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Environmental Costs of European Union Membership: A Structural Decomposition Analysis

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Abstract

The interest in this paper lies in the environmental costs of the European Union (EU). EU membership requires a series of economic and political changes that should impact the country's production and consumption structures and its trade relationships. These, in turn, will affect CO_2 emissions sources and levels. This is especially true for the former Soviet Union countries that recently joined the EU, given the difference in their levels of development and production structure. Using a structural decomposition analysis we are able to quantify the main drivers of changes in emissions differentiating six components, namely: emissions intensity, industrial structure and sourcing, consumer preferences, final demand sourcing and consumption level. Grouping the countries into five clubs, New European Union countries, Old European Union countries, the United States of America, China, and the Rest of the World, we measure trading pattern changes and their impact on CO_2 emission levels.

Keywords: CO_2 Emissions, European Union; Input-Output Analysis, Structural Decomposition Analysis
JEL Classification: P28, R15, Q56, F64

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1 Introduction

There is a major transformation underway in international trade flows that is intensified by multilateral trading system agreements and the transition from a Fordist to a more flexible production system in many world economies. The consequence of this transformation in international trade is greater production and commercial integration among countries, the insertion of certain economies into specialized markets in the world, the expansion of production scale, and the fragmentation of the production and distribution of supplements, i.e. intermediate inputs and logistic processes. Among these transformations, we can highlight the trade dissociation of consumption and production, as well as increases in the consumption and production of goods, which leads to economic growth. Thus, the world has become increasingly integrated, given the technological advances especially in the fields of communication and information, the reduction of trade barriers, and foreign investments.

One instrument that fosters the increase of international trade, and is of particular importance to this paper, is the formation of monetary unions or free trade areas. There are costs and benefits involved in participating in such agreements. From the costs perspective, one can note the loss of monetary policy as a macroeconomic tool for stabilization. From the benefits side, one can point to the increase in trade, investment, and diversification of consumption basket (Micco et al., 2003). A large part of the trade literature focuses on the impacts of the formation of the European Economic and Monetary Union (EU) showing that this has a considerable effect on the member countries' patterns of international trade, e.g., Bun and Klaassen (2002); Micco et al. (2003); Barr et al. (2003); De Nardis and Vicarelli (2003); Flam and Nordström (2006); de Sousa and Lochard (2004); Faruqee (2004); Baldwin et al. (2005).

The interest in this paper lies in the environmental costs of EU related economic restructuring. From an historical perspective, there have been different waves of entrance into the EU. For the specific aim of this paper, we are interested in the wave that occurred in the 2000s. Cyprus, Slovakia, Slovenia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, and the Czech Republic joined EU in 2004, while Bulgaria and Romania joined the EU in 2007. As discussed by Barlow and Radulescu (2005); Grosjean et al. (2013); BenYishay and Grosjean (2014); Tarabar and Young (2017) and Tarabar (2017), EU membership requires a series of economic and political changes that should impact the country's production and consumption structure and its trade relationships. These institutional reforms affected the productivity of these economies (Driffield et al., 2013), which in turn, should affect the CO_2 emissions level and source (Brizga et al., 2013; Malik and Lan, 2016; Bae et al., 2017). This is especially true for countries that entered the EU recently since there is a clear distinction in levels of development, and perhaps more interestingly, because most of these countries were part of the Soviet Union (USSR). Our hypothesis is that the entrance of new countries into EU should increase the trade among these countries and the EU's old members which would increase or change the structure of emissions (Levinson, 2009; Douglas and Nishioka, 2012; Brunel, 2017; Levinson, 2015; Shapiro and Walker, 2015). Thus, this paper contributes to better understanding the spatial pattern of CO_2 emissions, considering the economic and political reforms towards a more market-based economy occurring in former soviet countries upon joining the EU.

Although there are gains linked to the evolution and growth of the world economy due to the increase in the international trade, this process can be accompanied by negative externalities, such as environmental degradation, deforestation, and pollution, among others. Hence, free trade can have contradictory effects. On the on hand, it can facilitate the consumption and production of goods, which leads to economic growth which, consequently can contribute to increase pollution. On the other hand, free trade-induced economic growth leads to an increase in GDP and the willingness to pay for environmental improvement and the adoption of greener production technologies (Choi et al., 2010; Shahbaz and Leitão, 2013; Sharma, 2011).

According to Hoekstra et al. (2016), this scenario of changes in trade patterns and growth of trade volume had a strong influence on distribution of environmental pressures among countries, in particular for CO_2 emissions. The dissociation between consumption and production mentioned earlier enables transferring the emission burden of production from one country to another (Dietzenbacher et al., 2012; Oshita, 2012; Xu and Dietzenbacher, 2014; Lan et al., 2016; Malik and Lan, 2016; Vale et al., 2018). For the specific case of CO_2 emissions, the actual scenario for developed countries presents a trend of stabilization of national emissions, but with an increase in the global emissions rooted in their consumption. As for developing countries, both consumption and production are sources of increasing emissions, but emissions from production side increase more than those from consumption side. Therefore, developing countries are generating emissions that are rooted in their exports to developed countries. Thus, the net imports of emissions by the majority of developed countries increased and the same pattern occurred for the net exports of emissions by the majority of developing countries (Arto and Dietzenbacher, 2014). It is important to highlight that this process is also motivated, at a certain level, by the low production cost and moderate environmental regulations of the developing countries. Hence, there is an incentive for developed countries to outsource their production process (Zhang et al., 2017).

To quantify the main causes of changes in emissions, we employ a structural decomposition analysis (SDA), in line with those developed by Oosterhaven and Van Der Linden (1997); Arto and Dietzenbacher (2014) and Hoekstra et al. (2016), which enables us to disentangle the different drivers of such changes, namely: emissions intensity, industrial structure and sourcing, consumer preferences, final demand sourcing and consumption level. We use the World Input-Output Database (WIOD) and the countries grouped into five clubs or regions: New European Union countries (NEU), Old European Union countries (OEU), the United States of America (USA), China (CHN), and the Rest of the World (ROW). By creating these groups, we are able to quantify emissions costs of the entrance of the new countries into the EU.

The main results show that changes in economic structure, driven by market reforms and new institutions in the NEU club are important to explain the changes in CO_2 emissions. Although NEU countries diminished their emissions intensity, i.e., emission-output ratio, the total emissions increased. This increased emissions are due to an increase trade with OEU countries, especially the transfer of emission in final goods exports.

These results are important because the environmental costs are not associated with domestic production only. As new countries join the EU or other trade agreement regions, we should expect a change in the sourcing of intermediate and final goods. The facilitated access to new technology should help mitigate but not overcome these sourcing costs.

In the remainder of the paper, we proceed as follows. Section 2 describes the structural decomposition analysis methodology and the World Input Output Database (WIOD); section 3 presents our results; and, section 4 concludes, providing some policy implications.

2 Method and data

2.1 Method

The Structural Decomposition Analysis (SDA) is a standard method based on input-output models that allows the division of changes in output, income or other variables into explanatory factors, such as technological variation or final demand variation (Miller and Blair, 2009; **?**). We follow the work of Xu and Dietzenbacher (2014) and Hoekstra et al. (2016) and extend the SDA for a Multi-Region Input-Output (MRIO) model and to assess the effect of different groups of countries in CO_2 emission in terms of sourcing.

Starting from a standard MRIO with M regions indexed by superscripts t and r, and N industries indexed as i, j, we can define its main components as gross output (x), intermediate interindustry and inter-country transactions (Z), and industry final demand (f). The classic input-output relationship holds, such that $x \equiv Z + f \equiv Ax + f$, in which $A = Z(\hat{x})^{-1}$ is the multi-regional technical coefficient matrix, and $\hat{x}$ is the diagonal matrix vector x. If we solve this for the output, then, $x = Lf$, where $L = (I - A)^{-1}$ denoting the Leontief inverse multiplier matrix.

Define e_i as the emission intensity, i.e., the amount of CO_2 emission per unit of output i. Hence, we can incorporate the emission level into our framework as:

$$s = \hat{e}x = \hat{e}Lf \tag{1}$$

where s is the vector of total emissions directly and indirectly required to satisfy final demand.

As previously discussed, to enter EU countries should face economic and political reforms that in turn will affect their production structure. For instance, the reduced or non-existing trade tariffs within the EU should incentivize new members to trade more intermediate goods with old member and vice-versa. Also, households should have access to a different basket of goods and services. Both these changes should have an impact on the emission levels from new members and old members of EU. Therefore, by breaking down the change in emission levels in different components we are able to trace which are the main drivers of CO_2 emissions, namely, changes in energy intensity, in the countries' production structure, in the sourcing countries, or changes in final demand mix of goods and level of consumption.

We want to analyze emissions considering possible changes in sourcing patterns that occurred after the entry of new members into the EU. Therefore, we need to differentiate technology changes, i.e., changes in the production structure, from changes in sourcing of intermediate goods. For example, there may be no change in how a good is being produced, but only from where a country is acquiring its input. The same is true in case of final demand; there can be a change in the level and mix of goods, such that this mix can be broken down into types of goods and sourcing of goods. We follow Oosterhaven and Van Der Linden (1997) and Hoekstra et al. (2016) and differentiate the origin of emission in five clubs: new EU members (NEU), old

EU members (OEU), USA, China (CHN) and the Rest of the World (ROW).

To properly disentangle these components let us define $Z^{*t} = [z_{ij}^{*t} = \sum_r z_{ij}^{rt}]$ as the total input requirements of industry j for input of industry i in country t. Using Z^{*t} we can create $Z^{*} = [Z^{*t}] \equiv \begin{bmatrix} Z^{*1} & \dots & Z^{*M} \\ \vdots & \ddots & \vdots \\ Z^{*1} & \dots & Z^{*M} \end{bmatrix}$, which is the intermediate input requirements regardless of the source country. In practice, the Z^{*} matrix is the horizontal stacking of Z^{*t} which is then vertically stacked M times. The Z^{*t} is used to create the trade coefficient matrix $C = [c_{ij} = z_{ij}^{rt}/z_{ij}^{*}]$, which indicates the fraction of intermediate demand for total (worldwide) products i, for industry j in country s, that is actually satisfied by the supply from country r. Similarly, we can define a matrix F that will capture the trade coefficients for the final demand, and is created following the same steps presented above.

Matrices C and F, which allow the identification of each sourcing groups or clubs, are key to our decomposition strategy. The intuition is that C and F give us the weighted importance in trade for each country. Let $A^{*} = Z^{*}(\hat{x^{*}})^{-1}$. Thus, defining $A = C \circ A^{*}$, and $f = (F \circ B)y \equiv Gy$, in which the symbol $\circ$ is the Hadamard product, i.e. cell-by-cell multiplication, and $y = \sum_r f_{ij}^{rt}$, we can re-write equation 1 as:

$$s = \hat{e}LGy = \hat{e}(I - C \circ A^{*})^{-1}(F \circ B)y \tag{2}$$

2.1.1 Decomposition Analysis

The starting point for the decomposition of changes in CO_2 emissions between two period of time ($\Delta s = s_1 - s_0$) is the polar decomposition analysis by Dietzenbacher and Los (1998):

$$\begin{aligned} \Delta s = {} & (\Delta\hat{e})L_{1/2}G_{1/2}y_{1/2} && \text{emission intensity} \\ & + \hat{e}_{1/2}(\Delta L)G_{1/2}y_{1/2} && \text{industry structure} \\ & + \hat{e}_{1/2}L_{1/2}(\Delta G)y_{1/2} && \text{consumption pattern} \\ & + \hat{e}_{1/2}L_{1/2}G_{1/2}(\Delta y) && \text{consumption level} \end{aligned} \tag{3}$$

where the subscript $1/2$ is the average of both period of times.

Two of the most interesting components of equation 3 for our analysis are the industry structure and consumption pattern terms. By using the matrices C and F described above it is possible to further decompose these terms to properly identify changes in technical coefficients and changes in trade coefficients.

Start with $\Delta L = L_1 - L_0 = L_1(\Delta A)L_0$. As $A = C \circ A^*$, then by simple substitution we have $\Delta L = L_1 - L_0 = L_1\Delta(C \circ A^*)L_0$. Pre and post multiplying it for $(I - A_1)$ and $(I - A_0)$, respectively:

$$\Delta L = L_1(C_{1/2} \circ \Delta A^*)L_0 + L_1(\Delta C \circ A^*_{1/2})L_0 \tag{4}$$

where the first term $L_1(C_{1/2} \circ \Delta A^*)L_0$ is the effect of the actual changes in the technical coefficients, and the second term $L_1(\Delta C \circ A^*_{1/2})L_0$ indicates the effect of the changes in the trade coefficients.

Similarly, using $G = F \circ B$, it is possible to rewrite ΔG as $\Delta G = \Delta F \circ B_{1/2} + F_{1/2} \circ \Delta B$. Thus, using this plus equation 4, it is possible to re-write equation 3 as:

$$\begin{aligned}
\Delta s = {} & (\Delta\hat{e})L_{1/2}G_{1/2}y_{1/2} && \text{emission intensity} \\
& + \hat{e}_{1/2}[L_1(C_{1/2} \circ \Delta A^*)L_0]G_{1/2}y_{1/2} && \text{technology change} \\
& + \hat{e}_{1/2}[L_1(\Delta C \circ A^*_{1/2})L_0)]G_{1/2}y_{1/2} && \text{intermediate trade source} \\
& + \hat{e}_{1/2}L_{1/2}(F_{1/2} \circ \Delta B)y_{1/2} && \text{consumer preferences} \\
& + \hat{e}_{1/2}L_{1/2}(\Delta F \circ B_{1/2})y_{1/2} && \text{final demand source} \\
& + \hat{e}_{1/2}L_{1/2}G_{1/2}(\Delta y) && \text{consumption level}
\end{aligned} \tag{5}$$

Lastly, since we explore the entrance of former USSR countries in the EU as a shock to a country's trade pattern, we follow Hoekstra et al. (2016) and split the C and F matrices to reflect the geographic origin of the inputs. Define c^r as a $(MNxMN)$ matrix and d^r as a $(MxMN)$ matrix, both with ones for industries in each club r and zeros in all other industries. Then, we can re-write equation 5 to incorporate them, as such:

$$\begin{aligned}
\Delta s = {} & (\Delta\hat{e})_{1/2}G_{1/2}y_{1/2} \\
& + \sum_r \hat{e}_{1/2}[L_1(C_{1/2} \circ \Delta A^*)L_0] \circ c^r G_{1/2}y_{1/2} \\
& + \sum_r \hat{e}_{1/2}[L_1(\Delta C \circ A^*_{1/2})L_0)] \circ c^r G_{1/2}y_{1/2} \\
& + \sum_r [\hat{e}_{1/2}L_{1/2}(F_{1/2} \circ \Delta B)] \circ d^r y_{1/2} \\
& + \sum_r [\hat{e}_{1/2}L_{1/2}(\Delta F \circ B_{1/2})] \circ d^r y_{1/2} \\
& + \sum_r [\hat{e}_{1/2}L_{1/2}G_{1/2}] \circ d^r (\Delta y)
\end{aligned} \tag{6}$$

2.2 Data

The data to quantify the drivers of changes in CO_2 emissions and identify the environmental costs of EU come from the World Input-Output Database (WIOD). This database provides a time-series of the World Input-Output Tables (WIOTs) covering the period of 1995 to 2011. These tables have been constructed in a clear conceptual framework on the basis of officially published input-output tables in conjunction with national accounts from national statistical institutes around the world and international trade statistics such as OECD and UN National Accounts (Dietzenbacher et al., 2013; Timmer et al., 2015).

The WIOD covers 27 EU countries and 13 other major countries in the world and a model for the rest of the world. These 40 countries represent approximately 90% of world trade. The WIOTs provide details for 35 industries classified according to the International Standard Industrial Classification revision 3 (see Table A5 in the Appendix). The WIOD also provides the environmental satellite accounts for emissions expressed in Megatonne (Mt) of CO_2 at the industry level.

Thus, WIOD we create five groups[1] of countries to quantify emissions costs of the entrance of the new countries into the EU. Given our focus, the first two groups are straightforward: New European Union countries (NEU) and Old European Union countries (OEU). The other three groups are the United States of America (USA), China (CHN), and the Rest of the World[2] (ROW) were based on the relative importance in terms of trade with NEU countries.

The SDA requires the use of input-output tables expressed in constant prices to analyze the structural changes across different periods. Therefore, we have used the input-output tables in previous year's prices available from

[1] *NEU*: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Malta, Poland, Romania, Slovak Republic, and Slovenia; *OEU*: Austria, Belgium, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Sweden; *ROW*: Australia, Brazil, Canada, India, Indonesia, Ireland, Italy, Japan, Korea, Mexico, Russia, Taiwan, and Turkey.

[2] Although Russia was the main country of the USSR, its trade balance with NEU group is smaller than the other groups. For instance, in 1995 Russia share of exports and imports from NEU were 10.1% and 17.1%, respectively; in 2007, its exports and imports share from NEU were 7.8% and 15.1%, respectively. Moreover, a preliminary network analysis based on trade balances provides little support for Russia to be a separate club. This analysis is available upon request. Therefore, we decided to aggregate the results of Russia in the ROW. Nevertheless, he participation of Russia of the emissions changes in the ROW between 1995-2007 was: 26.2% of the technology component, 26.9% of the sourcing component, and 15.4% of the consumption component.

WIOD and chained the outcomes in the year-to-year changes.[3] Thus, for the change in 1996, we have used the input-output tables of 1995 (in current prices) and 1996 (in constant prices of 1995). Also, following Arto and Dietzenbacher (2014) and Xu and Dietzenbacher (2014), the results have been cumulated over the full sample period. We consider only the period 1995-2007 to avoid the dramatic influence of the 2008 financial crisis on the flow of world trade and consequently the emission transfers through exports.

3 Results

Table 1 shows the results of decomposition of the CO_2 emissions between 1995 and 2007 for the five clubs (NEU, OEU, USA, CHN and ROW) presented as a percentage change[4] of the global emissions. The effects are aggregated into three categories: technology (emissions intensity and industrial structure), sourcing (industry and final demand) and consumption (consumer preferences and consumption level).

The overall increase in CO_2 emissions in the period was 6,343.9 Mt. The result of the decomposition shows an increase in total emissions in the OEU (3.1%), USA (5.6%), CHN (44.3%) and ROW (47.6%). Only the NEU club reveals a reduction in total emissions (-0.7%). These results reinforce previous evidence that, among the few countries that managed to reduce emissions in the 1990s and 2000s, most of these countries emerged from the former Soviet Union (Brizga et al., 2013).

For all clubs there was a reduction in emission due to the emissions intensity (e) of -7,142.3 Mt, which means that there was a more efficient use of fuels. However, the effects of technological changes on the industrial structure component (L) reduced emissions only in the NEU (-1.4%) and in the USA (-9.9%). The reduction of emissions through technological changes (A) was driven by productivity gains (Yörük and Zaim, 2005) and research and development investments in low-carbon technologies (Steinberger and Roberts, 2010). However, the reduction of emissions driven by the technological component was overcome by the increase in the consumption level (171.8%, equivalent to 10,896.3 Mt of CO_2).

Global trade was responsible for the 18.1% increase in total emissions. The transfer of emissions through a change in sourcing patterns was nega-

[3] Los et al. (2014)detail the procedures for the construction of WIOTs in previous year's prices.

[4] Table A1 in the Appendix shows the results of the decomposition of the emissions into Mt of CO_2.

Table 1: Decomposition of changes in CO2 emissions (in % of global change) between 1995 and 2007.

	Source	NEU	OEU	USA	CHN	ROW	Total
Technology	Emissions Intensity	-4.6	-11.2	-4.5	-46.6	-45.6	-112.6
	Industrial Structure	-1.4	2.4	-9.9	18.6	13.5	23.2
Sourcing	Industry	-0.1	-0.9	-3.5	10.3	2.9	8.7
	Final Demand	0.6	-1.2	-1.8	9.8	2.1	9.4
Consumption	Consumer Preferences	-0.6	-0.3	-5.2	1.5	4.1	-0.5
	Consumption Level	5.4	14.3	30.6	50.8	70.6	171.8
Total	Emissions	-0.7	3.1	5.6	44.3	47.6	100.0
	Sourcing	0.5	-2.2	-5.3	20.1	5.0	18.1

tive only in the OEU (-2.2%) and in the USA (-5.3%). Change in sourcing patterns, in the countries with emission-intensive technologies, that is, those countries that have higher CO_2 emissions per unit of production, was responsible for the 25.6% increase in global emissions – NEU (0.5%), CHN (20.1%) and ROW (5.0%), which corresponds to the increase of the emissions embodied in exports (Table 1). The sourcing effect transferred 1,148.6 Mt of CO_2 distributed between NEU (30.6 Mt), CHN (1,274.1 Mt) and ROW (316.8 Mt) as shown in Table A1 in the Appendix.

Figure 1 shows the evolution of the CO_2 emissions decomposition between 1995 and 2007 for NEU and OEU clubs. This represents the accumulated change in emissions for each year from 1996 to 2007.The decomposition of the emissions for the six components is detailed in Figures A1.2-A1.7 in the Appendix. Tables A2.1-A2.5 in the Appendix presents the variation in sectorial emissions for each component of the decomposition and for each country club.

The OEU club's emissions increased 198.9 Mt of CO_2 over this period. Changes in the NEU club's emissions, also showed an increasing trend, except for the period between 1997 and 1999, accumulating a reduction of -42.2 Mt of CO_2 (Figure 1.1). The reduction in total emissions in the NEU club was driven mainly by changes in the industrial structure component, in particular in the electricity production industry (Table A3.1 in the Appendix). This reduction was boosted by market reforms that the NEU club went through after the disintegration of the Soviet Union, such as privatization, enterprise restructuring and competition policy (BenYishay and Grosjean, 2014; Tarabar, 2017). These reforms had strong effects in the electricity industry in Central and Eastern Europe during the 1990s; this in turn, increased their

Figure 1: Decomposition of change in CO2 emissions (in Mt), 1995-2007

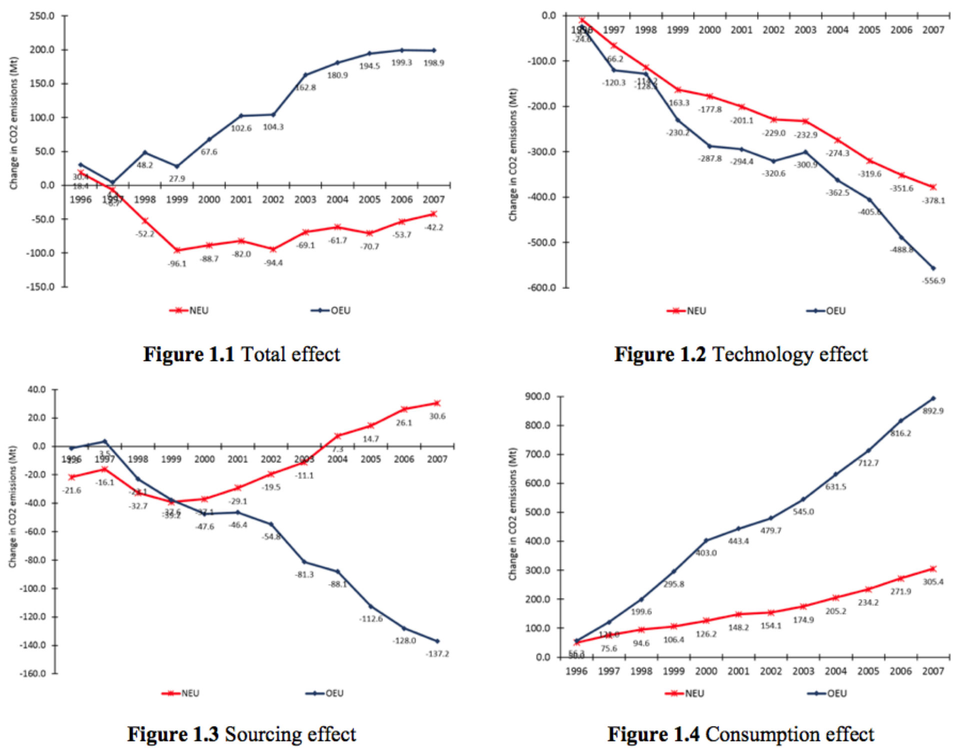


Figure 1.1 Total effect

Figure 1.2 Technology effect

Figure 1.3 Sourcing effect

Figure 1.4 Consumption effect

energy efficiency and mitigated CO_2 emissions (Stern and Davis, 1998; Pesic and Ürge-Vorsatz, 2001). In addition to improved energy efficiency, the European Union climate policy contributed to reduced CO_2 emissions in the post-Soviet Union countries (Bae et al., 2017).

Technology changes generated variations of emissions in the NEU of -378.1 Mt of CO_2 and in -556.9 Mt of CO_2 in the OEU (Figure 1.2). The technological changes in the NEU were composed by the reduction of -291.8 Mt of CO_2 from the emissions intensity component (related to efficiency in the use of fuels), concentrated in the following industries: electricity (-65.4 Mt), metals (-47.9 Mt), chemicals (-33.9 Mt) and non-metallic (-33.4 Mt). Further, the NEU club reduced the emissions in -86.3 Mt originating in the industrial structure component – with the reduction of -107.1 Mt of CO_2 in the electricity industry (Figure A1.2 and A1.3 and Table A3.1 in the Appendix). The reduction in emissions in the OEU club, through technology changes, occurred only in the emissions intensity component (-711.4 Mt); meanwhile, the industrial structure component increased emissions by 154.6 Mt of CO_2 (Figure A1.2 and A1.3 and Table A3.2 in the Appendix).

Sourcing patterns change generated a change in emissions of -137.2 Mt for the OEU club and 30.6 Mt for the NEU club (Figure 1.3). The increase in emissions in the NEU club through sourcing matches the period of entry of these countries into the European Union. The cost of increasing CO_2 emissions in the NEU through the change in sourcing patterns, is related to the greater insertion of the countries of this club in the global production chains. In these supply chains, production is fragmented in different territories, with the tendency of emission-intensive activities to be shifted to low-income countries (Hoekstra et al., 2016; Vale et al., 2018).

In this context, Bae et al. (2017) identified that the increased inflow of foreign direct investment in the countries of the former Soviet Union also increased its CO_2 emissions; this increase has not been fully offset by improved energy efficiency and EU climate policy. Malik and Lan (2016) also identified in an analysis for 186 countries from 1990 to 2010 that changes supply chain to improve technological efficiency are not sufficient to reduce emissions. Therefore, although the NEU club enjoys greater welfare resulting from the increase of income after its insertion into the EU, this club also loses welfare due to the environmental cost of the CO_2 emissions.

The CO_2 emissions through the consumption component (Figure 1.4) has increased over time for the NEUs (305.4 Mt) and the OEUs (892.9 Mt). Although the consumer preferences component, which measures a change in emissions due to changes in final consumption basket, has reduced emissions by -39.4 Mt in the NEU and -16.9 Mt in the OEU (Figure A1.5 in the Appendix). Therefore, while increased incomes in these countries have increased emissions through higher consumption level (Figure A1.6 in the Appendix), there was a reduction in emissions due to the change in the composition of final demand. Thus, the economic development of these countries created a shift from consumption of fuels and food to manufactured goods with lower emission intensity.

Emissions reduction due to change in consumer preferences was generated mainly in agriculture, refined petroleum and nuclear fuel industry and electricity industry (for the NEU club: -5.4 Mt, -6.7 Mt and -39.9 Mt; for the OEU club: -6.1 Mt, -8.3 Mt and -27.6 Mt, respectively[5]). Emissions increase in the OEU consumer preferences component between 2002 and 2006 (Figure A1.5.c in the Appendix) was concentrated in the electricity industry

[5] Results detailed in Tables A3.1 and A3.2 in the Appendix

of Germany and United Kingdom (in 2002) and the mining and quarrying industry in Greece (between 2003 and 2006).

The overall change in OEU club emissions was higher than in the NEU club; this is an indirect consequence of the size of these countries' economies. While the NEU club concentrates 2.0% of the world's value added, the OEU club generates 26.8% of this additional value. To control for this effect, the change in emissions were divided by the total added value of each club. The results are shown in Figures A1.1-A1.7 in the Appendix. The NEU club presented the highest changes in emissions when taking into account the size of the production. This can be explained by greater intensity in the generation of emissions in the NEU club. Although NEU countries have been able to reduce their emission levels, they still have a lower level of energy efficiency compared to the OEU countries.

SDA's results were also partitioned into emissions associated with domestic activities and associated with international trade. Thus, it is possible to identify to what extent the outsourcing of production across national borders on the transfer affect emission levels. The change in emissions through increasing foreign outsourcing is detailed in Figure 2, which highlights the shift in sourcing patterns for the NEU and OEU clubs. The complete results for each SDA effect are presented in Tables A2.1-A2.5 in the Appendix, which also show the results of this decomposition for the other country clubs (USA, CHN, ROW).

Figure 2: Changing sourcing patterns of changes in territorial CO_2 emissions (in Mt), 1995-2007

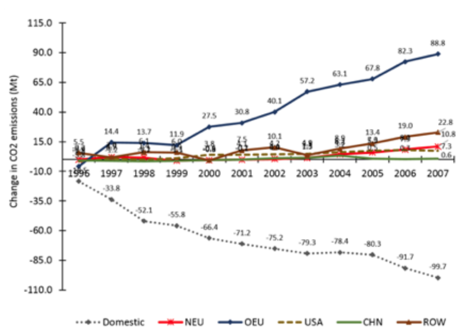


Figure 2.1 New European Union countries (NEU).

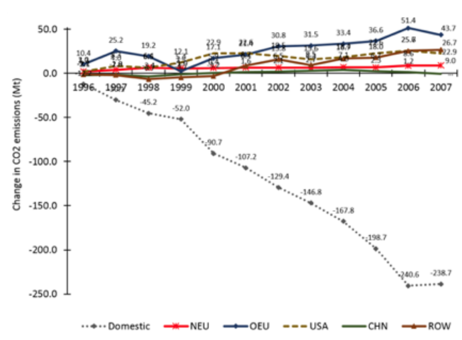


Figure 2.2 Old European Union countries (OEU).

The shift in sourcing patterns captures the environmental costs of emissions embodied in international trade, which has been impacted by the fragmentation of global production (Zhang et al., 2017). Emissions growth embodied in imports (168.0 Mt) was lower than the emissions realized in exports (213.5 Mt) in the NEU club between 1995 and 2007. This emissions transfer through imports was caused by trade between the NEU club members (26 Mt), OEU (42.0 Mt), USA (4.3 Mt), CHN (43.9 Mt) and ROW (51.8 Mt) clubs. On the other hand, in the OEU the growth of emissions embodied in imports (1,266.6 Mt) was larger than the growth of emissions embodied in exports (554.4 Mt). Global CO_2 emissions to cover imports into the OEU club originated in the trade between OEU club members (205.9 Mt), NEU (106.7 Mt), USA (34.4 Mt), CHN (371.4 Mt) and ROW (548.3 Mt). Xu and Dietzenbacher (2014) also identified that the growth of emissions embodied in imports from developed countries is greater than the growth of emissions embodied in exports.

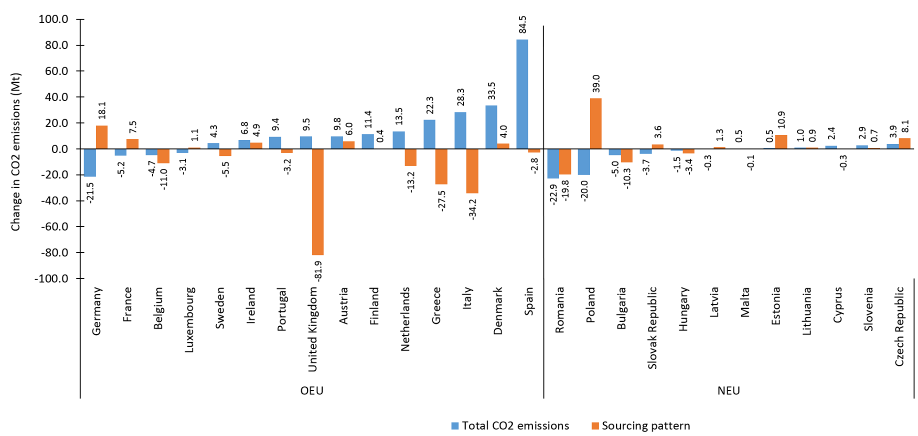
Sourcing pattern change was responsible for an increase of 30.6 Mt of CO_2 in NEU emissions (-4.4 Mt in the intermediate inputs trade and 34.9 Mt in the supply of final products and services), while domestic sourcing effect reduced its emissions by -99.7 Mt of CO_2 (Figure 2.1). The transfer of emissions from NEU to OEU, due to a change in the patterns of trade, was 88.8 Mt of CO_2. This export of emissions, through outsourcing of production, was caused by the supply of intermediate inputs (41.4 Mt) and final products (47.4 Mt). This result provides supporting evidence that OEU club is transferring the emission-intensive production to the NEU club evidenced by Lan et al. (2016); Malik and Lan (2016); Hoekstra et al. (2016); Vale et al. (2018)

Lower production costs and less stringent environmental regulations in the NEU club may have been one of the incentives for the OEU club to outsource its production in those countries. This is an environmental cost that accompanies welfare benefits generated by the greater economic integration between NEU and OEU. The emissions transfer among countries that make up the NEU club also suggests that economic integration among the countries of this club has remained small in spite of an increase since 2003 (Figure 2.1).

Sourcing effect in the OEU club reduced emissions by -137.2 Mt of CO_2 or -2.2% of global emissions. This reduction was driven mainly by the effect of domestic sourcing (-238.7 Mt) due to the change in the patterns of trade within each country of the club; even though emissions increased by 43.7 Mt of CO_2 due to an integration among the countries within the club. The transfer of emissions embodied in exports from OEU to NEU increased global emissions by only 9.0 Mt of CO_2 (Figure 2.2); this transfer was concentrated in the trade of intermediate inputs (5.4 Mt, i.e., 60.0%).

Figure 3 shows the change in CO_2 emissions for the studied period. Romania (-22.9 Mt) and Poland (-20.0 Mt) were the driver of total reductions in CO_2 emissions in the NEU club during the period from 1995 to 2007. Although Germany reduced its total emissions (-21.5 Mt), the increase in CO_2 emissions in the OEU club was mainly caused by Spain (84.5 Mt), Denmark (33.5 Mt), Italy (28.3 Mt), and Greece (22.3 Mt). The reduction of emissions in the OEU club through changes in its production structure, which affected sourcing patterns (-137.2 Mt), occurred mainly in the United Kingdom (-81.9 Mt), Italy (-34.2 Mt), Greece (-27.5 Mt), and Netherlands (-13.2 Mt), whilst Germany (18.1 Mt) increased emissions exports. As for the NEU club, Poland (39.0 Mt), Estonia (10.9 Mt), and Czech Republic (8.1 Mt) made the largest emissions transfers through outsourcing of production. On the other hand, Romania (-19.8 Mt) and Bulgaria (-10.3 Mt) have reduced emissions embodied in exports.

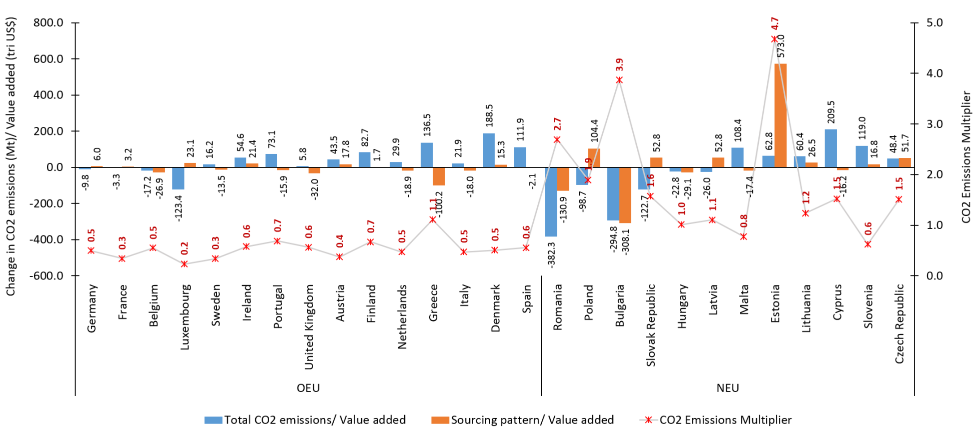
Figure 3: Change in CO_2 Emissions between 1995 and 2007



The contribution of each country to changes in CO_2 emissions considering the size of its economy is presented in Figure 4, as the ratio of total emissions to the value added of each country. In the NEU club, Romania, Bulgaria, Slovak Republic and Poland were the most intensive countries in reducing CO_2 emissions. In the OEU club, Denmark, Greece, Spain and Finland are responsible for the largest increases in emissions proportional to the size of their value added. Figure 4 also shows the interregional CO_2 emissions multiplier for each country[6]. The total reduction of the emissions in the NEUs is reflected on the CO_2 emissions multiplier, which identifies the ability of these countries to propagate emissions through their industrial linkages in the global production structure (Figure A2 in the Appendix).

The main source of this reduction occurred in the electricity industry, and refined petroleum and nuclear fuel industry (Tables A3.1 and A4.1 in the Appendix). This can be explained by the substitution of energy sources to cleaner fuels, the development of greener technologies, and improved energy efficiency. This effect suggests the importance of policies focused on encouraging emission reductions in specific sectors that have a larger capacity to propagate the global effects of emissions transfers. Despite the downward trend, NEU emissions multiplier (0.9) was still significantly higher than the OEU emissions multiplier (0.4) in the year 2007. This difference reflects the type of fuel used in industry and the energy efficiency in less developed countries (Malik and Lan, 2016; Hoekstra et al., 2016; Zhang et al., 2017; Vale et al., 2018)

Figure 4: Change in CO_2 Emissions between 1995 and 2007/ Value Added 2007 and CO2 Emissions Multiplier



4 Implications and Conclusions

This study set out to understand the effect of structural changes in the New European Union countries (NEU) upon joining the EU on their CO2 emis-

[6]Emissions multiplier by industry and country club are detailed in Tables A4.1-A4.5 in the Appendix.

sions. We used a Structural Decomposition Analysis (SDA) on the World Input-Output Database (WIOD) from 1995 to 2007. This analysis contributes to the debate on the environmental impact of increased economic integration between NEU and OEU and the structural changes that have taken place in the production structure of Eastern European countries after the end of the Soviet Union.

Focusing on the NEU countries, the main results show that the changes in economic structure, driven by market reforms and new institutions that have altered trade relationships, were important to explain the evolution in their CO_2 emissions. Further, the technology changes caused by the improved efficiency in the use of fuels and by the change in the production structure were responsible for reducing emissions in this club. The change in emission-intensity was driven by the EU's climate policy, which encouraged reforms in the NEU club. The effect of this policy on emissions reduction was observed mainly in the electricity, metals, chemicals, non-metallic, and refined petroleum and nuclear fuel industries. These industries are key to mitigating the effects of CO_2 emissions and can be policy targets for accelerating the adoption of measures to increase energy efficiency and substituting for cleaner energy sources. However, although the NEU club has reduced emissions by technological improvements, this club still has low energy efficiency.

The OEU countries, which are more efficient in terms of the use of energy sources and less emission-intensive, maintained a high growth in total emissions driven by the consumption of final goods. However, this club managed to reduce emissions through trade by transferring part of the responsibility for the total emissions to other countries. In addition, the emissions growth embodied in exports of the OEU club was less than the growth in emissions embodied in its imports. This decrease in emissions exports was influenced by the change in the trade structure between NEU and OEU, which has increased the transfer of emissions between the two clubs. The transfer of emissions from NEU to OEU was carried out mainly through trade of final goods. On the other hand, the trade of intermediate inputs drove the transfer of emissions from OEU to NEU.

The implication of these results is that emissions' reductions associated with technology advances were not big enough to compensate for increases caused by the change in sourcing patterns and the levels of consumption throughout the 2000s in the NEU club. The change of sourcing patterns in the NEU club is related to the entry of foreign direct investment in these countries, in a context of increased outsourcing through the international fragmentation of production and greater integration with other countries of the EU.

These results are important for policy makers because the environmental costs in the European Union, especially in the NEU club, is a problem that goes beyond domestic accountability for emissions, given the increase in international outsourcing and the greater integration between NEU and OEU. This result helps in measuring the effects of trade on CO_2 emissions and identifying the responsibility for these emissions. Therefore, policies to mitigate emissions, besides focusing on increasing energy efficiency, should also consider changes in the pattern of international trade.

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Appendix

Table A1 - Decomposition of changes in territorial CO_2–emissions (in Mt) of each club between 1995–2007.

	Source	NEU	OEU	USA	CHN	ROW	Total
Technology	Emissions Intensity	-291.8	-711.4	-288.2	-2,957.0	-2,893.9	-7,142.3
	Industrial Structure	-86.3	154.6	-631.2	1,179.3	857.7	1,474.1
Sourcing	Industry	-4.4	-58.7	-221.3	652.4	186.4	554.4
	Final Demand	34.9	-78.5	-114.3	621.7	130.3	594.2
Consumption	Consumer Preferences	-39.4	-16.9	-331.8	93.5	261.9	-32.8
	Consumption Level	344.8	909.9	1,939.8	3,222.8	4,479.0	10,896.3
Total	Emissions	-42.2	198.9	353.1	2,812.7	3,021.4	6,343.9
	Sourcing	30.6	-137.2	-335.6	1,274.1	316.8	1,148.6

Table A2.1 - Decomposition of changes in territorial CO_2-emissions (in Mt) of New European Union Member between 1995 and 2007

	Source	DOM	NEU	OEU	USA	CHN	ROW	Total
Technology	Emissions Intensity	-291.8	0.0	0.0	0.0	0.0	0.0	-291.8
	Industrial Structure	-76.0	-0.9	-10.0	-2.3	0.8	2.1	-86.3
Sourcing	Industry	-68.7	5.4	41.4	3.9	0.6	13.0	-4.4
	Final Demand	-31.0	5.4	47.4	3.4	0.0	9.8	34.9
Consumption	Consumer Preferences	-44.7	2.4	-2.4	0.0	0.3	5.0	-39.4
	Consumption Level	256.5	13.7	30.2	7.0	3.9	33.4	344.8
Total	Emissions	-255.7	26.0	106.7	12.0	5.6	63.3	-42.2
	Sourcing	-99.7	10.8	88.8	7.3	0.6	22.8	30.6

Table A2.2 - Decomposition of changes in territorial CO_2-emissions (in Mt) of Old European Union Member between 1995 and 2007

	Source	DOM	NEU	OEU	USA	CHN	ROW	Total
Technology	Emissions Intensity	-711.4	0.0	0.0	0.0	0.0	0.0	-711.4
	Industrial Structure	96.0	7.0	17.0	-7.7	7.7	34.6	154.6
Sourcing	Sourcing Industry	-111.2	5.4	16.8	11.7	0.6	18.0	-58.7
	Sourcing Final Demand	-127.5	3.6	26.9	11.2	-1.4	8.7	-78.5
Consumption	Consumer Preferences	-40.3	4.6	7.8	-0.7	1.3	10.5	-16.9
	Consumption Level	539.0	21.4	137.5	49.0	23.5	139.6	909.9
Total	Total Emissions	-355.5	42.0	205.9	63.4	31.7	211.4	198.9
	Total Sourcing	-238.7	9.0	43.7	22.9	-0.8	26.7	-137.2

Table A2.3 - Decomposition of changes in territorial CO_2-emissions (in Mt) of the United States between 1995 and 2007

	Source	DOM	NEU	OEU	USA	CHN	ROW	Total
Technology	Emissions Intensity	-288.2	0.0	0.0	0.0	0.0	0.0	-288.2
	Industrial Structure	-613.5	0.5	-4.6	0.0	4.7	-18.4	-631.2
Sourcing	Industry	-163.4	0.2	-9.0	0.0	0.6	-49.6	-221.3
	Final Demand	-113.4	0.2	9.5	0.0	0.0	-10.6	-114.3
Consumption	Consumer Preferences	-349.9	0.7	6.3	0.0	0.9	10.2	-331.8
	Consumption Level	1,766.3	2.7	32.1	0.0	17.7	121.0	1,939.8
Total	Emissions	237.9	4.3	34.4	0.0	23.9	52.6	353.1
	Sourcing	-276.8	0.4	0.5	0.0	0.5	-60.3	-335.6

Table A2.4 - Decomposition of changes in territorial CO_2-emissions (in Mt) of China between 1995 and 2007

	Source	DOM	NEU	OEU	USA	CHN	ROW	Total
Technology	Emissions Intensity	-2,957.0	0.0	0.0	0.0	0.0	0.0	-2,957.0
	Industrial Structure	980.4	6.5	38.8	30.2	0.0	123.5	1,179.3
Sourcing	Industry	-68.6	16.8	147.4	170.8	0.0	386.0	652.4
	Final Demand	25.1	9.4	127.3	178.8	0.0	281.1	621.7
Consumption	Consumer Preferences	31.5	3.5	4.2	8.2	0.0	46.1	93.5
	Consumption Level	2,882.3	7.7	53.9	96.9	0.0	182.0	3,222.8
Total	Emissions	893.7	43.9	371.4	485.0	0.0	1,018.7	2,812.7
	Sourcing	-43.4	26.2	274.6	349.6	0.0	667.1	1,274.1

Table A2.5 - Decomposition of changes in territorial CO_2-emissions (in Mt) of the Rest of the World between 1995 and 2007

	Source	DOM	NEU	OEU	USA	CHN	ROW	Total
Technology	Emissions Intensity	-2,893.9	0.0	0.0	0.0	0.0	0.0	-2,893.9
	Industrial Structure	688.3	-5.5	55.8	-20.5	75.3	64.3	857.7
Sourcing	Industry	-391.9	-3.6	134.7	173.6	24.6	249.1	186.4
	Final Demand	-254.4	2.2	136.0	114.0	8.1	124.4	130.3
Consumption	Consumer Preferences	245.1	3.4	-7.2	2.2	9.8	8.6	261.9
	Consumption Level	3,301.9	55.4	229.0	279.7	202.6	410.4	4,479.0
Total	Emissions	695.0	51.8	548.3	549.1	320.4	856.8	3,021.4
	Sourcing	-646.3	-1.4	270.7	287.6	32.7	373.5	316.8

Table A3.1 - Total CO_2 Emissions by Industry between 1995 and 2007 (in Mt): New European Union members

Industry	Emissions Intensity	Industrial Structure	Industrial Sourcing	Consumer's Preference	Final Demand Sourcing	Consumption Level	Total Emissions
Agriculture	–15.6	–3.9	–0.6	–7.9	–2.2	24.3	–5.7
Mining	–30.0	–12.8	–35.1	14.6	–3.0	54.5	–11.8
Food	10.5	–5.3	–0.5	–9.9	–3.0	24.3	16.1
Textiles	1.1	–6.8	–1.2	–1.8	–8.9	7.6	–10.1
Leather	–0.3	–0.1	0.0	–0.1	–0.3	0.2	–0.6
Wood	–4.8	–0.5	–0.9	–2.3	–0.5	6.2	–2.7
Paper	6.4	–22.1	–3.8	–2.7	–1.7	28.2	4.3
Ref. Petroleum; Nuclear	–52.8	–11.2	–21.5	–2.7	–9.3	87.6	–10.0
Chemicals	–39.8	–3.6	–13.5	4.1	–13.7	66.6	0.0
Rubber	–2.4	–0.9	–0.8	0.0	–0.3	3.1	–1.3
Non–Metallic	3.5	–4.0	–13.7	–12.0	–0.9	53.2	26.1
Metals	–67.6	–19.6	–23.2	1.4	–10.2	73.5	–45.7
Machinery	–0.1	–1.3	–1.9	–0.5	–2.4	8.2	2.0
Electrical	–20.8	3.5	–2.1	5.4	–0.7	7.9	–6.7
Transport	–9.7	–1.2	–1.7	1.2	–1.4	11.2	–1.5
Manufacturing	–4.0	–0.4	–0.5	0.1	–1.1	3.1	–2.7
Electricity	460.6	–528.6	–59.6	–259.3	–37.5	873.3	448.9
Construction	–16.5	–3.0	–0.2	–9.1	–0.1	24.4	–4.4
Maintenance	–5.4	–0.2	0.0	0.2	0.0	3.5	–1.9
Wholesale Trade	–34.0	2.5	–0.3	6.4	–0.7	18.3	–7.8
Retail Trade	–71.0	–2.0	–0.4	5.5	–0.3	45.7	–22.6
Hotels	–26.9	–1.1	–0.4	–4.0	–0.3	29.8	–2.8
Inland Transport	21.8	–16.5	–3.8	–5.6	–2.9	70.8	63.8
Water Transport	0.3	1.2	–17.6	5.5	–4.7	21.6	6.2
Air Transport	0.9	–11.8	–13.1	–9.6	–4.3	69.9	32.1
Other Transport	20.8	–0.8	0.1	1.0	–0.4	15.3	36.1
Telecommunications	–10.3	2.0	–0.7	4.6	–0.3	11.6	6.9
Financial Intermediation	–33.9	9.7	–0.5	4.0	–0.3	16.5	–4.3
Real Estate Activities	–7.9	0.5	–0.1	–0.6	0.0	5.8	–2.3
Renting M&Eq	–76.1	16.9	–2.2	11.0	–1.9	52.6	0.4
Public Admin	–168.9	–5.2	–0.3	–62.7	–0.3	141.6	–95.8
Education	–3.7	–1.8	–0.1	–0.8	0.0	7.0	0.5
Health	–44.8	–1.2	0.0	–2.3	0.0	40.8	–7.5
Personal Services	–66.9	–1.4	–1.2	–3.0	–0.5	31.3	–41.7
Private HH	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: The coloring scheme ranges from red to blue, with blue representing positive variation in emissions and red negative variation. Shading breaks are from different percentiles.

Table A3.2 - Total CO_2 Emissions by Industry between 1995 and 2007 (in Mt): Old European Union members

Industry	Emissions Intensity	Industrial Structure	Industrial Sourcing	Consumer's Preference	Final Demand Sourcing	Consumption Level	Total Emissions
Agriculture	–18.2	–10.3	–0.6	–6.1	0.2	25.4	–9.6
Mining	4.0	–11.8	–21.0	21.5	–18.1	19.2	–6.3
Food	–14.5	–2.6	–1.3	–6.8	–1.5	25.4	–1.5
Textiles	–6.8	–1.0	–2.3	–2.6	–4.6	7.5	–9.8
Leather	–0.4	–0.1	–0.1	–0.4	–0.4	0.7	–0.8
Wood	–1.5	0.1	–0.2	–0.2	–0.2	2.3	0.3
Paper	–10.5	–3.8	0.0	–2.0	–0.2	14.8	–1.8
Ref. Petroleum; Nuclear	–45.4	3.9	3.9	–8.3	–3.1	48.0	–1.1
Chemicals	–62.0	–3.8	–1.6	5.1	3.4	45.2	–13.7
Rubber	–5.7	1.1	–0.8	0.2	–0.6	4.5	–1.3
Non–Metallic	–43.2	4.8	–8.8	–5.5	–2.8	74.5	19.0
Metals	–76.1	–2.7	–4.0	5.5	–7.3	73.1	–11.4
Machinery	–4.9	0.7	–0.4	0.6	–1.2	5.0	–0.1
Electrical	–5.6	2.2	–1.6	2.3	–1.6	3.5	–0.8
Transport	–10.1	2.1	–0.7	3.1	–1.8	6.5	–1.0
Manufacturing	–2.8	0.6	–0.3	0.0	–1.5	4.6	0.6
Electricity	–273.9	122.4	–9.4	–27.6	–19.1	315.0	107.5
Construction	–0.8	–2.7	–0.1	–4.2	–0.2	15.2	7.2
Maintenance	–7.2	0.7	0.0	0.5	–0.1	5.7	–0.3
Wholesale Trade	–13.1	1.8	–0.3	1.2	–0.7	10.0	–1.1
Retail Trade	–13.5	0.0	–0.3	–0.3	–0.5	8.4	–6.2
Hotels	–3.2	0.0	–0.2	–0.6	–0.1	4.4	0.3
Inland Transport	–18.3	7.2	–4.8	–5.2	–3.3	52.5	28.1
Water Transport	–21.8	26.1	–3.4	6.5	–0.6	35.6	42.3
Air Transport	15.4	0.6	–1.0	10.5	–11.9	42.0	55.6
Other Transport	–2.1	3.4	0.4	–0.3	–0.1	4.8	6.2
Telecommunications	–7.7	3.4	–0.1	3.2	–0.1	3.0	1.7
Financial Intermediation	–5.7	0.6	0.4	1.1	0.0	2.6	–0.9
Real Estate Activities	–5.1	0.5	–0.1	–0.1	–0.1	3.2	–1.6
Renting M&Eq	–16.6	6.7	0.1	2.3	–0.4	11.1	3.2
Public Admin	–13.9	–1.1	–0.1	–3.7	0.0	9.6	–9.2
Education	–5.3	1.2	0.0	–4.2	0.0	5.2	–3.1
Health	–11.7	1.1	0.0	2.1	0.0	7.3	–1.3
Personal Services	–3.3	3.2	0.2	–4.4	0.1	14.0	9.8
Private HH	0.0	0.0	0.0	–0.1	0.0	0.1	0.0

Note: The coloring scheme ranges from red to blue, with blue representing positive variation in emissions and red negative variation. Shading breaks are from different percentiles.

Table A3.3 - Total CO_2 Emissions by Industry between 1995 and 2007 (in Mt): United State

Industry	Emissions Intensity	Industrial Structure	Industrial Sourcing	Consumer's Preference	Final Demand Sourcing	Consumption Level	Total Emissions
Agriculture	–15.6	–3.9	–0.6	–7.9	–2.2	24.3	–5.7
Mining	–30.0	–12.8	–35.1	14.6	–3.0	54.5	–11.8
Food	10.5	–5.3	–0.5	–9.9	–3.0	24.3	16.1
Textiles	1.1	–6.8	–1.2	–1.8	–8.9	7.6	–10.1
Leather	–0.3	–0.1	0.0	–0.1	–0.3	0.2	–0.6
Wood	–4.8	–0.5	–0.9	–2.3	–0.5	6.2	–2.7
Paper	6.4	–22.1	–3.8	–2.7	–1.7	28.2	4.3
Ref. Petroleum; Nuclear	–52.8	–11.2	–21.5	–2.7	–9.3	87.6	–10.0
Chemicals	–39.8	–3.6	–13.5	4.1	–13.7	66.6	0.0
Rubber	–2.4	–0.9	–0.8	0.0	–0.3	3.1	–1.3
Non–Metallic	3.5	–4.0	–13.7	–12.0	–0.9	53.2	26.1
Metals	–67.6	–19.6	–23.2	1.4	–10.2	73.5	–45.7
Machinery	–0.1	–1.3	–1.9	–0.5	–2.4	8.2	2.0
Electrical	–20.8	3.5	–2.1	5.4	–0.7	7.9	–6.7
Transport	–9.7	–1.2	–1.7	1.2	–1.4	11.2	–1.5
Manufacturing	–4.0	–0.4	–0.5	0.1	–1.1	3.1	–2.7
Electricity	460.6	–528.6	–59.6	–259.3	–37.5	873.3	448.9
Construction	–16.5	–3.0	–0.2	–9.1	–0.1	24.4	–4.4
Maintenance	–5.4	–0.2	0.0	0.2	0.0	3.5	–1.9
Wholesale Trade	–34.0	2.5	–0.3	6.4	–0.7	18.3	–7.8
Retail Trade	–71.0	–2.0	–0.4	5.5	–0.3	45.7	–22.6
Hotels	–26.9	–1.1	–0.4	–4.0	–0.3	29.8	–2.8
Inland Transport	21.8	–16.5	–3.8	–5.6	–2.9	70.8	63.8
Water Transport	0.3	1.2	–17.6	5.5	–4.7	21.6	6.2
Air Transport	0.9	–11.8	–13.1	–9.6	–4.3	69.9	32.1
Other Transport	20.8	–0.8	0.1	1.0	–0.4	15.3	36.1
Telecommunications	–10.3	2.0	–0.7	4.6	–0.3	11.6	6.9
Financial Intermediation	–33.9	9.7	–0.5	4.0	–0.3	16.5	–4.3
Real Estate Activities	–7.9	0.5	–0.1	–0.6	0.0	5.8	–2.3
Renting M&Eq	–76.1	16.9	–2.2	11.0	–1.9	52.6	0.4
Public Admin	–168.9	–5.2	–0.3	–62.7	–0.3	141.6	–95.8
Education	–3.7	–1.8	–0.1	–0.8	0.0	7.0	0.5
Health	–44.8	–1.2	0.0	–2.3	0.0	40.8	–7.5
Personal Services	–66.9	–1.4	–1.2	–3.0	–0.5	31.3	–41.7
Private HH	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: The coloring scheme ranges from red to blue, with blue representing positive variation in emissions and red negative variation. Shading breaks are from different percentiles.

Table A3.4 - Total CO_2 Emissions by Industry between 1995 and 2007 (in Mt): China

Industry	Emissions Intensity	Industrial Structure	Industrial Sourcing	Consumer's Preference	Final Demand Sourcing	Consumption Level	Total Emissions
Agriculture	–25.9	–8.1	3.5	–59.6	9.3	111.5	30.7
Mining	–36.3	–8.9	–2.0	–2.2	17.3	93.0	60.8
Food	–99.4	20.4	2.6	–5.2	5.4	55.8	–20.2
Textiles	–69.3	7.5	11.4	–8.4	20.2	27.7	–11.0
Leather	–4.5	0.2	0.5	–0.6	1.2	2.4	–0.9
Wood	–13.5	3.8	2.5	0.1	1.1	6.8	0.7
Paper	–52.6	9.9	7.8	–1.2	4.7	29.3	–2.1
Ref. Petroleum; Nuclear	–42.3	–4.4	15.8	1.1	10.9	58.2	39.3
Chemicals	–278.9	49.5	51.9	–11.4	33.7	167.6	12.5
Rubber	–43.3	6.8	6.3	0.8	5.4	15.5	–8.5
Non–Metallic	–320.9	15.6	47.6	20.9	38.3	403.1	204.7
Metals	–345.7	43.6	128.7	36.9	88.3	306.6	258.4
Machinery	–66.8	10.2	3.5	1.9	13.2	27.1	–10.8
Electrical	–33.9	7.8	5.4	4.5	6.4	9.4	–0.4
Transport	–33.8	8.3	4.2	5.0	3.6	15.5	2.9
Manufacturing	–17.6	0.1	1.0	0.2	4.4	4.4	–7.5
Electricity	–1,317.6	999.1	316.5	76.6	321.0	1,611.1	2,006.7
Construction	4.3	–0.1	0.3	9.4	0.3	37.0	51.2
Maintenance	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wholesale Trade	–20.8	–5.3	3.3	–0.5	1.7	11.0	–10.6
Retail Trade	–4.9	–2.0	0.9	0.1	1.5	5.4	1.0
Hotels	–3.2	1.1	0.7	–0.1	0.5	7.5	6.6
Inland Transport	–24.8	–7.5	7.9	1.7	9.4	63.0	49.7
Water Transport	–21.2	16.2	18.5	4.2	11.7	48.3	77.8
Air Transport	–4.1	–2.6	8.3	2.1	7.9	21.3	32.9
Other Transport	1.3	11.0	0.6	1.4	0.8	11.1	26.2
Telecommunications	–2.4	0.8	0.3	1.6	0.4	3.2	3.9
Financial Intermediation	–3.1	–0.8	0.3	0.2	0.3	2.3	–0.8
Real Estate Activities	–10.3	–1.4	0.2	0.4	0.2	5.1	–5.7
Renting M&Eq	–8.3	2.5	2.4	1.1	1.3	10.5	9.5
Public Admin	–7.3	0.1	0.0	1.0	0.1	12.4	6.3
Education	–24.5	0.3	0.1	3.9	0.1	14.0	–6.0
Health	–3.5	0.5	0.1	2.5	0.1	5.9	5.7
Personal Services	–21.9	5.1	1.2	4.8	0.9	19.7	9.8
Private HH	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: The coloring scheme ranges from red to blue, with blue representing positive variation in emissions and red negative variation. Shading breaks are from different percentiles.

Table A3.5 - Total CO_2 Emissions by Industry between 1995 and 2007 (in Mt): Rest of the World

Industry	Emissions Intensity	Industrial Structure	Industrial Sourcing	Consumer's Preference	Final Demand Sourcing	Consumption Level	Total Emissions
Agriculture	–40.4	–18.6	5.5	–64.3	1.3	142.0	25.4
Mining	110.8	–57.8	14.9	–12.4	–1.5	220.0	273.9
Food	–6.2	7.1	2.9	–16.0	2.1	61.0	51.0
Textiles	–4.5	–1.9	–2.5	–6.5	7.0	27.2	18.7
Leather	–1.1	–0.3	–0.1	–0.9	–0.2	2.0	–0.6
Wood	7.3	–2.3	–0.6	–1.7	1.2	9.4	13.3
Paper	–29.4	–3.3	1.0	–2.0	0.6	27.7	–5.5
Ref. Petroleum; Nuclear	73.0	–70.6	–8.9	–37.8	6.6	180.5	142.9
Chemicals	–46.3	–8.9	4.4	–8.1	2.7	177.6	121.4
Rubber	–82.9	38.9	–17.0	–2.9	0.3	117.5	53.9
Non–Metallic	–50.2	–31.9	24.7	–13.0	1.9	274.1	205.6
Metals	–63.3	–55.5	–14.3	0.5	4.3	355.2	227.0
Machinery	–20.2	2.2	0.6	1.2	1.0	11.2	–3.9
Electrical	–53.5	23.0	–3.6	20.1	–6.2	33.6	13.4
Transport	–9.1	1.6	1.3	3.2	1.7	14.9	13.6
Manufacturing	–84.0	–8.7	14.0	–8.3	30.7	66.4	10.1
Electricity	–1,905.6	913.2	102.4	409.6	42.3	1,830.6	1,392.5
Construction	–28.7	1.0	0.0	–6.1	0.4	52.7	19.2
Maintenance	–2.9	–0.1	–0.2	0.3	–0.1	6.6	3.6
Wholesale Trade	–31.8	0.5	–2.8	3.6	0.1	29.7	–0.7
Retail Trade	–28.9	–5.9	0.2	–4.0	–0.3	45.9	6.9
Hotels	–61.6	5.0	1.5	–4.5	1.5	35.6	–22.4
Inland Transport	–35.5	–16.9	5.6	–31.2	5.9	203.6	131.4
Water Transport	–306.2	114.9	68.5	55.4	7.5	158.3	98.5
Air Transport	–17.2	4.5	–9.2	–1.9	17.5	122.9	116.6
Other Transport	–6.8	4.7	1.7	–1.5	0.6	25.6	24.2
Telecommunications	–38.3	13.9	1.1	16.0	0.3	18.5	11.5
Financial Intermediation	–14.7	1.5	–1.7	2.6	–0.1	13.9	1.4
Real Estate Activities	–8.9	–0.7	0.2	–1.0	0.0	14.0	3.7
Renting M&Eq	–26.1	16.8	–5.3	9.4	–0.6	33.9	28.1
Public Admin	–49.7	–0.9	0.2	–13.6	0.5	66.9	3.2
Education	–4.3	0.6	0.2	–10.8	0.1	23.9	9.6
Health	–14.2	1.1	0.1	–3.8	0.2	28.0	11.3
Personal Services	–12.6	–8.2	1.7	–7.6	0.9	48.1	22.4
Private HH	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: The coloring scheme ranges from red to blue, with blue representing positive variation in emissions and red negative variation. Shading breaks are from different percentiles.

Table A4.1 - CO_2 Emissions Multiplier: New European Union members

Industry	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Agriculture	2.1	1.8	1.5	1.2	1.3	1.3	1.2	1.1	0.9	0.7	0.7	0.7
Mining	3.3	3.0	2.8	2.2	2.3	2.4	2.2	2.0	1.5	1.3	1.1	0.9
Food	2.2	1.9	1.7	1.4	1.4	1.5	1.3	1.2	1.0	0.8	0.7	0.7
Textiles	2.1	1.8	1.6	1.3	1.3	1.3	1.1	1.1	0.8	0.7	0.6	0.6
Leather	2.3	1.9	1.8	1.3	1.3	1.4	1.2	1.1	0.9	0.7	0.7	0.6
Wood	2.5	2.0	1.8	1.4	1.4	1.5	1.4	1.3	1.0	0.8	0.7	0.7
Paper	2.4	2.1	2.0	1.7	1.7	1.7	1.6	1.4	1.1	0.9	0.8	0.7
Ref. Petroleum; Nuclear	11.7	11.5	8.6	3.5	4.3	4.5	3.7	3.8	3.4	2.1	2.1	1.5
Chemicals	6.1	5.4	4.7	3.9	4.1	4.1	3.2	3.1	2.6	2.0	1.6	1.5
Rubber	3.4	2.8	2.6	2.0	2.2	2.2	1.9	1.7	1.3	1.1	0.9	0.9
Non–Metallic	7.2	6.0	6.0	5.0	4.8	5.2	4.8	4.2	3.3	2.6	2.3	2.1
Metals	4.4	3.9	3.9	3.3	3.5	3.5	3.3	3.0	2.3	1.8	1.6	1.4
Machinery	3.1	2.6	2.5	2.2	2.2	2.2	2.1	1.9	1.4	1.2	1.0	0.9
Electrical	3.2	2.5	2.5	2.2	2.2	2.0	2.0	1.9	1.3	1.0	0.9	0.8
Transport	3.6	2.9	2.9	2.7	2.6	2.7	2.5	2.2	1.6	1.3	1.2	1.1
Manufacturing	3.2	2.4	2.4	1.7	1.7	1.7	1.6	1.4	1.1	0.9	0.8	0.7
Electricity	14.9	14.1	14.3	12.2	10.8	12.0	11.0	9.8	7.7	6.4	5.7	5.3
Construction	3.0	2.5	2.2	1.7	1.7	1.8	1.7	1.5	1.2	0.9	0.8	0.7
Maintenance	1.9	1.6	1.4	1.2	1.1	1.1	1.1	1.0	0.8	0.6	0.6	0.5
Wholesale Trade	1.3	1.1	0.9	0.7	0.8	0.8	0.7	0.7	0.5	0.4	0.4	0.4
Retail Trade	1.3	1.1	1.0	0.8	0.8	0.8	0.8	0.7	0.6	0.4	0.4	0.4
Hotels	1.8	1.4	1.3	1.0	1.0	1.1	1.0	0.9	0.7	0.5	0.5	0.5
Inland Transport	4.4	4.0	3.7	2.8	2.8	3.1	3.0	2.7	2.3	1.8	1.7	1.6
Water Transport	2.4	2.3	2.0	1.5	1.7	1.6	2.1	1.2	1.0	0.8	0.8	0.8
Air Transport	3.5	3.0	2.6	1.8	1.8	2.1	2.0	1.7	1.3	1.0	1.1	1.0
Other Transport	1.8	1.5	1.4	1.0	1.0	1.0	1.0	0.9	0.7	0.5	0.5	0.5
Telecommunications	1.0	0.8	0.8	0.6	0.6	0.6	0.5	0.5	0.4	0.3	0.3	0.3
Financial Intermediation	0.7	0.7	0.7	0.5	0.5	0.5	0.4	0.4	0.3	0.2	0.2	0.2
Real Estate Activities	1.0	0.9	0.8	0.7	0.8	0.8	0.7	0.7	0.6	0.5	0.4	0.4
Renting M&Eq	1.3	1.1	1.0	0.7	0.7	0.8	0.7	0.6	0.5	0.4	0.4	0.4
Public Admin	1.4	1.2	1.1	0.8	0.8	0.8	0.8	0.7	0.5	0.4	0.4	0.3
Education	1.5	1.3	1.1	0.8	0.8	0.8	0.8	0.7	0.5	0.4	0.4	0.3
Health	2.0	1.6	1.4	1.1	1.2	1.2	1.0	0.9	0.8	0.6	0.6	0.5
Personal Services	1.9	1.6	1.6	1.1	1.2	1.2	1.1	1.0	0.8	0.7	0.6	0.5
Private HH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: The coloring scheme ranges from green to yellow to red; Green shades are lower CO_2 multipliers, yellow to average multipliers, and red to higher multipliers. Shading breaks are from different percentiles.

Table A4.2 - CO_2 Emissions Multiplier: Old European Union members

Industry	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Agriculture	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4
Mining	1.1	1.0	1.1	1.2	1.2	1.3	1.2	1.2	1.0	0.9	0.8	0.7
Food	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.4	0.3	0.3	0.3
Textiles	0.3	0.3	0.4	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.2
Leather	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
Wood	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.3	0.3	0.3	0.3
Paper	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.3	0.3	0.3
Ref. Petroleum; Nuclear	1.5	1.4	1.8	1.5	1.6	1.4	1.5	1.5	1.2	1.0	0.9	0.8
Chemicals	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.5	0.5	0.5	0.4
Rubber	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.3	0.3	0.3	0.3
Non–Metallic	1.6	1.6	1.8	1.7	1.8	2.0	2.0	1.8	1.5	1.4	1.3	1.3
Metals	0.9	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.7	0.6	0.6	0.5
Machinery	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.2
Electrical	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
Transport	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3
Manufacturing	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.3	0.3	0.3	0.3
Electricity	3.6	3.5	3.7	3.9	3.9	4.5	4.5	4.1	3.3	2.7	2.5	2.2
Construction	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.3	0.3	0.3	0.3
Maintenance	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.2	0.2
Wholesale Trade	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1
Retail Trade	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Hotels	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
Inland Transport	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.6	0.6	0.6	0.5
Water Transport	1.5	1.4	1.6	1.5	1.5	1.6	1.6	1.5	1.3	1.1	1.0	0.9
Air Transport	1.2	1.2	1.3	1.4	1.3	1.5	1.4	1.3	1.2	1.1	1.1	1.1
Other Transport	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.2	0.3	0.2
Telecommunications	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Financial Intermediation	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Real Estate Activities	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Renting M&Eq	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Public Admin	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Education	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Health	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Personal Services	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
Private HH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: The coloring scheme ranges from green to yellow to red; Green shades are lower CO_2 multipliers, yellow to average multipliers, and red to higher multipliers. Shading breaks are from different percentiles.

Table A4.3 - CO_2 Emissions Multiplier: United States

Industry	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Agriculture	0.8	0.7	0.7	0.7	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.6
Mining	1.4	1.4	1.4	1.6	1.4	0.9	0.9	1.0	0.8	0.8	0.6	0.6
Food	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.5	0.6
Textiles	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.5
Leather	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.4	0.4
Wood	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.6	0.6	0.6
Paper	0.7	0.6	0.6	0.6	0.6	0.7	0.6	0.6	0.6	0.5	0.5	0.5
Ref. Petroleum; Nuclear	2.4	2.3	2.2	2.6	2.4	1.6	1.6	1.7	1.2	1.1	0.9	0.8
Chemicals	1.2	1.0	1.0	1.0	1.2	1.1	1.0	1.0	0.9	0.9	0.8	0.7
Rubber	0.7	0.7	0.6	0.6	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.5
Non–Metallic	2.4	2.3	2.2	2.2	2.2	2.2	2.1	2.1	2.2	2.1	2.0	1.9
Metals	1.2	1.2	1.1	1.1	1.1	1.1	1.0	1.0	0.9	0.9	0.8	0.8
Machinery	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4
Electrical	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2
Transport	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4
Manufacturing	0.5	0.5	0.6	0.3	0.7	0.4	0.2	0.4	0.3	0.3	0.4	0.3
Electricity	8.1	8.4	8.0	7.1	7.0	6.1	6.9	7.7	7.3	6.8	6.4	6.0
Construction	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3
Maintenance	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
Wholesale Trade	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1
Retail Trade	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
Hotels	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.3
Inland Transport	1.1	1.1	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.9	0.8	0.8
Water Transport	3.0	2.9	2.9	2.8	2.6	2.4	2.4	2.3	2.0	2.0	1.9	1.9
Air Transport	1.7	1.9	1.9	2.2	2.0	2.0	1.8	1.7	1.4	1.6	1.4	1.6
Other Transport	0.5	0.4	0.4	0.5	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4
Telecommunications	0.2	0.3	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Financial Intermediation	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Real Estate Activities	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.1
Renting M&Eq	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1
Public Admin	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
Education	0.6	0.6	0.5	0.6	0.5	0.5	0.6	0.5	0.5	0.4	0.4	0.4
Health	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
Personal Services	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
Private HH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table A4.4 - CO_2 Emissions Multiplier: China

Industry	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Agriculture	1.9	1.6	1.6	1.5	1.4	1.3	1.3	1.3	1.3	1.2	1.1	1.0
Mining	5.1	4.1	4.2	3.6	3.1	3.1	3.0	3.2	3.2	2.8	2.8	2.7
Food	2.5	2.1	2.1	1.9	1.8	1.6	1.6	1.6	1.6	1.4	1.3	1.2
Textiles	3.0	2.4	2.4	2.2	2.1	2.0	2.0	2.1	2.2	2.0	1.9	1.7
Leather	2.3	2.0	1.9	1.8	1.7	1.6	1.5	1.6	1.7	1.5	1.4	1.3
Wood	3.1	2.5	2.6	2.3	2.2	2.1	2.1	2.2	2.2	2.0	1.9	1.7
Paper	4.2	3.6	3.4	2.9	2.8	2.5	2.4	2.5	2.7	2.5	2.4	2.1
Ref. Petroleum; Nuclear	5.7	5.0	5.1	4.5	3.9	3.7	3.6	3.9	3.7	3.3	3.2	2.9
Chemicals	7.2	5.9	5.8	5.1	4.7	4.2	4.1	4.2	4.0	3.7	3.5	3.1
Rubber	4.7	3.9	3.8	3.4	3.1	2.9	2.8	3.0	3.1	2.9	2.7	2.4
Non–Metallic	8.6	7.2	7.3	6.7	6.3	5.8	5.7	6.3	7.1	6.4	5.8	5.0
Metals	7.3	6.4	6.2	5.7	5.3	4.9	4.9	5.0	4.9	4.6	4.0	3.5
Machinery	4.4	3.6	3.5	3.2	3.1	2.8	2.8	3.0	3.0	2.9	2.6	2.3
Electrical	4.1	3.5	3.3	2.9	2.7	2.5	2.4	2.5	2.7	2.6	2.3	2.1
Transport	4.1	3.5	3.3	3.0	2.8	2.5	2.4	2.5	2.6	2.5	2.2	2.0
Manufacturing	3.7	2.9	2.8	2.5	2.3	2.1	2.0	2.1	2.2	2.0	1.8	1.6
Electricity	36.8	29.7	25.8	22.6	22.5	20.7	20.1	21.1	17.7	16.2	17.7	14.7
Construction	4.6	3.9	3.9	3.5	3.3	3.0	2.9	3.2	3.4	3.2	2.9	2.6
Maintenance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wholesale Trade	2.0	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.2	1.0	0.9	0.8
Retail Trade	2.1	1.7	1.7	1.6	1.5	1.4	1.3	1.3	1.3	1.1	0.9	0.8
Hotels	2.1	1.7	1.7	1.6	1.6	1.5	1.4	1.5	1.6	1.4	1.3	1.2
Inland Transport	3.0	2.7	2.7	2.5	2.4	2.2	2.1	2.2	2.2	2.1	1.9	1.7
Water Transport	5.8	5.6	4.5	3.9	3.7	3.2	3.0	3.1	3.0	2.9	2.7	2.5
Air Transport	4.2	4.0	4.7	4.0	3.5	3.6	3.6	4.2	4.4	3.8	3.4	3.3
Other Transport	2.2	2.1	2.1	1.9	1.9	1.7	1.7	2.0	2.1	1.8	1.7	1.5
Telecommunications	2.4	2.1	2.0	1.7	1.6	1.5	1.4	1.4	1.4	1.2	1.1	0.9
Financial Intermediation	1.3	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.7	0.6	0.5
Real Estate Activities	1.3	1.0	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.5	0.4	0.3
Renting M&Eq	2.7	2.3	2.2	2.0	1.8	1.6	1.5	1.6	1.7	1.5	1.4	1.3
Public Admin	2.6	2.2	1.9	1.7	1.5	1.3	1.2	1.3	1.3	1.2	1.1	1.0
Education	3.5	2.9	2.7	2.3	2.1	1.8	1.6	1.6	1.6	1.4	1.3	1.2
Health	4.3	3.6	3.4	2.9	2.6	2.2	2.0	2.1	2.2	2.1	2.0	1.8
Personal Services	3.5	2.8	2.6	2.2	2.0	1.8	1.7	1.7	1.8	1.6	1.5	1.3
Private HH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: The coloring scheme ranges from green to yellow to red; Green shades are lower CO_2 multipliers, yellow to average multipliers, and red to higher multipliers. Shading breaks are from different percentiles.

Table A4.5 - CO_2 Emissions Multiplier: Rest of the World

Industry	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Agriculture	0.8	0.8	0.8	0.8	1.0	0.9	1.0	1.0	0.9	0.8	0.8	0.6
Mining	2.2	2.1	2.0	2.5	3.2	3.4	3.5	3.8	3.8	3.3	3.0	2.5
Food	0.9	0.8	0.9	0.9	1.1	1.0	1.0	1.0	0.9	0.8	0.8	0.7
Textiles	1.2	1.1	1.1	1.3	1.5	1.4	1.5	1.5	1.4	1.2	1.2	1.0
Leather	1.0	0.8	0.9	1.0	1.2	1.1	1.1	1.1	1.0	0.9	0.8	0.7
Wood	1.1	1.0	1.1	1.2	1.5	1.3	1.5	1.5	1.4	1.1	1.1	1.0
Paper	1.3	1.1	1.2	1.4	1.6	1.5	1.5	1.5	1.3	1.2	1.1	1.0
Ref. Petroleum; Nuclear	2.5	2.3	2.3	3.0	3.5	3.1	3.5	3.7	3.3	3.0	2.8	2.2
Chemicals	2.2	2.0	2.0	2.3	3.0	2.6	2.7	2.7	2.4	2.1	2.0	1.6
Rubber	1.7	1.5	1.6	1.8	2.1	1.9	2.0	2.1	1.9	1.7	1.6	1.3
Non–Metallic	4.2	3.7	4.1	5.4	5.5	5.3	5.4	5.2	4.9	4.4	4.0	3.5
Metals	2.7	2.4	2.6	3.2	3.4	3.2	3.2	3.3	2.9	2.4	2.4	2.0
Machinery	1.4	1.1	1.3	1.4	1.7	1.5	1.6	1.4	1.3	1.1	1.1	0.9
Electrical	1.2	0.9	1.1	1.3	1.5	1.4	1.4	1.4	1.3	1.1	1.0	0.9
Transport	1.1	0.9	1.1	1.1	1.3	1.2	1.3	1.2	1.2	1.0	1.0	0.8
Manufacturing	1.5	1.2	1.4	1.4	1.6	1.5	1.5	1.5	1.3	1.2	1.2	1.0
Electricity	11.0	10.4	9.9	12.0	13.7	12.9	12.1	11.0	9.7	8.7	8.0	7.3
Construction	1.3	1.2	1.2	1.5	1.6	1.6	1.6	1.6	1.5	1.3	1.2	1.0
Maintenance	0.7	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.5	0.5	0.4
Wholesale Trade	0.5	0.4	0.5	0.5	0.6	0.5	0.6	0.5	0.5	0.4	0.4	0.3
Retail Trade	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.4	0.4
Hotels	1.0	0.9	0.8	0.9	1.1	1.0	1.0	1.0	0.8	0.7	0.7	0.6
Inland Transport	1.6	1.4	1.4	1.8	2.2	2.0	1.9	1.8	1.7	1.5	1.4	1.2
Water Transport	4.0	3.7	3.4	4.0	4.2	3.8	3.8	3.8	3.5	3.2	3.1	2.8
Air Transport	3.9	3.5	3.7	3.7	3.5	3.5	3.8	3.8	3.3	3.0	2.9	2.3
Other Transport	1.2	0.9	0.9	1.2	1.4	1.2	1.2	1.2	1.1	0.9	0.9	0.7
Telecommunications	0.6	0.6	0.5	0.7	0.8	0.7	0.8	0.7	0.6	0.5	0.5	0.4
Financial Intermediation	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.3	0.3	0.2	0.2
Real Estate Activities	0.6	0.5	0.5	0.5	0.5	0.6	0.4	0.4	0.4	0.3	0.3	0.3
Renting M&Eq	0.5	0.5	0.5	0.6	0.7	0.6	0.6	0.6	0.6	0.5	0.5	0.4
Public Admin	0.7	0.6	0.6	0.7	0.8	0.7	0.7	0.7	0.6	0.5	0.4	0.4
Education	0.7	0.6	0.6	0.7	0.8	0.8	0.7	0.6	0.5	0.5	0.4	0.4
Health	0.8	0.7	0.7	0.8	0.9	0.9	0.9	0.8	0.7	0.6	0.6	0.5
Personal Services	1.0	0.9	0.9	1.0	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.6
Private HH	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0

Note: The coloring scheme ranges from green to yellow to red; Green shades are lower CO_2 multipliers, yellow to average multipliers, and red to higher multipliers. Shading breaks are from different percentiles.

Table A5 - Industrial Composition of the World Input-Output Tables

Code	Industry
Agriculture	Agriculture, Hunting, Forestry and Fishing
Mining	Mining and Quarrying
Food	Food, Beverages and Tobacco
Textiles	Textiles and Textile Products
Leather	Leather, Leather and Footwear
Wood	Wood and Products of Wood and Cork
Paper	Pulp, Paper, Paper , Printing and Publishing
Ref. Petroleum; Nuclear	Coke, Refined Petroleum and Nuclear Fuel
Chemicals	Chemicals and Chemical Products
Rubber	Rubber and Plastics
Non-Metallic	Other Non-Metallic Mineral
Metals	Basic Metals and Fabricated Metal
Machinery	Machinery, Nec
Electrical	Electrical and Optical Equipment
Transport	Transport Equipment
Manufacturing	Manufacturing, Nec; Recycling
Electricity	Electricity, Gas and Water Supply
Construction	Construction
Maintenance	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel
Wholesale Trade	Wholesale Trade and Commission Trade, Except for Motor Vehicles and Motorcycles
Retail Trade	Retail Trade, Except for Motor Vehicles and Motorcycles; Repair of Household Goods
Hotels	Hotels and Restaurants
Inland Transport	Inland Transport
Water Transport	Water Transport
Air Transport	Air Transport
Other Transport	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
Telecommunications	Post and Telecommunications
Financial Intermediation	Financial Intermediation
Real Estate Activities	Real Estate Activities
Renting M&Eq	Renting of M&Eq and Other Business Activities
Public Admin	Public Admin and Defense; Compulsory Social Security
Education	Education
Health	Health and Social Work
Personal Services	Other Community, Social and Personal Services
Private HH	Private Households with Employed Persons

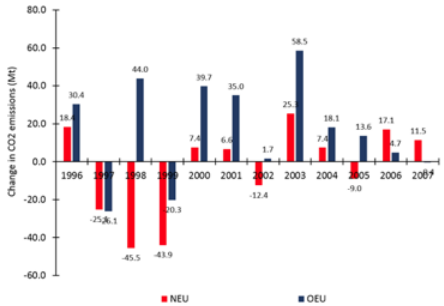

Fig A1.1.a Total Emission CO2 (in Mt): level

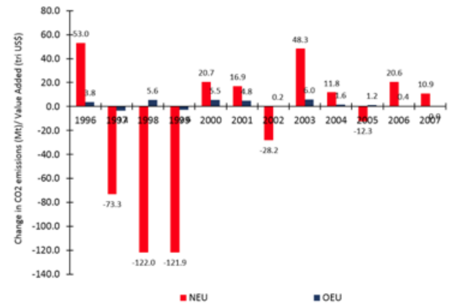

Fig A1.2.b Total Emission CO2 (in Mt): emission /value added

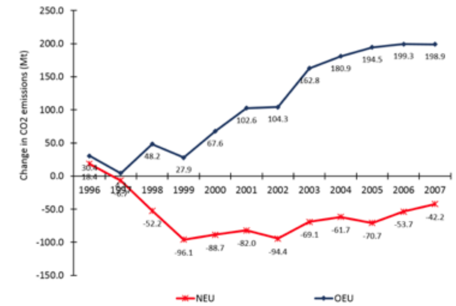

Fig A1.3.c Total Emission CO2 (in Mt): cumulate

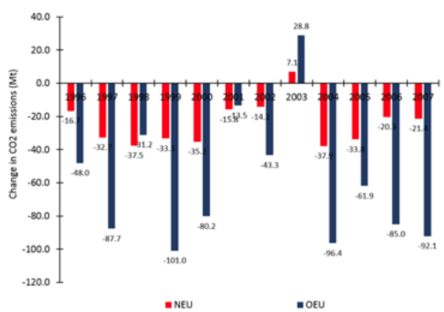

Fig A1.2.a Intensity: level

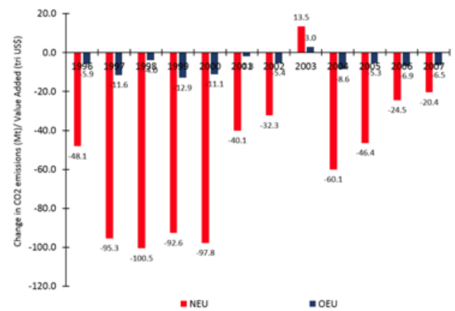

Fig A1.2.b Intensity: emission /value added

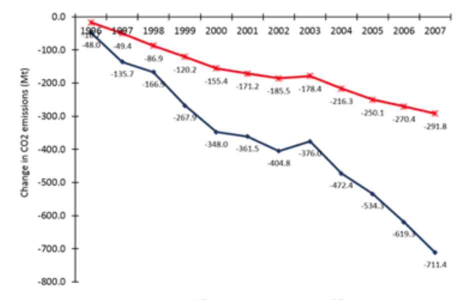

Fig A1.2.c Intensity: cumulate

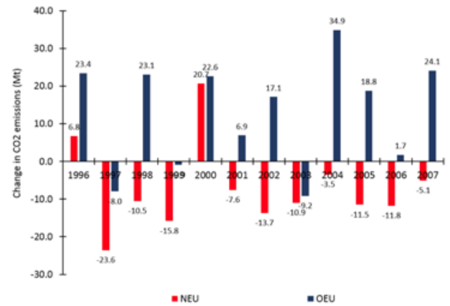

Fig A1.3.a Industrial structure: level

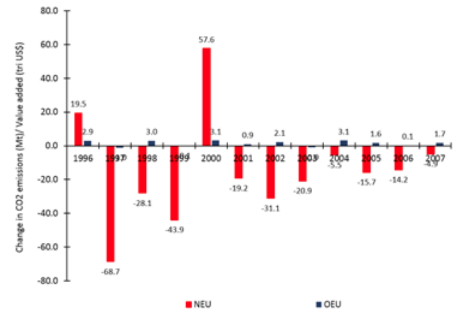

Fig A1.3.b Industrial structure: emission /value added

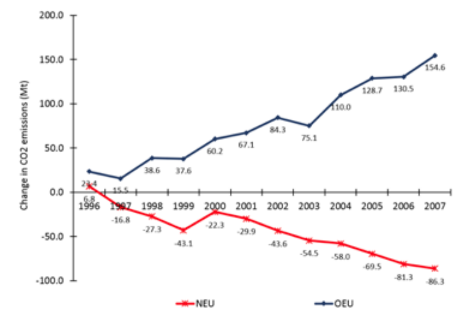

Fig A1.3.c Industrial structure: cumulate

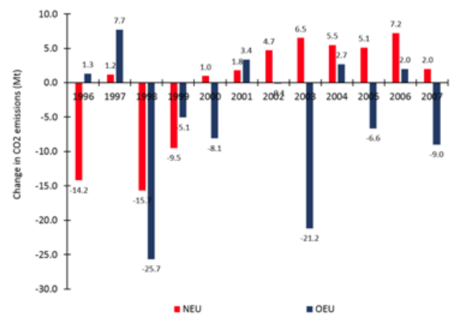

Fig A1.4.a Industrial sourcing: level

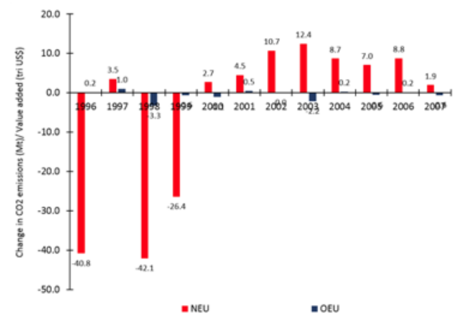

Fig A1.4.b Industrial sourcing: emission /value added

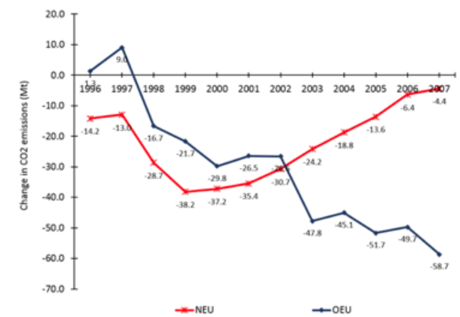

Fig A1.4.c Industrial sourcing: cumulate

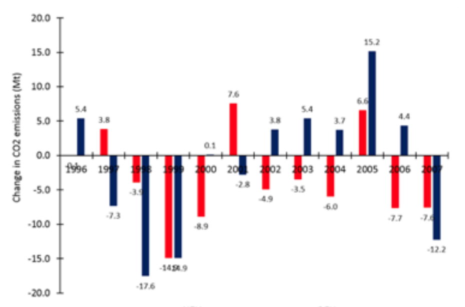

Fig A1.5.a Consumer's preference: level

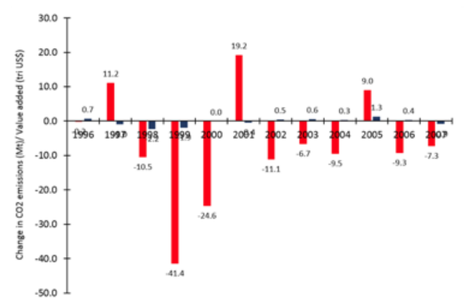

Fig A1.5.b Consumer's preference: emission /value added

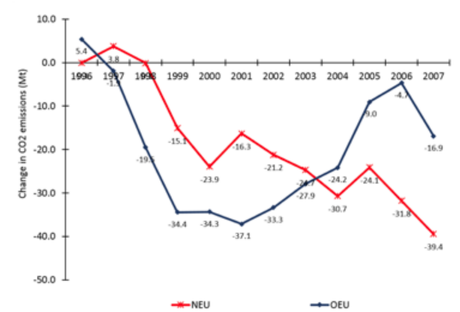

Fig A1.5.c Consumer's preference: cumulate

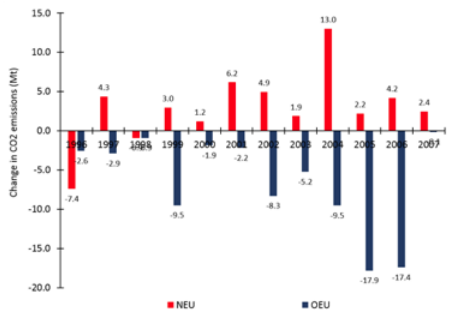

Fig A1.6.a Final demand sourcing: level

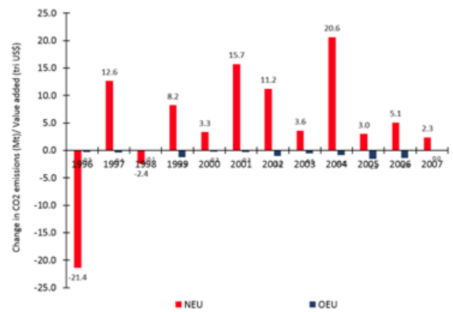

Fig A1.6.b Final demand sourcing: emission /value added

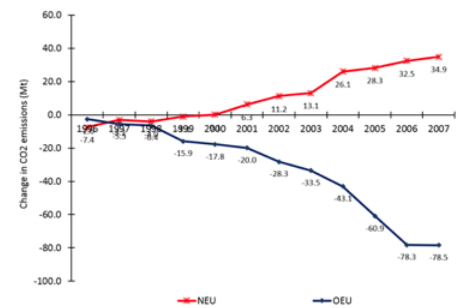

Fig A1.6.c Final demand sourcing: cumulate

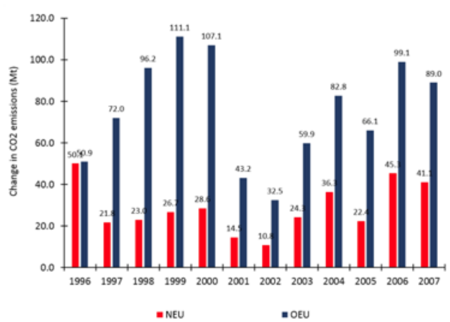

Fig A1.7.a Consumption level: level

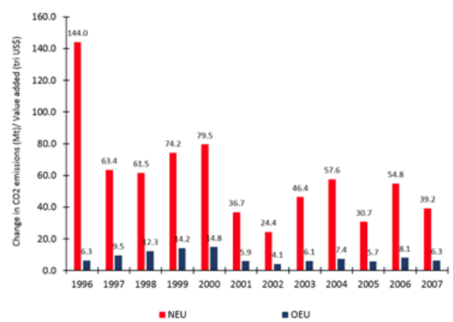

Fig A1.7.b Consumption level: emission /value added

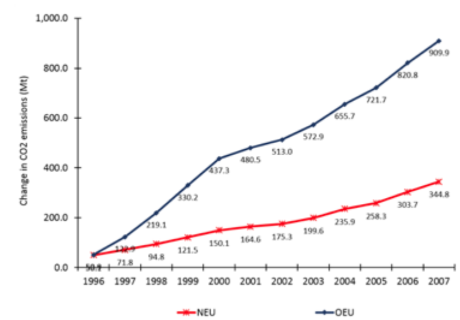

Fig A1.7.c Consumption level: cumulate

Figure A2 - CO_2 Emissions Multiplier, 1996-2007