Emissions and Trade; a Structural Decomposition Analysis for the Netherlands

Harry Wilting, Rutger Hoekstra and Sjoerd Schenau

Abstract:

The pollution haven hypothesis states that there is a shift of high polluting industries to countries with lower environmental standards. This paper examines the hypothesis for the Netherlands by relating developments in emissions of CO_2, CH_4, N_2O, NO_x, SO_2 and NH_3 in Dutch industries to changes in trade patterns. The study concerns the period 1990-2004 in which emissions for all substances that were investigated, except for CO_2, decreased substantially. The study is carried out by using a structural decomposition analysis of emissions including import and export effects. The analyses show that the export effect compensates the import effect for CH_4, N_2O, NO_x, SO_2 and NH_3 implicating that there is no net shift of pollution to abroad. Only CO_2 shows a small decrease in emissions resulting from trade effects, but the effect is too small to draw hard conclusions.

Keywords: International trade, environment, input-output analysis, pollution haven

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Introduction

The extent of environmental policy differs over countries. Some countries have strict regulations and monitoring regarding environmental pressure. For other countries environmental aspects have lower political attention. This fact raised among economists the so-called 'pollution haven hypothesis' (PHH). The hypothesis states that there is a shift of high polluting industries to countries with lower environmental standards, mostly developing countries. In this way, the developed countries achieve their environmental goals easier, but the over-all effect may not be positive for the environment. The theoretical literature on the PHH is extensively; some of the articles in this field are (Antweiler et al., 2001; Neumayer, 2001; Eskeland and Harrison, 2003).

Several studies investigated the PHH empirically (for an overview see Temurshoev, 2006). Input-output studies directed at the PHH mostly consider the embodied environmental load of imports and exports. The embodied environmental loads of these flows in a specific country are used for calculating the environmental balance of trade (among others Machado et al., 2001; Munksgaard and Pedersen, 2001; Muradian et al., 2002). The PHH states that for developing countries the environmental balance (exports minus imports) increases in time. Another way to test the PHH is to compare the environmental effects of a hypothetical increase of the same amount in both imports and exports. In case there is a net increase in environmental load in a developing country this is in line with the PHH again. Dietzenbacher and Mukhopadhyay (2004), e.g., find for India a net decrease which is contradictory with the PHH.

This study is not directly interested in the embodied environment load of trade flows, but starts from the changes in environmental load in a country. The question is in which extent these changes can be explained by changes in trade, i.e. substitution processes between domestic production and production abroad. By using a decomposition method the substitution effects on the environmental load are determined. A decomposition method explains the changes in a certain parameter on the basis of changes in explanatory variables. A decomposition applied to an input-output model is referred to as structural decomposition analysis (SDA; Rose and Casler, 1996). There are several examples of studies on structural decomposition analysis of energy use (Mukhopadhyay and Chakraborty, 1999; Jakobsen, 2000), emissions (Wier, 1998; De Haan, 2001; Hoen and Mulder, 2003; Rørmose and Olsen, 2005) or physical flows (Hoekstra and Van den Bergh, 2003) in a specific region. Hoekstra and Van den Bergh (2002) give a more comprehensive overview of SDA studies on environmental issues.

The general decomposition analysis distinguishes an efficiency effect, a technological effect, and a final demand effect. The technological effect concerns the effect of changes in input-output coefficients. Such a change may be due to a more efficient use of a certain input or a substitution between inputs, but also to a shift between domestic and imported inputs. In order to identify the import effect the technological effect has to be decomposed further. The same holds for the final demand effect which encloses an import effect too. Goods and services in e.g. private consumption are partly produced domestically and partly come from abroad. Furthermore, the export effect is defined as the effect of shifting between exports and domestic final demand. The SDA also provides insight in changes in the environmental load at a sectoral level. We, therefore are able to answer the question if there is a shift to importing more dirty products or exporting more clean products resulting in lower emissions in the Netherlands and higher emissions abroad (PHH). SDA studies including trade effects are quite scarce. Dietzenbacher et al. (2004) distinguish trade effects in the decomposition of consumption per worker. Hoekstra and Van den Berg (2003) based their decomposition of material use on a technological matrix including imports by adding imports to final demand. Jakobsen (2000) distinguishes two import effects and one export effect.

This study aims at a structural decomposition of emissions in Dutch industries in the period 1990-2004. The substances CO_2, CH_4, N_2O, NH_3, NO_x and SO_2, which show different developments in emissions in this period, are studied. Environmental regulation based on national and European policy is rather strict in the Netherlands (MNP, 2006). According to the PHH this would lead to trade effects resulting in an extra net decrease in emissions in Dutch industries.

Methodology

The standard input-output model for calculating sectoral output **x** for a certain final demand **y** is

$$x = L\ y \tag{1}$$

with $\mathbf{L = (I - A)^{-1}}$ the Leontief inverse matrix. Matrix **A** is the matrix of input-output coefficients, sometimes referred to as the technological matrix, which defines the intermediate input requirements per unit output of each sector. Matrix **I** is the identity matrix.

A decomposition of equation 1 is

$$\Delta x = \Delta L\ y + L\ \Delta y \tag{2}$$

In this way the change in production is decomposed in two effects. The first term at the right hand side of equation 2 is the input-output coefficient effect due to changes in the intermediate input structure and the second term concerns the final demand effect reflecting changes in structure or level of final demand.

There are several ways to calculate the seperate effects in practice. Equation 3a, e.g., weighs the change in the Leontief inverse with final demand of the first year and it weighs the change in demand with the Leontief inverse matrix of the second year:

$$\Delta x = x_1 - x_0 = L_1 y_1 - L_0 y_0 = \Delta L\, y_0 + L_1\, \Delta y \tag{3a}$$

Another way to write down the decomposition in equation 2 is:

$$\Delta x = \Delta L\, y_1 + L_0\, \Delta y \tag{3b}$$

In equation 3b the weights are opposite to those in equation 3a. Equations 3a and 3b are the only two complete decompositions for two variables. Complete decompositions are decompositions without interaction terms (in this case $\Delta L\ \Delta y$). The number of complete decompositions for n variables is n! which asks a reasonable amount of calculations for large n. Dietzenbacher and Los (1998) investigated several decomposition methods and their averages. They found that the average of two special cases, the so-called polar decompositions, is a good measure for the outcome based on all n! decompositions. In a polar form, all weights at the right side of a factor are of the same year and all weights at the left side of the factor of the other year. Equations 3a and 3b give the polar forms for 2 variables.

Assuming that the vector of environmental load intensities **e** defines the environmental load per unit of output for all industries, the input-output model for calculating the environmental load **E** is:

$$E = e\, x = e\, L\, y \tag{4}$$

The two polar decompositions of the environmental load **E** in equation 4 are (for n = 3):

$$\Delta E = \Delta e\, L_1\, y_1 + e_0\, \Delta L\, y_1 + e_0\, L_0\, \Delta y \tag{5a}$$

$$\Delta E = \Delta e\ L_0\ y_0 + e_1\ \Delta L\ y_0 + e_1\ L_1\ \Delta y \qquad (5b)$$

So, the decomposition of the environmental load **E** in equation 4 on the basis of the average of the polar decompositions is:

$$\Delta E = \tfrac{1}{2}\,(\Delta e\ L_1\ y_1 + \Delta e\ L_0\ y_0) + \tfrac{1}{2}\,(e_0\ \Delta L\ y_1 + e_1\ \Delta L\ y_0) + \tfrac{1}{2}\,(e_0\ L_0\ \Delta y + e_1\ L_1\ \Delta y) \qquad (5c)$$

In this way the change in environmental load is decomposed in three effects. The first term at the right hand side of equation 5c is the intensity effect, which measures the changes in emissions per unit of output for each sector. The second term is the input-output coefficient effect due to changes in the intermediate input structure and the third term concerns the final demand effect reflecting changes in demand.

The input-output coefficients effect and the final demand effect are further decomposed in order to investigate the import and export effects. This is described in the remainder of this section.

Decomposition of changes in the input-output coefficients

The input effect describes the changes in environmental load arising from changes in the input-output coefficients. Changes in input-output coefficients are among others the result of substitution between inputs or the more efficient use of inputs. Furthermore, the changes may result from substitution between domestic and imported inputs. In order to indicate the latter effect, the decomposition of the technological matrix is further worked out. The change in the Leontief inverse **L** depends on the change in the matrix of input-output coefficients **A**. We use the additive decomposition[2] of the Leontief inverse matrix (Rose and Casler, 1996):

$$\Delta L = (I - \Delta A)^{-1} \qquad (6)$$

The matrix of input-output coefficients concerns the inputs that are produced domestically. The technological matrix $\mathbf{A^t}$ concerns all input coefficients, thus including the imported input coefficients. So, each coefficient of the domestic input-output coefficients matrix is a fraction of the corresponding coefficient in the technological matrix. The matrix of input-output coefficients can be decomposed as follows:

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[2] The multiplicative decomposition of the relationship between the Leontief inverse and the matrix of input-output coefficients is: $\Delta L = L_0\ \Delta A\ L_1 = L_1\ \Delta A\ L_0$.

$$\Delta A = \Delta A^s \circ A^t + A^s \circ \Delta A^t \qquad (7)$$

The elements of $\mathbf{A^s}$ give for each coefficient of **A** (domestic coefficients) the share (fraction) in the corresponding coefficient of the technological matrix $\mathbf{A^t}$. The symbol '$\circ$' is the sign for the Hadamard product, which is the element-wise product for two matrices of the same dimensions. Now, the first term at the right hand side of equation 7 is the import effect concerning the intermediate inputs. The second term shows the technological effect.

Decomposition of changes in final demand

Final demand is the term used for economic demand categories like exports, (private and government) consumption and investments. The final demand matrix **Y** has dimensions i by j, where j is the number of final demand categories and i the number of sectors distinguished in the input-output table. In general, SDAs of environmental load in a certain region only consider domestically produced final demand. In this study we want to investigate the trade effect; is there a shift from domestically produced final demand to imported final demand or the other way around?

We distinguish four determinants in decomposing final demand. Changes in these determinants yield four types of determinant effects. These are respectively, the product mix effect, i.e. shifts in the mix of the i products consumed; the import effect, i.e. shifts between domestic and imported products; the category effect, i.e. shifts between the j final demand categories; and the final demand level effect, i.e. the effect of growth in the overall level of final demand. Equation 8 describes the decomposition:

$$\Delta Y = (\Delta Y^s \circ Y^m)\, y^c\, y^l + (Y^s \circ \Delta Y^m)\, y^c\, y^l + (Y^s \circ Y^m)\, \Delta y^c\, y^l + (Y^s \circ Y^m)\, y^c\, \Delta y^l \qquad (8)$$

The elements of matrix $\mathbf{Y^m}$, describing the mix of each final demand category, are based on the total final demand of an economy including imports. They are equal to the total final demand elements divided by their equivalent domestic column sums. So, in case of imported final demand for a final demand category, the column sum of the corresponding elements in matrix $\mathbf{Y^m}$ may be above 1. The elements of matrix $\mathbf{Y^s}$ describe for each element the share of the domestically produced demand in total demand. The elements of vector $\mathbf{y^c}$ indicate the share of each final demand category in final demand. Scalar $\mathbf{y^l}$, finally, represents total level of final demand. The symbol '$\circ$' is the sign for the Hadamard product again.

In our calculations we do not consider imported goods, which are re-exported without undergoing any procession. For the exports, therefore, we only have a domestic part and, as a consequence, all elements in the column of $\mathbf{Y^s}$ corresponding to exports are equal to 1.

Above the separate pieces of the model for the decomposition of the environmental load **E** were presented. The overall equation used in the decomposition analysis is:

$$E = e\,(I - A^s \circ A^t)^{-1}\,(Y^s \circ Y^m)\,y^c\,y^l \qquad (9)$$

The overall import effect is the sum of the effect of the changes in $\mathbf{A^s}$ and $\mathbf{Y^s}$. The import effect takes place both at production and demand. When the import effect is positive, emissions have risen because of a relative shift from imports in intermediate inputs and/or final demand to domestic production. In case of a negative import effect, emissions decreased arising from substitution of domestic production by imports. A negative import effect supports the PHH for developed countries (in case the extra imports are produced in developing countries). The import effect is not the same as the change in embodied environmental load of imports. If, e.g., level of final demand increases ceteris paribus, the embodied environmental load of imports increases too, but the import effect is zero. The import effect, as determined in this study, is therefore only a structural effect.

Besides the import effect we also defined an export effect. An export effect in accordance with the import effect would be the change in the share of the countries export in the world market. However, this share cannot be related to the environmental load in the country itself. Therefore, we defined the export effect as the change in the share in the national market. The export effect is the change in emissions caused by a shift in final demand between exports and domestic final demand. So, the export effect is equal to a category effect based on the shares of two final demand categories, viz. exports and domestic demand ($\mathbf{y^c}$). A positive export effect, indicating a rise in emissions, occurs when there is a shift to the final demand category with the most polluting structure. If the share of exports increases in final demand, emissions will rise when the structure of exports is less clean than the structure of domestic final demand. For developed countries this situation is not in line with the PHH. On the other hand, if the structure of exports is cleaner than the structure of domestic demand, a shift to exports will result in a decrease in emissions. The import effect and the export effect together form the trade effect. For developed countries, the PHH is falsified if the export effect is above the import effect.

An empirical application to the Netherlands

The decomposition method described (including trade effects) was applied to the Netherlands for the period 1990-2004. The effects were calculated on the basis of a decomposition of equation 9 by taking the averages of the outcomes for each effect in the polar decompositions (according to Dietzenbacher and Los, 1998). We investigated the trade effect for the following substances: CO_2, CH_4, N_2O, NH_3, NO_x and SO_2. Figure 1 shows the developments in the emissions of these substances in Dutch industries in the period 1990-2004. All substances except CO_2 decrease in emissions in this period. The study started from the view of production, so only emissions in production sectors were considered. Therefore, the figures include emissions from production sectors abroad (fisheries and transport sectors), but do not include direct emissions of Dutch inhabitants.

<Insert Figure 1>

For our application, we used 38 x 38 sector by sector input-output tables from the Dutch system of National Accounts (Statistics Netherlands, 2005). For each year in the period 1990-2004, we used the domestic table and the import table. According to imports we only considered the competitive imports; the value of the non-competitive imports was in the order of just 1-2% of total imports in the Netherlands in the period 1990-2004. Furthermore, we left out the imports that are re-exported again, since they have (in the calculations) no effect on emissions in Dutch industries. The aggregation level of 38 industries is determined by the aggregation level of emission data available for the substances under consideration. The emission data were derived from the Environmental Accounts which are integrated in the National Accounts (NAMEA). Use of the NAMEA has the advantage that the environmental data fit with the economic data of industries.

For all years, tables are available in both current prices and in prices of the previous year. For each year, we calculated the effects of the changes in the input-output table (in prices of the former year) compared to the tables of the previous year (in current prices). The effects for the period 1990-2004 are simply a summation of all year-to-year effects. In this way no deflation procedures over the whole period were required (De Haan, 2001).

<Insert Table 1>

Table 1 shows the results of the decomposition analysis. Efficiency changes, as expressed in lower emission intensities, decreased emissions of all substances substantially. Changes in structure both at production and final demand also decreased emissions by Dutch industries. These effects are (partly) cancelled out by the effects of economic growth. This level effect results in 26% (SO_2) up to 39% (CO_2) growth in emissions. The increase in demand is about 43% in 1990-2004, but due to different changes in emission intensities, the level effect differs over the substances (interaction effects).

According to the trade effect, import changes decreased emissions by shifting from domestic production to imports both for intermediate inputs as for final demand. This is in line with the PHH (as the Netherlands is a developed country). Contrary, emissions increased due to an export effect arising from a shift to exports in final demand. In the Netherlands, exports have a more polluting structure than domestic demand. This positive export effect is not in line with the PHH. The overall trade effect shows for all substances except CO_2 an increase of emissions. So, only for CO_2 the PHH is not falsified by the outcomes in this study.

<Insert Table 2>

Table 2 shows the outcomes of the decomposition analysis for CO_2 emissions at the level of industries. Only a few industries show large effects. E.g., the change in CO_2 intensity of the chemical industry contributes greatly to the change in CO_2 emissions by production. This decrease is cancelled out by an increase in emissions at the energy sector as a result of rising demand. This effect not only reflects the demand for electricity by end users, but it also reflects the intermediate demand for electricity. Other industries require more electricity for fulfilling their final demand which leads to more emissions in the electricity sector. The other substances show similar patterns in decompositions; for each substance the efficiency effect concentrated in one or two specific industries.

In this study, we are especially interested in trade effects. Although the trade effects at the level of individual industries are small there are some differences at the level of (more aggregated) sectors. Agriculture and manufacturing have a negative import effect on CO_2 emissions; by importing relatively more agricultural and manufactured goods, emissions in the Netherlands decrease. This decrease is (almost) neutralized by the shift to exports in final demand. Exports have a higher share of agriculture and manufacturing than domestic final demand. In the energy sector, the export effect enhances the import effect at electricity production. The trend of importing more electricity in the past period decreased Dutch CO_2 emissions. Trade and services show the same pattern. Both the import effect (importing relatively more services) and the export effect (a shift to more exports with a lower share of services) diminish CO_2 emissions in the Netherlands.

Table 3 shows the integrated trade effects for all industry-substance combinations. In agriculture, the trade effect resulted in a small increase in emissions of CH_4, N_2O and NH_3. Although emissions decreased with about 5-8% resulting from a shift to importing agricultural goods, export effects are even higher. For most manufacturing industries import and export effects are outweighed except for basic manufacturing (petroleum, chemical and metals) which have a relatively high share in exports. Furthermore, transport related emissions of NO_x and SO_2 increased as a result of the export effect in water transport. Overall, trade resulted in an increase in emissions in the period 1990-2004. This outcome gives no evidence for the PHH.

<Insert Table 3>

In order to test the robustness of the outcomes, we compared the 1990-2004 outcomes with the outcomes for the period 1990-2003 (see last two rows of table 3). The sign of the trade effect changes for two of the six substances and in this sense the outcomes seem to be less robust. The trade effect is the composite effect of two opposite effects, the import and export effect. The relative differences in these underlying effects for the two periods considered are smaller than for the composite effect. So, the outcomes of the individual effects (import and export effect) are rather robust. This is in line with Hoen and Mulder (2003) that also reports that the overall outcomes of separate effects are rather robust.

<Insert Figure 2>

Figure 2 shows, as an example, the decomposition for CH_4 emissions for the whole period 1990-2004. The figure shows that there are year-to-year fluctuations in emissions and effects which are probably caused by uncertainties in monitoring of economic and environmental processes. However, the effects over the whole period give evidence of a more robust character. The overall trade effect is both positive and negative in the period 1990 till 2004, but the fluctuations are rather small. This confirms the suggestion that the export effects outweighs the import effects.

Discussion and conclusions

This study elaborated a structural decomposition analysis in order to find evidence for the PHH for the Netherlands. Little evidence was found for the hypothesis that emissions in the Netherlands decreased resulting from shift from industries to other countries. For most substances, decreases in emissions resulting from import substitution in intermediate inputs and demand were cancelled out by a shift in final demand to relatively more polluting exports. Only for CO_2, which is the only substance considered for which emissions increased in the period 1990-2004 (figure 1), a small decrease in emissions was found due to the trade effect. However, considering uncertainties in emission monitoring, the effects are too small to draw hard conclusions.

The calculations were carried out at the level of 38 industries. It may be that the aggregation level of the industries is too high to find a trade effect. In case the more polluting industries within an industry move to abroad it is not recognized as a structure effect, but as an intensity effect. However, the outcomes are in line with studies for other countries that did not find evidence for the PHH either. In fact, pollution abatement and prevention costs are relatively small in operating costs for firms (Eskeland and Harrison, 2003). Other factors seem to be more important for companies in location decisions, e.g. labour costs, political stability and the size of the domestic market.

The study shows that Dutch emissions decreased due to substitution in intermediate inputs and demand by imports. Further research into the countries of origin of these imports and the eco-efficiency of the industries concerned should show the overall effects of this substitution. Only in case the extra imports are produced in developing countries there may be evidence for the PHH. The same holds for the shift to exports in final demand. When it is clear which foreign production is replaced with the Dutch exports, overall effects can be determined.

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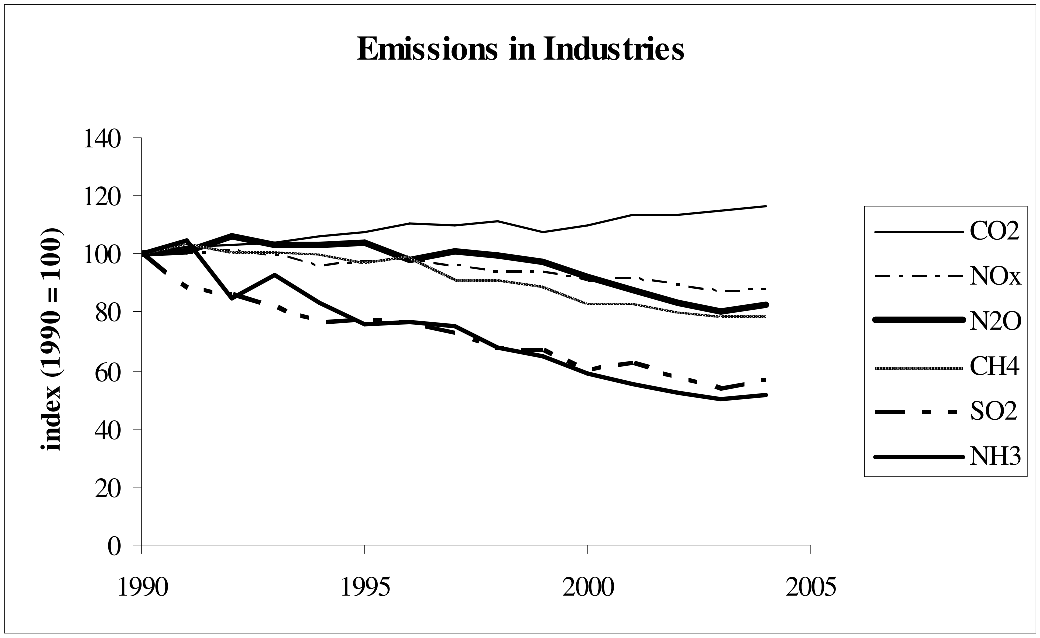

Figure 1 Development in emissions in Dutch industries in the period 1990-2004.

Table 1 Decomposition of changes in emissions in Dutch industries, 1990-2004 (as percentage of the total amount emitted by all industries in 1990).

	Efficiency Effect	Import Effect Production	Structure Effect Production	Import Effect Demand	Export Effect Demand	Structure Effect Demand	Level Effect Demand	Total
CO_2	-19.1	-4.4	2.2	-1.6	5.5	-4.7	38.8	16.7
CH_4	-37.6	-8.6	-8.3	-1.5	10.1	-9.3	33.5	-21.5
N_2O	-41.2	-8.2	-5.7	-2.5	12.2	-6.9	35.2	-17.1
NO_x	-42.4	-3.8	-0.1	-1.2	6.9	-5.8	34.1	-12.2
SO_2	-64.7	-2.1	-0.1	-0.5	8.1	-10.2	26.2	-43.2
NH_3	-59.9	-6.2	-10.5	-1.7	8.8	-5.8	26.7	-48.6

Table 2 Decomposition of changes in CO_2 emissions, 1990-2004 (as percentage of the total amount emitted by all industries in 1990).

	Efficiency Effect	Import Effect Production	Structure Effect Production	Import Effect Demand	Export Effect Demand	Structure Effect Demand	Level Effect Demand	Total
Agriculture and forestry	-1.7	-0.5	-0.9	-0.1	0.8	-0.7	2.4	-0.7
Fishing	-0.1	-0.2	-0.1	-0.1	0.1	-0.1	0.3	-0.2
Crude petroleum and natural gas production	0.0	-0.3	0.1	0.0	0.1	-0.2	0.5	0.2
Other mining and quarrying	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.3
Manufacture of food products, beverages and tobacco	-0.5	-0.2	-0.1	-0.2	0.3	-0.4	1.2	0.0
Manufacture of textile and leather products	0.0	0.0	0.0	0.0	0.0	-0.1	0.1	0.0
Manufacture of paper and paper products	-0.6	-0.1	0.0	-0.1	0.1	-0.1	0.4	-0.4
Publishing and printing	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Manufacture of petroleum products	-1.1	0.0	0.1	0.1	1.2	-2.4	3.1	0.9
Manufacture of chemicals and man-made fibers	-8.2	-1.3	0.3	-0.4	2.0	-0.5	4.4	-3.5
Manufacture of rubber and plastic products	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Manufacture of basic metals	-1.9	-0.4	-0.1	0.0	0.7	-0.5	1.8	-0.3
Manufacture of fabricated metal products	-0.7	0.0	0.0	0.0	0.0	-0.1	0.2	-0.6
Manufacture of machinery and equipment n.e.c.	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Manufacture of electrical and optical equipment	0.1	-0.1	0.0	0.0	0.0	0.0	0.1	0.2
Manufacture of transport equipment	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Recycling	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Manufacture of wood and wood products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Manufacture of other non-metallic mineral products	-0.6	0.0	0.0	-0.1	0.0	-0.3	0.7	-0.5
Other manufacturing	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Electricity, gas, steam and hot water supply	1.0	-0.6	1.4	-0.4	-0.9	-0.5	11.6	11.7
Collection, purification and distribution of water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Construction	0.0	0.0	0.0	0.0	-0.1	-0.1	0.3	0.1
Trade and repair of motor vehicles/cycles	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.2
Wholesale trade	0.0	0.0	0.1	0.0	0.0	0.1	0.3	0.5
Retail trade, hotels, restaurants and repair	0.0	0.0	-0.2	0.0	0.0	0.1	0.5	0.4
Land transport	-0.1	-0.1	-0.1	0.0	0.1	-0.3	1.9	1.4
Water transport	-1.0	-0.2	-0.3	0.0	0.8	-0.7	1.8	0.4
Air transport	-2.8	-0.2	0.3	-0.1	0.9	1.4	2.6	2.2
Supporting transport activities	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Business activities and telecommunications	-0.3	-0.2	0.3	-0.1	-0.1	0.5	0.9	1.2
Public administration and social security	-1.4	0.0	0.0	0.0	-0.2	-0.1	0.8	-1.0
Subsidized education	0.1	0.0	0.0	0.0	-0.1	0.0	0.2	0.2
Health and social work activities	0.0	0.0	0.0	0.0	-0.1	0.1	0.4	0.5
Sewage and refuse disposal services	-0.3	-0.1	1.5	0.0	-0.2	0.1	1.3	2.2
Other services	0.2	0.0	0.0	0.0	-0.1	0.1	0.3	0.5
Trade and transport margins	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other goods and service n.e.c.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**-19.1**	**-4.4**	**2.2**	**-1.6**	**5.5**	**-4.7**	**38.8**	**16.7**

Table 3 Decomposition of changes, trade effects for 1990-2004 and 1990-2003 (as percentage of the total amount emitted by all industries in 1990).

	CO_2	CH_4	N_2O	NO_x	SO_2	NH_3
Agriculture and forestry	0.1	1.4	1.1	0.1	0.0	0.9
Fishing	-0.2	0.0	0.0	-0.8	-0.4	0.0
Crude petroleum and natural gas production	-0.2	-1.1	0.0	-0.1	0.0	0.0
Other mining and quarrying	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of food products, beverages and tobacco	-0.1	0.0	0.0	0.0	0.0	0.0
Manufacture of textile and leather products	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of paper and paper products	0.0	0.0	0.0	0.0	0.0	0.0
Publishing and printing	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of petroleum products	1.2	0.0	0.0	0.5	3.1	0.0
Manufacture of chemicals and man-made fibers	0.3	0.1	0.9	0.2	0.3	0.1
Manufacture of rubber and plastic products	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of basic metals	0.4	0.0	0.0	0.1	0.3	0.0
Manufacture of fabricated metal products	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of machinery and equipment n.e.c.	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of electrical and optical equipment	0.0	0.0	-0.1	0.0	0.0	0.0
Manufacture of transport equipment	0.0	0.0	0.0	0.0	0.0	0.0
Recycling	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of wood and wood products	0.0	0.0	0.0	0.0	0.0	0.0
Manufacture of other non-metallic mineral products	-0.1	0.0	0.0	-0.1	-0.1	0.0
Other manufacturing	0.0	0.0	-0.1	0.0	0.0	0.0
Electricity, gas, steam and hot water supply	-1.9	0.0	0.0	-0.6	-0.4	0.0
Collection, purification and distribution of water	0.0	0.0	0.0	0.0	0.0	0.0
Construction	-0.1	0.0	0.0	-0.1	0.0	0.0
Trade and repair of motor vehicles/cycles	0.0	0.0	0.0	0.0	0.0	0.0
Wholesale trade	0.0	0.0	0.0	0.0	0.0	0.0

Retail trade, hotels, restaurants and repair	-0.1	0.0	0.0	0.0	0.0	0.0
Land transport	0.0	0.0	0.0	0.0	0.0	0.0
Water transport	0.6	0.0	0.0	3.1	3.0	0.0
Air transport	0.7	0.0	0.0	0.7	0.1	0.0
Supporting transport activities	0.0	0.0	0.0	0.0	0.0	0.0
Business activities and telecommunications	-0.3	0.0	0.0	-0.4	0.0	0.0
Public administration and social security	-0.2	0.0	0.0	-0.3	-0.2	0.0
Subsidized education	-0.1	0.0	0.0	0.0	0.0	0.0
Health and social work activities	-0.1	0.0	-0.1	0.0	0.0	0.0
Sewage and refuse disposal services	-0.3	-0.2	-0.2	-0.1	0.0	0.0
Other services	-0.1	0.0	0.0	0.0	0.0	0.0
Trade and transport margins	0.0	0.0	0.0	0.0	0.0	0.0
Other goods and service n.e.c.	0.0	0.0	0.0	0.0	0.0	0.0
Total 1990-2004	**-0.5**	**0.1**	**1.5**	**1.9**	**5.6**	**0.9**
Total 1990-2003	**-0.4**	**-1.6**	**0.7**	**1.4**	**4.9**	**-0.3**

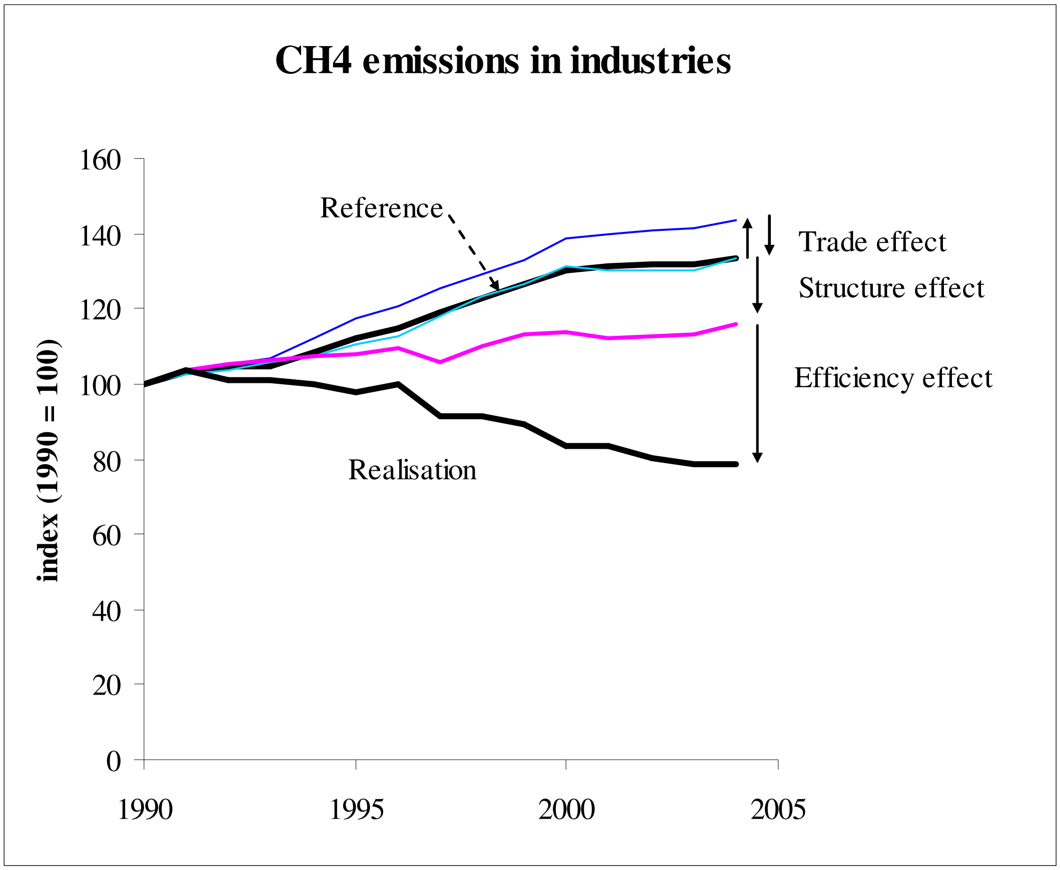

Figure 2 Change in CH_4 emissions decomposed in a level effect (reference line), a trade effect, a structure effect and an efficiency effect.