23] Significance levels of the t criteria.

DIST	-1.561	0	-1.533	0	-1.532	0	-1.395	0
EU	0.694	0	0.693	0	0.728	0	-	-
BOR	0.725	0	0.738	0	0.716	0	0.735	0
LNG	0.01	0.946	-	-	-	-	-	-
KPai	**-0.985**	**0**	-	-	-	-	-	-
KPae	**0.178**	**0.158**	-	-	-	-	-	-
KPbi	-	-	**-0.47**	**0.015**	-	-	-	-
KPbe	-	-	**0.074**	**0.573**	-	-	-	-
KPci	-	-	-	-	**-0.123**	**0.43**	**0.039**	**0.782**
KPce	-	-	-	-	**0.202**	**0.037**	**0.457**	**0.001**

The countries with actual emission levels higher than the Kyoto targets (KPb > 1) will increase their import in the regulated industries with 0.47% per every percent of emissions abatement. In this category belong 19 countries, all of them amongst the largest economies in the world; therefore we can anticipate that the implementation of the Kyoto Protocol's targets will have substantial effects over the structure and volume of international trade. The increased import will cause carbon leakage consisting of rise in export and respectively the production in the rest of the world thus offsetting the emission abatements conducted in the Annex B countries.

The third regression yields statistically significant estimates for the parameter of the exporter's carbon intensity (KPc_e). The coefficient value (0.202) indicates that countries with 1% higher carbon intensity (laxer environmental policy) export 0.202% more goods from the regulated industries. The compliance with the Kyoto targets will cause the Annex B countries to mitigate their emissions and lower the carbon intensity of their economies, thus shifting the comparative advantages in the international trade towards the developing countries which can maintain their carbon intensity or even increase it. This result reconfirms the proposition that the national differences in the stringency of environmental policy influence the patterns of international trade. Based on the findings from second and third regressions we can conclude that the leakage effect is determined from both exporter and importer environmental policy.

The fourth regression deals with leakage effects within the EU. The estimate of the KPc_e parameter is 0.457 or 2.26 times bigger than the estimate from the third regression. This value indicates that carbon leakage within the EU is roughly 2 times more severe than in the general sample. We explain this result with two general reasons. First the EU is substantially heterogeneous in terms of environmental policy due to the lax regulation in the newly accepted members[24]. The second reason is the free trade among the member-states which allows the leakage effect to occur in full extent. These findings are consistent with Copeland and Taylor's[25] statement that trade liberalization may induce leakage even if the environmental policy is fixed. Trade policy is commonly used for reducing emission leakage but it is inapplicable to the intra EU trade. Therefore in October 2007 the European Commission issued a decision[26] for additional emission abatements in the 12 new member states. Despite the environmental reasoning, the severity and the selective nature of the decision suppose probable economic motives for its adoption.

5. Conclusions

In this study we find that the in the stringency of environmental policy affects the international trade patterns by increasing trade in the pollution intensive industries. The

[24] The carbon intensities of the new member-states is extremely higher than the EU-15 countries. For example the value of the indicator in Bulgaria (2.14) is 12 times larger than Sweden (0.18).
[25] **Copeland, B., Taylor, M.** Op. Cit. 2003. p.116.
[26] European Commission decision No IP/07/1614, Brussels, 26 October 2007.

mitigation of greenhouse gasses emissions required in the Kyoto Protocol will increase the country-level divergence in the environmental regulation and induce significant carbon leakage. Due to the leakage effect the emission abatements in the Annex B countries will be offset by an increase in the developing countries and the transition economies. We prove that the emission leakage is also largely influenced by trade policy.

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Annex 1

Countries included in the sample and their corresponding Kyoto variables

№	Country	Kyoto variables		
		KPa	KPb	KPc
1	Algiers	0	0.001	0.7985
2	Australia	0	0.001	0.6889
3	Austria	1	1.336	0.2831
4	Belarus	0	0.001	2.0128
5	Belgium	1	1.098	0.3772
6	Brasilia	0	0.001	0.6170

7	Bulgaria	1	0.530	2.1444
8	Canada	1	1.353	0.6057
9	China	0	0.001	1.5207
10	Croatia	1	1.345	0.6900
11	Cyprus	0	0.001	0.5798
12	Czech republic	1	0.833	1.0374
13	Denmark	1	1.246	0.2529
14	Egypt	0	0.001	1.0910
15	Estonia	1	0.533	1.2993
16	Finland	1	1.156	0.3888
17	France	1	0.991	0.2522
18	Georgia	0	0.001	1.4159
19	Germany	1	1.033	0.3493
20	Greece	1	1.006	0.5619
21	Hungary	1	0.730	0.7434
22	Iceland	1	0.863	0.1963
23	India	0	0.001	1.3398
24	Iran	0	0.001	1.7293
25	Ireland	1	1.126	0.3075
26	Italy	1	1.219	0.3158
27	Japan	1	1.214	0.3122
28	Latvia	1	0.461	0.5342
29	Lithuania	1	0.431	0.6778
30	Luxemburg	1	1.315	0.3074
31	Macedonia	0	0.001	2.2348
32	Malta	0	0.001	0.4794
33	Mexico	0	0.001	0.4565
34	Moldova	0	0.001	4.7021
35	Nederland	1	1.096	0.3316
36	New Zeeland	1	1.221	0.7229
37	Nigeria	0	0.001	2.1156
38	Norway	1	1.085	0.1766
39	Philippines	0	0.001	0.8626
40	Poland	1	0.731	1.1456
41	Portugal	1	1.121	0.4390
42	Romania	1	0.634	1.2715
43	Russia	1	0.664	2.0510
44	Slovakia	1	0.769	0.9269
45	Slovenia	1	1.080	0.5377
46	South Korea	0	0.001	0.3260
47	Spain	1	1.311	0.3496
48	Sweden	1	0.930	0.1815
49	Switzerland	1	1.099	0.1396
50	Turkey	0	0.001	0.7296
51	UK	1	1.017	0.2837
52	Ukraine	1	0.422	3.8960
53	Uruguay	0	0.001	1.5442
54	USA	0	0.001	0.5353
55	Vietnam	0	0.001	1.3871