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Original article

The evolution of carbon dioxide emissions embodied in international trade in Poland: An input-output approach

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ABSTRACT

International agreements that aim to reduce carbon dioxide emissions have raised concerns due to the risk of carbon leakage caused by trade liberalization. This study aims to analyse the carbon dioxide emissions related to trade flows for the case of Poland, in order to further investigate the interrelationship between emissions and the quick economic growth the country has faced since 2000. The communist past, the quick liberalization of the economy, the trade opening, entrance to the EU and the intense carbon economy, are some of the characteristics that make Poland an interesting case. The data available data from 1996 to 2008 were collected using the World Input-Output Database and were analyzed using the Input-Output method, and more concretely by constructing a multi-regional input-output model for the years studied. The findings indicate that there were substantial effects on the emissions of Poland that resulted from the opening of the economy and joining the European Union. Poland is a net importer of carbon emissions from other European countries; however, this phenomenon seems to be regulated by EU legislation. Additionally, it was shown that Polish imports from countries with less strict environmental policies significantly embody higher levels of emissions than its exports. This observation calls for stricter environmental regulations to avoid carbon leakage.

KEY WORDS: Input-Output analysis, multi-regional model, ecological economics, carbon leakage

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1. Introduction

The issue of climate change has been of high importance over the past years and many countries have agreed on a legally binding deal, in order to cut down on greenhouse gases (GHG) emissions, and to prevent climate change. According to this deal, known as the Kyoto Protocol, the so called Annex I countries are committed to reduce their carbon dioxide (CO_2) emissions by 5.2%, from 1990 levels. However, as many have pointed out (e.g. SUBAK, 1995; LENZEN, 1998) these efforts can be undermined, as the participant countries can achieve a reduction in their CO_2 emissions simply by importing goods and services from developing countries. This phenomenon, also known as carbon leakage, is associated with trade that allows the reallocation of environmentally polluting activities to countries with lower environmental standards.

However, despite the increased interest on the topic (more information can be found in the review from WIEDMANN (2009)), there has been little research on individual countries, for example Austria (KRATENA & MEYER, 2010), the United Kingdom (BARRETT ET AL., 2013), the USA (WEBER & MATTHEWS, 2007) and China (ZHANG, 2015). To our knowledge there is no extensive research on the case of Poland, with the exception of MIZGAJSKI (2013) based only on data from 2004.

Thus, the present study aims to fill this aforementioned gap by examining how the CO_2 emissions embedded in trade, have changed since the collapse of the Soviet Union, and during the period of growth in Poland. The rest of the article is structured as follows: following this introduction, section two presents the specific characteristics of the case of Poland, section three provides a literature review and section four describes the methodology used. The results obtained will be presented in section five while section six will conclude.

2. The case of Poland

Poland makes an interesting case study due to its unique environmental, economic and political characteristics inherited from the communist era. For instance, the high energy demanding industrial sector, the centralized planning, the high levels of corruption and bureaucracy, the low levels of public interest and the rather symbolic environmental legislation (LIPTON & SACHS, 1990; HENNING, 2017) are some of the factors that still affect all aspects of Polish socio-economic and environmental performance.

After the collapse of the Soviet Union, in 1991, the post-communist democratic government in Poland started a process of liberalization with radical changes in the economy and policy sector. During the 1990s, the country experienced a reduction in its overall emissions due to the collapse of the previous energy intensive economy and the deep recession caused by the reconstruction of the economy (LIPTON & SACHS, 1990).

However, this period of transition that lasted more or less until 1999, was followed by a period of rapid growth. The expansion of the political, economic and cultural relations with Western Europe and the United States was the focus of this new source of growth. This breakthrough gave Poland the possibility to join the market for the free transfer of people and goods and to become a European Union (EU) member state in 2004.

Poland has experienced a period of fast growth over the past decade and now, is the fifth fastest growing economy in the EU and the largest economy among Eastern European countries (WORLD BANK, 2018). The economic performance of the country is characterized by high levels of economic growth; an average of 3.9% annually for the period 1997-2014 (authors' calculations based on EUROSTAT, 2018). This is almost 2.5% higher than the EU average (1.6% average growth annually for the period 1997-2014) (Fig. 1).

Poland was the only EU country to avoid the 2009 recession, according to the INTERNATIONAL MONETARY FUND (2015) and has shown a sustainable growth rate since then. Manufacturing is still the most important sector of the Polish economy making up 20.4% of the Polish Value Added (VA) (% of the GDP) followed by the residential sector and transport. Additionally, coal still dominates the economy (51% of total primary energy supply) and the carbon intensity of Poland is among the highest in Europe (CONTI ET AL., 2016).

The amount of exports and imports as a percentage of GDP is close to 50%, and both imports and exports have shown a significant increase since 1996 and especially imports have increased sharply since 2008, highlighting that Poland is being transformed into an importing economy (Fig. 2). Indeed, Polish products were reported to be sold in 218 countries in 2014 (WITS, 2018).

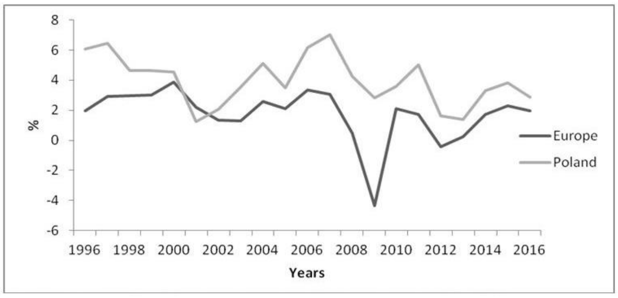

Fig. 1. GDP growth rate for Poland and the EU (annual %) (Source: Authors' own elaboration based on data from World Bank, 2018b)

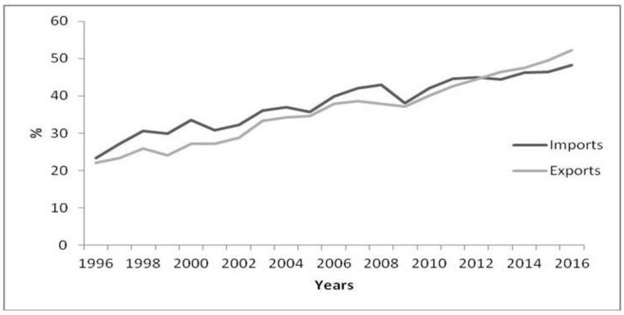

Fig. 2. Exports of goods and services as % of GDP for Poland (Source: Authors' own elaboration based on data from World Bank (2018c)

2.1. Poland and the EU

The EU has come up with strict environmental regulations and ambitious environmental targets, such as the 2020 target. According to this energy package, the Union aims to achieve a 20% reduction in GHG emissions compared to the 1990 levels, a 20% share of renewable energy in final energy consumption and a 20% reduction of the primary and final energy consumption compared to the projected EU baseline (EUROPEAN COMMISSION, 2014). Among the various instruments adopted to help the Union achieve these targets, the EU Emissions Trading System (ETS) is currently the biggest carbon market and functions under a cap and trade system. In the current third phase (2013-2020), the nation based cap is replaced by an EU common cap, while more sectors and gases are included (BURAS, 2017).

Following the fall of communism in Poland in 1989, the country's carbon emissions were sharply reduced and Poland ratified the Kyoto Protocol in 1996. The country met its target for the period 2008-2012: a decrease of 6% based on the 1988 levels for CO_2, CH_4 and N_2O. However, Poland recently raised significant concerns on the further reduction of CO_2 emissions proposed by the EU in the Kyoto Protocol extension. The Polish government expressed worries regarding the effectiveness of the ETS and the Prime Minister Beata Szydło threatened to quit ETS if the review comes with further obligations for the Polish industries (BURAS, 2017). Poland does not agree with the adoption of a single timeline and a single approach and as SKOCZKOWSKI (2017) aptly points out "*Hardly any other area of the EC policy evokes such discussion and controversy as the climate policy, especially when it comes to binding emission reduction targets and instrument to accomplish them. It especially applies to Poland where in general climate policy is questionable and commonly seen as being against national interest*." Despite this, one should acknowledge that being a member of the EU has been the most important external factor when it comes to GHG emissions reduction placing significant pressure for energy transition and cleaner technologies (MARCUS ET AL., 2015). The CO_2 emissions have been significantly reduced since 1996 (Fig. 2), however, the country still lags behind compared to the EU average and its economy is among the least carbon-efficient in the EU mainly due to its high dependence on coal.

3. Input-Output tables

In the present times of globalization, in which phenomena and forces are connected and interrelated, topics such as sustainable growth, pollution, international trade or physical flows, can only be understood with a broad perspective. In line with this, the Input-Output tables developed by LEONTIEF (1941) have been used widely in calculating emissions embodied in bilateral trade aiming to explain trade patterns in the context of emissions. For instance, the paper by DÍAZ ET AL. (2016) examines the relevance of using multi-country Input-Output tables in measuring emissions among countries, focusing on Spain. The authors conclude that Spain has some negative trade emissions with China, Russia and the United States, more even than the rest of the EU as a whole. In our study, we follow a similar approach aiming to investigate the changes in the economy and emissions from both, the supply and demand side, due to joining the EU by one representative Eastern European country.

Concerning emissions of GHG, strong changes in the patterns of trade in a country, lead to changes in productive structure and final demand. These changes generate shifts in the composition of the emissions by economic sectors or branches, which in turn, depend on the level of technology and its use. With regard to this, a remarkable note is given by RUEDA-CANTUCHE & AMORES (2010) who concluded that developed countries may reduce their emissions produced at the same time, but they may also increase their consumption-based emissions. Another example comes from the study of LENZEN (1998) who focuses on primary energy and GHG using an Input-Output table analysis. In a similar way, SERRANO & DIETZENBACHER (2010) also apply the perspective of GHG emissions associated with the consumption in Spain. In the present analysis we are also interested in these branches of economics to disaggregate our study more clearly and to better understand which aspects contributed most to the total emissions.

Moreover, in this article, special attention is paid to the changes in supply and in the final demand, relating the local economy and the rest of the world. This is consistent with the hypothesis that Poland, as a representative ex-communist country and new member of the EU, has faced important changes in its patterns of trade, its economic growth and thus in its CO_2 emissions. One of our references for this approach is also the paper of EDENS ET AL. (2011) that constructs bilateral emission trade balances for the Netherlands and 17 regions for the period between 1996 and 2007 as well as the work of REMUZGO & SARABIA (2013) that analyzes the distribution of the emissions among sectors.

4. Methodology

This study is based on the World Input-Output Database (WIOD) data for Poland for the years 1996-2008. The time frame was chosen based on the data available at the time of the research. With Poland being the country of interest, a table was designed depicting the Polish intermediate consumption by sector during these years. The emission exports produced by Poland and used in production by other countries were calculated and added to the matrix. By having all these factors in the columns of an Input-Output matrix one could easily see the relationship between the total output of a country and the sum of all the cells in one sector.

The rows of the Input-Output matrix represented the production and imports of Poland by sector. In addition, the Value Added and the CO_2 emissions per sector were included.

In the columns, the sum of the intermediate consumptions and imports of each column, plus the Value Added that equals the total output produced was represented. In this way, an Input-Output table for each of the years was constructed, leading to a total of twelve matrices to analyze.

The methodology used for this study is properly defined as Input-Output analysis, and more concretely, the multi-regional Input-Output model (LEONTIEF, 1941; 1953; 1970). Forty countries and their interactions were analyzed using a dual perspective matrix of emissions. The model is defined in the following way:

$$X_j = f(Z_{ij}, Fd_{ij}) \Rightarrow X = f\,(Z, Fd) \qquad (1)$$

where: X denotes the output, Z the inter-sectoral flows within the country and between countries and Fd the final demand for each country. We first read Z, X and Fd from the table, and form the technological coefficient matrix (matrix A) by multiplying inter-sectoral flows by the inverse of the diagonal matrix of the total output:

$$A = Z * diag(X^{-1}) \qquad (2)$$

It is a first advance for analysis, since it tells us the quantity of row product *i* that is required to produce one unit of the column product *j*. Then, the Leontief matrix and Leontief inverse matrix are computed as follows:

$$M = (I - A)\ (3)$$
$$M^{-1} = (I - A)^{-1}\ (4)$$

The Leontief inverse matrix allows us to capture the (extra) production in sector *i* that is necessary to satisfy an (extra) final demand of one Euro for goods *j*. Similarly having the direct emissions from WIOD we calculated the emission coefficients and the emission multiplier matrix:

$$E = e(I - A)^{-1}Fd \quad (5)$$

Now, e is a vector of the CO_2 emission coefficients and E is the emission multiplier matrix. From there we calculate the final demand matrix:

$$E = S * Fd\ (6)$$

The final demand matrix includes the aggregate on of the final consumption expenditure by households, final consumption expenditure by non-profit organizations serving households (NPISH), final consumption expenditure by government, gross fixed capital formation, changes in inventories and valuables and exports for each country. Moreover, S represents the emission intensity matrix which enables us to evaluate the emissions required to satisfy the inter-sectoral flows. The total emissions matrix allows us to calculate the total emissions to satisfy one unit of final demand of each country by sector. Also, aggregating the sector of each country simplifies our matrix and gives us the dual perspective matrix of emissions by country; that is without examining each sector in detail. This is done by summing up the columns and rows of each country when we get the emissions needed to satisfy the consumption of each country (columns) and the emissions due to production (rows).

5. Results

After analyzing the results using the methodology described above, we observed that throughout the years USA, China, Russia and Czech Republic have been the most important trade partners of Poland, followed by Italy, France and the UK. The emissions embodied in trade with the most important partners are represented in Table 1.

Table 1. CO_2 emissions embodied in trade between Poland and its most important trade partners (1996–2008) [kt]

	1996				1998				1999			
	CO_2 emis-sions in exports from Poland	CO_2 emis-sions in imports to Poland	CO_2 emis-sions balance	Total CO_2 emis-sions in bilateral Trade	CO_2 emis-sions in exports from Poland	CO_2 emis-sions in imports to Poland	CO_2 emis-sions balance	Total CO_2 emis-sions in bilateral Trade	CO_2 emis-sions in exports from Poland	CO_2 emis-sions in imports to Poland	CO_2 emis-sions balance	Total CO_2 emis-sions in bilateral Trade
AUT	1 882	200	-1 683	2 082	2 565	307	-2 258	2 872	2 450	373	-2 077	2 822
CAN	592	301	-292	893	622	304	-318	925	615	415	-200	1 030
CHI	562	1 447	885	2 008	480	1 821	1 340	2 301	440	2 490	2 049	2 930
CZR	2 146	1 548	-599	3 694	2 265	1 703	-562	3 967	2 084	1 938	-146	4 022
DNK	1 701	374	-19 399	25 034	1 820	445	-17 685	24 506	1 608	329	-15 510	24 269

DEU	22 217	2 817	-1 327	2 075	21 095	3 410	-1 375	2 264	19 890	4 380	-1 279	1 937
ESP	1 326	365	-960	1 691	1 315	578	-737	1 893	1 330	658	-672	1 989
FIN	669	315	-354	984	724	374	-349	1 098	652	459	-192	1 111
FRA	3 977	774	-3 203	4 750	3 584	980	-2 604	4 564	3 444	1 186	-2 258	4 630
GBR	3 265	1 185	-2 080	4 450	3 611	1 430	-2 181	5 041	3 667	1 408	-2 259	5 074
HUN	1 226	335	-891	1 561	1 242	386	-856	1 629	881	420	-461	1 300
ITA	3 803	1 104	-2 699	4 908	3 990	1 440	-2 551	5 430	3 993	1 563	-2 430	5 557
NTH	2 360	609	-1 751	2 969	2 174	697	-1 477	2 871	2 528	928	-1 600	3 456
RUS	5 142	10 634	5 492	15 777	6 149	11 303	5 154	17 452	4 583	14 465	9 882	19 048
SWE	1 585	228	-1 357	1 814	1 569	300	-1 269	1 869	1 665	342	-1 323	2 007
USA	4 853	1 112	-3 741	5 965	5 666	1 397	-4 269	7 062	5 159	1 427	-3 732	6 586
	57 308	**23 347**	**-33 960**	**80 655**	**58 871**	**26 876**	**-31 995**	**85 747**	**54 988**	**32 782**	**-22 207**	**87 770**

	2000				2001				2002			
AUT	2 267	639	-1 628	2 906	2 485	623	-1 862	3 108	2 227	638	-1 588	2 865
CAN	890	393	-497	1 283	820	424	-396	1 244	646	454	-192	1 100
CHI	704	2 172	1 467	2 876	1 004	2 318	1 314	3 322	1 076	2 730	1 653	3 806
CZR	1 756	1 945	189	3 701	1 814	1 830	15	3 644	1 804	1 543	-261	3 347
DNK	1 393	334	-1 059	1 727	1 241	371	-13 618	22 450	1 349	352	-12 274	21 702
DEU	21 425	4 457	-16 968	25 882	18 034	4 416	-870	1 612	16 988	4 714	-997	1 701
ESP	1 655	679	-976	2 335	1 662	696	-965	2 358	1 659	685	-974	2 345
FIN	741	412	-329	1 153	674	391	-283	1 064	538	431	-106	969
FRA	3 926	1 130	-2 795	5 056	3 802	1 157	-2 645	4 960	3 797	1 196	-2 601	4 993
GBR	4 048	1 358	-2 690	5 406	4 406	1 173	-3 233	5 580	4 013	996	-3 016	5 009
HUN	1 051	404	-647	1 455	1 008	375	-633	1 383	1 088	396	-692	1 484
ITA	4 320	1 537	-2 783	5 857	3 923	1 524	-2 399	5 447	3 865	1 452	-2 413	5 317
NTH	2 085	825	-1 260	2 911	2 090	846	-1 244	2 935	2 127	889	-1 237	3 016
RUS	2 699	25 997	23 298	28 696	2 522	19 761	17 239	22 283	3 269	16 818	13 549	20 087
SWE	1 970	284	-1 686	2 254	1 599	283	-1 316	1 882	1 724	286	-1 438	2 010
USA	6 638	1 782	-4 857	8 420	6 155	1 580	-4 575	7 735	5 543	1 476	-4 067	7 019
	57 569	**44 348**	**-13 220**	**101 917**	**53 239**	**37 768**	**-15 471**	**91 007**	**51 713**	**35 057**	**-16 656**	**86 769**

	2003				2004				2005			
	CO_2 emissions in exports from Poland	CO_2 emissions in imports to Poland	CO_2 emissions balance	Total CO_2 emissions in bilateral Trade	CO_2 emissions in exports from Poland	CO_2 emissions in imports to Poland	CO_2 emissions balance	Total CO_2 emissions in bilateral Trade	CO_2 emissions in exports from Poland	CO_2 emissions in imports to Poland	CO_2 emissions balance	Total CO_2 emissions in bilateral Trade
AUT	3 051	548	-2 503	3 599	2 605	534	-2 071	3 139	2 612	689	-1 923	3 301
CAN	899	382	-517	1 281	862	378	-483	1 240	974	407	-567	1 381
CHI	1 366	3 912	2 546	5 278	1 490	192 439	190 949	193 928	1 450	7 133	5 683	8 583
CZR	2 248	1 560	-688	3 807	2 555	1 996	-558	4 551	2 314	2 043	-272	4 357
DNK	1 373	349	-1 024	1 723	1 451	303	-1 149	1 754	1 380	335	-1 044	1 715
DEU	22 657	4 536	-18 121	27 193	20 090	4 975	-15 115	25 066	17 799	5 239	-12 560	23 038
ESP	2 083	665	-1 418	2 748	2 312	791	-1 521	3 104	2 332	784	-1 548	3 116
FIN	701	375	-326	1 076	706	376	-330	1 082	732	334	-398	1 067
FRA	4 729	1 240	-3 489	5 969	4 964	1 126	-3 838	6 090	4 977	1 157	-3 820	6 133

GBR	4 826	1 065	-3 762	5 891	5 030	1 107	-3 923	6 137	5 019	1 193	-3 826	6 212
HUN	1 307	425	-882	1 733	1 728	473	-1 256	2 201	1 852	503	-1 349	2 356
ITA	4 524	1 506	-3 018	6 030	5 086	1 527	-3 560	6 613	5 245	1 487	-3 758	6 732
NTH	2 347	937	-1 409	3 284	2 217	990	-1 227	3 207	2 089	1 100	-989	3 188
RUS	3 657	15 505	11 848	19 161	4 240	14 307	10 067	18 546	4 058	14 437	10 379	18 494
SWE	2 154	297	-1 857	2 451	2 081	342	-1 740	2 423	2 007	309	-1 698	2 315
USA	5 857	1 443	-4 414	7 300	6 140	1 745	-4 395	7 885	6 018	1 804	-4 214	7 821
	63 779	**34 745**	**-29 034**	**98 524**	**63 558**	**223 409**	**159 851**	**286 967**	**60 857**	**38 953**	**-21 905**	**99 810**

	2006				2007				2008			
AUT	2 427	549	-1 878	2 976	2 337	627	-1 711	2 964	2 080	674	-1 406	2 755
CAN	978	587	-391	1 564	827	632	-195	1 458	893	727	-166	1 620
CHI	1 743	9 475	7 732	11 218	2 026	13 227	11 201	15 254	2 180	16 313	14 133	18 493
CZR	2 568	2 183	-385	4 751	2 499	2 609	110	5 107	2 737	2 405	-332	5 142
DNK	1 571	467	-12 163	24 463	1 515	521	-993	2 036	1 377	644	-733	2 020
DEU	18 313	6 150	-1 104	2 038	16 727	7 197	-9 530	23 923	15 162	7 673	-7 489	22 835
ESP	2 748	764	-1 984	3 512	2 955	980	-1 975	3 935	2 599	1 091	-1 509	3 690
FIN	683	495	-188	1 178	680	537	-143	1 216	756	681	-75	1 437
FRA	2 080	1 217	-862	3 297	5 321	1 299	-4 022	6 620	5 432	1 468	-3 963	6 900
GBR	5 842	1 328	-4 514	7 170	6 031	1 494	-4 537	7 525	5 044	1 723	-3 321	6 767
HUN	1 865	643	-1 222	2 507	1 664	725	-939	2 389	1 498	971	-527	2 469
ITA	5 839	1 675	-4 164	7 514	5 706	1 965	-3 741	7 671	4 874	2 208	-2 667	7 082
NTH	2 348	1 150	-1 198	3 499	2 300	1 344	-955	3 644	2 322	1 513	-809	3 836
RUS	4 111	15 409	11 298	19 519	3 844	14 639	10 795	18 482	5 172	15 349	10 178	20 521
SWE	2 243	349	-1 895	2 592	2 362	395	-1 967	2 757	2 442	403	-2 039	2 844
USA	6 340	1 970	-4 370	8 310	5 625	2 696	-2 928	8 321	4 805	3 402	-1 403	8 208
	61 699	**44 412**	**-17 287**	**106 110**	**62 417**	**50 885**	**-1 154**	**113 303**	**59 373**	**57 245**	**-2 128**	**116 618**

Among the export flows examined, the most important one is between Germany and Poland, however, even in this case the CO_2 emissions embodied in the trade flow have been reduced by almost 17% since 2004, the year Poland entered the EU. The pattern is different for the CO_2 emissions related with the trade exports between Poland and the rest of the European countries we examined, excluding Germany (Fig. 3). Nevertheless, the total CO_2 emissions are quite high indicating that the heavy industry-oriented Polish economy is a net importer of carbon emissions from other European countries. Despite that, there is not a significant change, especially since 2003, highlighting the fact that this phenomenon is regulated by the EU legislation. If Germany is also included in the analysis, it becomes clear that the largest amount of emissions created in Poland is due to trade within the EU (Fig. 4).

In the case of imports to Poland, China and Russia are Poland's carbon intensive partners implying that these countries emit a lot for consumption that actually takes place in Poland (Figures 5 and 6). Observing the time series it becomes obvious that the imports from Russia have declined after the post-Soviet growth period (since 2000). On the contrary, in the case of China, one can observe a rapid increase in the CO_2 emissions embodied in imports since the opening of the Polish economy. Overall, the CO_2 emissions embodied in imports (Fig. 7) from Poland seem to have three distinct periods. Initially, a significant increase during the period from 1996 to 2000 that is in line with the rapid growth period that followed the recession period after the collapse of the Soviet Union. After that, it can be seen that there is a decrease during the period before 2004, when Poland adopted stricter regulations regarding emissions in order to comply with the prerequisites for entrance to the EU. Since then, the emissions embedded in imports seem to have stabilized. On the contrary, the emissions embedded in exports (Fig. 8) show a less clear trend, however, they also seem to be stable since 2004.

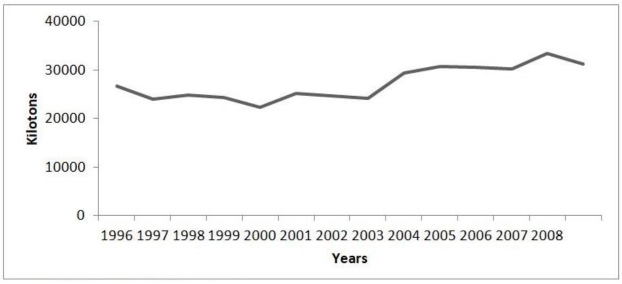

Fig. 3. CO_2 emissions embodied in exports from the EU-11* partners to Poland- excluding Germany (1996-2008) (Source: Authors' own elaboration)

* EU-11 partners for this research are the following: AUT, CSZ, DNK, ESP, FIN, FRA, GBR, HUN, ITA, NTH, SWE

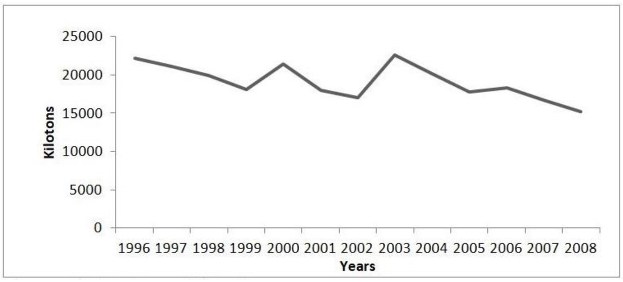

Fig. 4. CO_2 emissions embodied in exports from Poland to Germany (1996-2008) (Source: Authors' own elaboration)

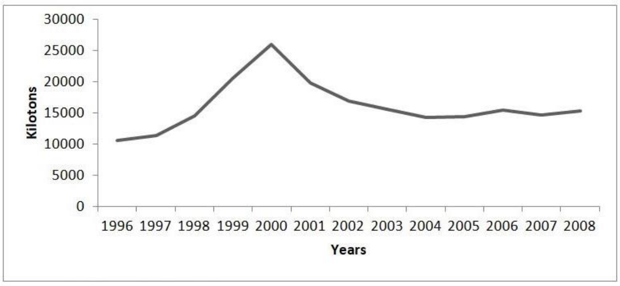

Fig. 5. CO_2 emissions embodied in the imports from Russia to Poland (1996-2008) (Source: Authors' own elaboration)

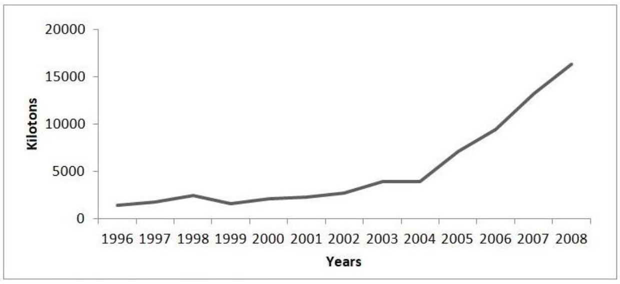

Fig. 6. CO_2 emissions embodied in the imports from China to Poland (1996-2008) Source: Authors' own elaboration

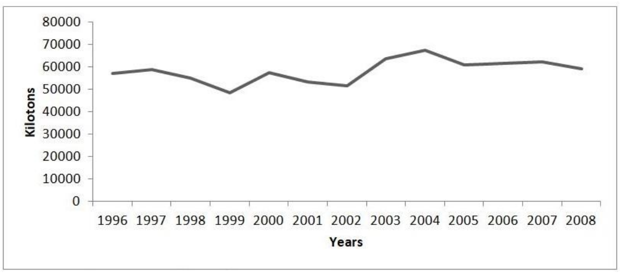

Fig. 7. Total CO_2 emissions embodied in imports to Poland (1996-2008) Source: Authors' own elaboration

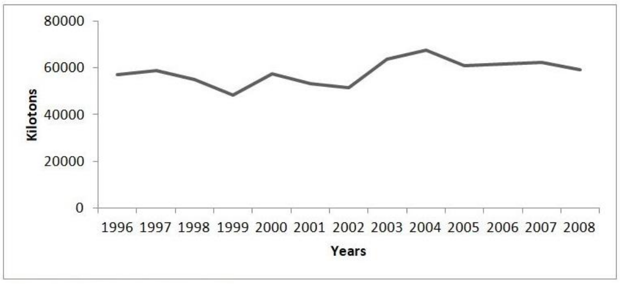

Fig. 8. Total CO_2 emissions embodied in exports from Poland (1996-2008) (Source: Authors' own elaboration)

6. Conclusions

Poland seems to be an exporter of CO_2 emissions mainly to countries with less strict environmental regulations (carbon leakage) while the country itself imports emissions from other EU countries. This phenomenon indicates the need for stricter policies globally, in the EU and at a national level in order to effectively regulate the trade exchange in CO_2 emissions.

A few critical events have had a substantial effect on Poland's CO_2 emissions. On the one hand, the liberalization of the economy made it possible to increase trade between distant countries, such as China, while on the other hand being part of the EU increased the trade with neighboring countries such as Germany. Although Poland still exports emissions to Russia, since the collapse of the Soviet Union, and later with Poland's admission to the European Union, its economic ties with Russia have dwindled (DOBROCZYÑSKI, 2003; ANDROSHCHUK, 2006). The economic alliance between the two countries has also suffered due to the EU imposed economic restrictions against the Russian government. The imports from EU-countries, even though high, remain stable throughout the period of time analyzed indicating strict control from the EU. The results obtained also explain why Poland raised serious concerns when it comes to stricter environmental regulations. This was mainly due to the role of Poland as a major exporter of goods in Europe especially food and beverages, construction and agricultural production (OLCZYK, 2011).

Comparing growth and emissions, it can be said that the economy of Poland has grown in a similar pattern to CO_2 emissions from the supply side. However, the progress of becoming more environmentally friendly cannot be analyzed in the light of the information used in this study. In a similar way, it is important to study which sectors generate the most emissions and to regulate/ mitigate their effects. Therefore, further research should conduct a decomposition analysis with variables such as technology, population, agriculture and manufacturing, among others.

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APPENDIX

Abbreviation codes	
AUT	Austria
CAN	Canada
CHI	China
CZR	Czech Republic
DNK	Denmark
DEU	Germany
ESP	Spain
FIN	Finald
FRA	France
GBR	Great Britain
HUN	Hungary
ITA	Italy
NTH	Netherlands
RUS	Russia
SWE	Sweden
USA	United States