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Explaining Dutch emissions of CO_2; a decomposition analysis

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Abstract

Decomposition of CO_2 data of the Netherlands shows that much progress has been made with reduction of CO_2 emissions by changing to less CO_2 intensive technologies. Demand also shifted to more products that are produced with less CO_2 emission. Further, shifts in the inputs needed in the production process also managed to decrease the CO_2 emissions. These effects, however, were more than compensated by increased CO_2 emission due to economic growth. Especially growth in exports led to substantial more CO_2 emissions. Consequently, emissions of CO_2 remain a persistent environmental problem in spite of large improvements in the field of energy efficiency and carbon content of energy use. Policy measures affecting marginal costs of 'dirty' products, like an international system of emissions trading, could affect the demand for these products, and hence decrease emissions efficiently. A different policy may affect the Dutch competitive position, since the emission of CO_2 is closely related to exports. In any way, action needs to be taken since the analysis suggests that otherwise the aims of the Kyoto-protocol may not be reached.

Keywords: input-output analysis, decomposition analysis, indirect effects, CO_2 emission, climate policy

JEL classification: C67 Q48 Q49 R15

1 Introduction

In 1997 many countries, including the European Union, signed the Kyoto treaty. According to the agreement made within the European Union, the emissions of greenhouse gases in the Netherlands in the years 2008-2012 should be on average 6% below the level of 1990. However, the emissions of CO_2, which is the main greenhouse gas, still show an increasing pattern. Part of this increase will be compensated by a decline in the emissions of other gases. Projects abroad by means of the Kyoto mechanisms Joint Implementation (JI) and Clean Development Mechanism (CDM) will also contribute to the realisation of the Dutch climate goal. The effectiveness of these projects is however doubtful. In addition, the Dutch government decided to realise at least 50 percent of the reductions domestically. As a consequence, the inland emissions of CO_2 remain important for the achievement of the Dutch Kyoto obligation.

Adequate information regarding the sources of these emissions will contribute to the effectiveness of policies to reduce them. Which sectors do emit large volumes of carbon dioxide? Which sectors are responsible for these emissions? What is the contribution of factors like carbon intensity and growth of output to the emissions of a particular sector? This paper addresses these questions.

The first question is easier to answer than the question as to who is responsible for the emission. For example, if the electricity sector produces CO_2 in order to satisfy the demand for electricity of another sector, both sectors are at least for a part responsible for the emission. Likewise, both sectors are able to decrease the amount of CO_2 emitted in this case. Electricity companies can switch to new technologies or less CO_2 intensive inputs to generate electricity, while electricity consuming firms can adopt technologies which decrease the use of power.

This paper contributes to the existing analyses of the emission of CO_2 by analysing which sectors are responsible (directly and indirectly) for the emission and by quantifying the magnitude of the theoretical factors expected to influence the emission. These factors generally include a scale effect, a technological effect and an composition effect. In order to find out who and what causes CO_2 emission, this paper uses two methodologies, both based on input-output analysis. First, the direct and indirect emissions of each sector are analysed in order to answer the question who emits the CO_2 and for whom this CO_2 was emitted. Afterwards, we analyse which factors contributed in which sectors to changes in the emission of CO_2. In this respect, we distinguish the following factors: level of emissions per unit of output (called ‘emission coefficient’, this is the intensity effect), mix of inputs in the production process (together with the intensity effect this is the technological effect), composition of final demand (the composition effect), and the level of final demand (the scale effect). This analysis is called decomposition analysis.

We focus our analysis on the emissions of CO_2 and ignore the other greenhouse gasses, because the former is the most important greenhouse gas showing an increasing pattern while the level of the other gases is declining. Another demarcation of the research is that we ignored emissions of consumers due to the fact that the decomposition method enables only analysis of producers.

The structure of the paper is as follows. Section 2 describes the goals set in the Kyoto protocol for the Netherlands. Then, Section 3 describes the method used to compute the effects of several factors on the emission of CO_2, and Section 4 describes the data used in the analysis. The results of the analyses are discussed in Section 5. Section 6 concludes and compares the outcomes with the goals and the instruments of the climate change policy.

2 The Kyoto protocol

In 1997, the European Union (EU) became a party to the Kyoto protocol. The EU committed itself to reduce its emissions of greenhouse gases by on average 8 percent in the years 2008-2012 compared to the level of 1990. The member states of the EU allocated this common obligation to the separate countries. For the Netherlands, the outcome of this allocation was that the average emission of greenhouse gasses in the years 2008-2012 has to be at least 6% lower than the emission in 1990, which comes down to an emission of 199 Mtonnes (millions of kilograms) CO_2 equivalents. Since the expected emission in 2010 is 239 Mtonnes CO_2 equivalents, the emission has to be reduced by 40 Mtonnes. The EU countries agreed that the reduction achieved abroad may be at most 50% percent of the total reduction. Further, about 30% of the reduction will be achieved by reducing the emission of non-CO_2 greenhouse gasses. All in all, this means that the domestic reduction of emission of CO_2 gas in the Netherlands has to be at least 8 Mtonnes compared to the base line scenario.[1] Domestic emissions of CO_2 are however allowed to rise in comparison to the 1990-level. Since the emission of CO_2 in 1990 was 212 Mtonnes whereas the average emission in the years 2008-2012 may not be higher than 231 Mtonnes, an increase of on average almost 1 Mton per year is the maximum increase allowed.

Between 1995 and 2000, the emission of greenhouse gasses has increased. Since the emission in 1995 was already higher than the emission in 1990, goals set by the government to reach the 1990 level in the year 2000 were not met. Furthermore, most progress was made by the reduction of the emission of non-CO_2 greenhouse gasses whereas the emission of CO_2 increased substantially. These developments raise doubt about the possibilities to reach the targets in the Kyoto protocol. In order to see whether they can still be reached and where policy may have the most effect, this paper analyses which factors caused the emission of CO_2 to increase and which factors decreased the CO_2 emission. Answering this question gives insights in the effects of policy measures and may help to develop new policy to reach the Kyoto goals.

[1] Since 50% of the emission reduction can be reached with projects abroad and 30% by decreasing the emission of non-CO2 gasses, only 20% of the reduction has to take place by actually reducing the emission of CO2. The total emission reduction was estimated to be 40 Mtonnes, hence 20% of this figure amounts to an actual reduction of 8 Mtonnes. The figures in this section are obtained from Ministry of Housing, Spatial Planning and Environment (2002).

3 Decomposition methods

The questions put in the section above will be answered by a decomposition analysis, which shows how much changes in certain factors contributed to changes in a specific variable. Decomposition analyses are widely used in energy studies; Ang (1995) provides an extensive literature review. Hoekstra and Van den Bergh (2003) summarise fundamental differences between different decomposition methods. The most important difference shows the existence of two different types of methods: Index Decomposition Analysis (IDA) and Structural Decomposition Analysis (SDA). The main difference between these two methods is the model used: SDA uses a full input-output table, whereas IDA uses indexes, generally computed at a sectoral level. Due to the data it uses, SDA is able to include technological effects and indirect effects. However, since the data are more difficult to obtain, IDA is more easy to apply and better capable of using more refined methods and more detailed data.

Generally, decomposition analyses use sectoral time data to explain which factors contributed how much to the total change in a certain variable. For example, increases in the emission of CO_2 can be attributed to increased energy levels, increased emission per unit of energy generated and changes in the composition of the produced goods in a country. Some studies, however, use the methodology in a different approach. Sun (1999) does not use sectoral data, but uses country data. Hence, he cannot compute the composition effect of the goods produced in the countries, but since he includes many countries his analysis includes a large part of world-wide emissions and he can analyse the consequences of shifts in the production of certain goods between countries. To reduce the level of CO_2 emissions, a country can simply start importing goods that cause a lot of the emissions. Although this reduces the emissions of a country, the world as a whole will not be better off. Analyses that focus on one country may suffer from this drawback; an intercountry study as the one of Sun (1999) does not have this disadvantage and even enables the analysis of the consequences of such shifts.

Another way to include intercountry effects is by substituting the time-dimension for a region-dimension. Schipper, Murtishaw, and Unander (2001) use sectoral data of different countries. This analysis shows how differences in countries lead to different levels of emissions, which may open the possibility to get the best of all worlds and reduce the levels in all countries by adapting the factors (such as technologies) which lead to lowest emissions. Luukkanen and Kaivo-oja (2002) include all dimensions: they analyse changes over time in sectoral data of several countries. Since the decomposition method is not suited to include three dimensions, they can only compare the outcomes of each country without analysing the reasons for the differences between countries.

An important difference, also recognised by Hoekstra and Van den Bergh (2003), between decomposition methods is whether or not they are complete. An incomplete method does not assign the entire change in a variable to the factors included in the analysis. The result is a residual which sometimes is substantial. For most methods, a revised version can be derived which attributes the residual to the other factors and turns an incomplete method into a complete method (see, e.g., Ang and Choi, 1997). Zhang and Ang (2001) apply several (complete and incomplete) decomposition methods to the same data. They choose an intercountry approach instead of a, more usual, intertemporal approach, which generally worsens the problem of the residual since intercountry data have greater variation than intertemporal data. Indeed, they find that for a specific incomplete method "the results (…) contain residuals that are so large that this effectively makes the method unsuitable for cross-country / region decomposition analysis" (Zhang and Ang, 2001, p. 185). Although the residuals of an other incomplete method are much smaller, they remain considerable. The comparison of different methods shows that they lead to different outcomes. However, the methods do find the same order of importance of the different factors and they generally (although not always) agree on the signs of the factors.

There has been some debate in decomposition analyses referring to the emission of CO_2 as to whether the actual emission of CO_2 or energy intensity should be the variable that is decomposed (Ang, 1999). Both variables are important for understanding the developments in the emission of CO_2. New technologies may change the energy intensity in production process as well as the CO_2 intensity of energy, although the former may be more likely than the latter. Since our focus will be on technological changes and whether or not these changes happen fast enough to reach the Kyoto goals, we choose a specification that will fit our need best. The Kyoto goals are stated in terms of CO_2 emission. Therefore, we choose a method that uses the emission of CO_2 as the prime variable, and we include the effects of changes in energy intensity in one of the explanatory factors.

This brings us to the question of which factors we want to include in the analysis and what specification we choose. Clearly, the nature of the problem we want to analyse is intertemporal: it tries to explain which factors and sectors contributed to changes in the emission over time for one country (The Netherlands). As mentioned above, we want to explicitly include the effects of technological changes. Further, we want to include the effects of economic growth, since most analyses show that this factor is responsible for most of the changes in CO_2 emission (see, e.g., Sun, 1999, Schipper, Murtishaw, and Unander, 2001, Albrecht, J., D. François, and K. Schoors, 2002). Many theoretical analyses also distinguish these two effects, together with a third effect, the composition effect. For example, Copeland and Taylor (2001) use a scale effect, a composition effect and a technique effect in explaining the growth of pollution. They define the scale effect as the factor that "measures the increase in pollution that would be generated if the economy were simply scaled up, holding constant the mix of goods produced and production techniques" (p. 38), and the composition effect as "the change in the share of the dirty good in national income" (p. 38). The technique effect measures the effect of changes in the intensity coefficients, since "(h)olding all else constant, a reduction in the emission intensity will reduce pollution". These three effects can be quantified empirically by applying an SDA. We are aware, however, that the exact specification of the SDA influences the results. In order to neutralise this effect, we choose a complete method that leads to results which are most likely to be close to the average of several different decomposition methods (Dietzenbacher and Los, 1998).

The general form of an SDA is described by, among others, Skolka (1989). The principle can best be described by a relation with two factors, but it is easily extended to more factors. Suppose that a variable x depends on two variables L and f in a multiplicative relation:

$$x = Lf \tag{3.1}$$

Changes in variable x can now be expressed as follows:

$$\Delta x = x_{t+1} - x_t = L_{t+1}f_{t+1} - L_t f_t = \Delta L f_t + L_{t+1}\Delta f \tag{3.2}$$

Which shows how much changes in variables L and f contributed to changes in variable x. This relation, however, is not unique, since it can also be written as

$$\Delta x = x_{t+1} - x_t = L_{t+1}f_{t+1} - L_t f_t = \Delta L f_{t+1} + L_t\Delta f \tag{3.3}$$

or as

$$\Delta x = x_{t+1} - x_t = L_{t+1}f_{t+1} - L_t f_t = \Delta L f_{t+1} + L_{t+1}\Delta f - \Delta L\Delta f \tag{3.4}$$

or as

$$\Delta x = x_{t+1} - x_t = L_{t+1}f_{t+1} - L_t f_t = \Delta L f_t + L_t\Delta f + \Delta L\Delta f \tag{3.5}$$

The last factor in the last two equations is interpreted as an interaction effect. The main differences between the decomposition equations are the weights of the factors and the interaction effect. The first two equation show inconsistent weights, since one factor is weighted with year *t*+1 and the other factor with year *t*. The last two methods have consistent weights, but they also have interaction effects. If the number of factors increases, the number of possible decomposition methods increases even further. Although theoretically none of the methods is preferred to the other methods, the outcomes may differ substantially. To solve this problem, usually an average of several methods is used. Dietzenbacher and Los (1998) try several methods and averages of these methods. They find that the average of two special cases, the so-called polar decomposition methods, are close to the overall results. Since this method keeps the number of necessary computations within reasonable limits and is likely to lead to meaningful results, this paper will also use the average of the polar decomposition methods.

A polar decomposition method is an equation in which all weights on the right hand side of each factor are from the same year, and all weights on the left hand side of each factor are from the other year. In the example with only two factors above, the first two possibilities are the polar decomposition methods.

The analysis of the CO_2 emission in this paper is based on SDA, which uses input-output tables to separate the effects of economic growth from technological effects on changes in CO_2-emission. Both factors are relevant for climate change policy: economic growth is often named as the most important reason why the emission of greenhouse gasses keeps increasing, and technological changes are often suggested for decreasing the emissions (see, *e.g.*, Ministry of Housing, Spatial Planning and Environment, 2002). Therefore, the derivation of the decomposition equation starts with the input-output model. Input output analysis establishes a direct relation between total output and final demand[2]:

$$x = Lf, \tag{3.6}$$

in which

x = a vector with total output per sector,

L = the Leontief inverse matrix,

f = a vector with total final demand per sector.

The Leontief inverse is calculated as

$$L = (I - A)^{-1} \tag{3.7}$$

in which

I = an identity matrix

A = the matrix with inputcoefficients: each element a_{ij} denotes total intermediate deliveries from sector *i* to sector *j* divided by total output of sector *j*, and can be interpreted as the amount of product *i* needed to produce one unit of the product of sector *j*.

The columns with input coefficient are often interpreted as the technology to produce the product of the sector belonging to the column. Hence, changes in this matrix can be interpreted

[2] For a description of input-output analysis, the reader is referred to Miller and Blair (1985).

as technological changes. They may, however, also denote outsourcing or substitution of domestic production for imports.

The vector with total final demand, f, is often written as a matrix, F, with final demand split up in certain categories, usually private consumption, government consumption, investments, and exports. The row totals of this matrix correspond to the vector with total final demand. There is another way to obtain the vector with total final demand from the matrix with final demand per category. First, divide the elements of F by their column totals:

$$\mathrm{B} = \mathrm{F}\hat{\mathrm{y}}^{-1} \qquad (3.8)$$

where a ^ above a variable indicates a matrix with the elements of the vector on its main diagonal and zeroes everywhere else, and

B = matrix with final demand coefficients,

y = vector with total final demand per category.

Then

$$\mathrm{f} = \mathrm{By} \qquad (3.9)$$

With the use of this relation, total output can be computed as

$$\mathrm{x} = \mathrm{LBy} \qquad (3.10)$$

The relation between CO_2 and input-output analysis can be achieved by expressing the emission of CO_2 per unit of total output:

$$\mathrm{c}' = \mathrm{co}_2{}'\,\hat{\mathrm{x}}^{-1} \qquad (3.11)$$

in which a ` indicates a row vector instead of a column vector, and

co_2 = vector with emission of CO_2 per sector,

c = vector with emission of CO_2 per sector divided by total output of that sector.

Total emission of CO_2, co_2, can be obtained by summing over all sectors, or as

$$co_2 = \mathrm{c}'\,\mathrm{x} = \mathrm{c}'\,\mathrm{LBy} \qquad (3.12)$$

With the last equation, changes in the total emission of CO_2 can be attributed to changes in the factors c, L, B and y. Although changes in the input coefficient matrix can be interpreted as technological changes, changes in the Leontief inverse are more difficult to interpret. Therefore, the Leontief inverses of periods *t* and *t*+1 are rewritten according to the following equations:

$$L_{t+1} = L_{t+1}(I - A_t)L_t = L_t(I - A_t)L_{t+1} \tag{3.13}$$

and

$$L_t = L_{t+1}(I - A_{t+1})L_t = L_t(I - A_{t+1})L_{t+1} \tag{3.14}$$

With these equation, the first polar decomposition expresses the relation as

$$\Delta co_2 = \Delta c' L_t B_t y_t + c_{t+1}' L_{t+1}\ \Delta A\ L_t B_t y_t + c_{t+1}' L_{t+1}\ \Delta B\ y_t + c_{t+1}' L_{t+1} B_{t+1} \Delta y \tag{3.15}$$

and the second polar decomposition becomes

$$\Delta co_2 = \Delta c' L_t B_t y_t + c_{t+1}' L_{t+1}\ \Delta A\ L_t B_t y_t + c_{t+1}' L_{t+1}\ \Delta B\ y_t + c_{t+1}' L_{t+1} B_{t+1} \Delta y \tag{3.16}$$

The average of these two methods yields the final equation of the decomposition method that will be used in the analysis:

$$\begin{aligned} &\Delta co_2 \\ &= \tfrac{1}{2}\Delta c\left(L_{t+1} B_{t+1} y_{t+1} + L_t B_t y_t\right) \\ &+ \tfrac{1}{2}\left(c_{t+1} L_{t+1}\ \Delta A\ L_t B_t y_t + c_t L_t\ \Delta A\ L_{t+1} B_{t+1} y_{t+1}\right) \\ &+ \tfrac{1}{2}\left(c_{t+1} L_{t+1}\ \Delta F\ B_t + c_t L_t\ \Delta F\ B_{t+1}\right) \\ &+ \tfrac{1}{2}\left(c_{t+1} L_{t+1} B_{t+1} + c_t L_t B_t\right)\Delta y \end{aligned} \tag{3.17}$$

This equation expresses the change in the emission of CO_2 as the result of four factors, respectively:

- changes in CO_2 intensity (emission coefficients)
- changes in input coefficients
- changes in the composition of final demand
- changes in the level of final demand (economic growth)

The first factor denotes the effects of technological changes that changed the emission of CO_2 per unit of output. The second factor denotes the effects of technological changes that change the products needed as inputs in the production process of a certain sector. It reflects how much the emission of CO_2 decreased due to a shift from CO_2 intensive inputs to CO_2 extensive inputs. However, this factor also reflects changes based on outsourcing and import substitution. The third factor denotes the effects on the emission of CO_2 due to changes in the composition of final demand. If final demand of CO_2 extensive inputs increased relative to demand of CO_2 intensive products, it shows a decrease in the total emission of CO_2, even if final demand of both sorts of products went up, since it only takes account of the composition of final demand. The effects of the level of final demand are denoted by the last factor.

4 Description of the data

The analysis uses input-output tables of 1995 and 2000. The data are obtained from the National Accounts of the Dutch national statistical office (Statistics Netherlands, 2002). The original 1995 table is issued at 105 sectors. Since CO_2 emission data are issued at 36 sectors, the original tables were aggregated to these sectors. The transport and trade margins were added as the 37th sector. Since there are no emission data of this sector, the analysis starts with an emission by this sector of zero. Appendix A describes the aggregation scheme and the sector classification of the 37 sectors used in the analyses.

Statistics Netherlands issues all data in current prices and in prices of the former year. A series of these data for all years between 1995 and 2000 was used to express the 2000 table in 1995 prices with the use of chain indices. Since this deflation method yields inconsistent results with respect to the totals (totals deflated in this way differ from the aggregation of the deflated elements), the totals were recomputed by aggregating the deflated elements in the input-output tables. The figures for imports were aggregated with the import duties, subsidies and taxes. Then, deflated value added was computed as the difference between the row total of a sector, the total of the intermediate deliveries in its column and its imports. The figures for final demand were aggregated into four categories: private consumption, government consumption, investments and exports, according to the scheme in Appendix A. Deflation took place at the most disaggregated level, after which the data were aggregated to the 37 sectors.

Finally, two changes were made to the input-output table. First, for statistical reasons the transport and trade margins are recorded as final demand and primary costs. However, since these margins have important economic feedback effects, they should be included in the intermediate deliveries for the current analysis. The total of this sector is zero, which is caused by a negative main diagonal element equal to the total of all other elements in the row or column. Since this is unwanted in input-output analysis, the element on the main diagonal was put to zero. Second, the sector 'Electricity Supply' has a very high delivery to itself. Statistics Netherlands explained that this element contains the deliveries of all generated electricity to the electricity distribution sector, which delivers it to other sectors. However, in the input-output table the sectors Electricity Supply and Electricity Distribution are aggregated, by which all electricity is counted twice and ends up in the main diagonal element of the electricity sector. This large element leads to an overestimation of the use of electricity by the electricity sector. According to figures of Statistics Netherlands, the element should be about 5% of the current value. Hence the main diagonal element of the sector 'Electricity Supply' was divided by 20 for both 1995 and 2000.

Finally, it is important to note that the figures of the emission of CO_2 are not yet final. They are estimates of Statistics Netherlands and will possibly change in future editions of the National Accounts. Former experiences with similar data allow for safely assuming that the conclusions of the analysis are robust to these changes.

5 Empirical results

Table 5.1 shows some basic features of the emission of CO_2 per sector. The second column indicates how much Mtonnes CO_2 each sector emitted in 2000 (the first column contains the names of the sectors). Not surprisingly, most CO_2 is emitted by the electricity sector, transportation, the oil industry and the chemical industry. Column three of Table 5.1 shows the emission figures divided by total output of the sectors. Although Fishery now has the first place, the list does not change much. Again, the electricity sector, transportation, the oil industry and the chemical industry have most CO_2-emission. Much of the emission of these sectors was done in order to produce intermediate goods. Hence, although the sectors did emit the CO_2, the emission took place in order to enable another sector to produce its product. For example, electricity used by a farmer causes CO_2 emission by the electricity sector for the agricultural sector. Indirectly, agriculture can be held responsible for this emission. Total CO_2 emission may decrease if the buying sectors use inputs with low CO_2 emissions instead of inputs with high CO_2 emission.

Input-output tables allow for the computation of indirect effects. These indirect effects are included in the elements of the Leontief inverse. If demand for the product of a certain sector increases, the initial increase in total output of an economy is this increase in final demand. However, to produce the extra demand, the sector needs intermediate inputs produced by other sectors, which increases the demand of other sectors as well. This is called the direct effect of the initial increase in demand. In order to produce the intermediate inputs of the direct effect, these sectors also need inputs, which further increases demand, and so on. These effects are the indirect effects. The direct effect of the increase in demand can be seen in the columns of the matrix with input coefficients. The direct and indirect effects are included in the Leontief inverse: an element l_{ij} of the Leontief inverse denotes the total increase in total output of product *i* if the final demand of product *j* increase by exactly one unit. Hence, a column sum of the Leontief inverse denotes the increase in total output of the entire economic system due to an increase in final demand of product *j* by exactly one unit. This is also known as the backward total output multiplier of sector *j*. Since the vector c contains the emission per total output of each sector, the vector c'L denotes the total extra emission of CO_2 in the economic system, directly and indirectly, due to the increase in final demand of sector *j* with one unit. These figures are denoted in the fourth column of Table 5.1.

Table 5.1 Basic emission data, 2000, prices of 1995

Sector	CO_2 emission *by* sectors	CO_2 emission / total output	Indirect CO_2 emission / final demand	CO_2 emission *for* sectors
	Mtonnes	kg / guilder	kg / guilder	Mtonnes
Agriculture and foresty	8.9	0.19	0.35	7.6
Fishing	2.7	2.89	3.01	2.3
Crude petroleum and natural gas production	1.9	0.10	0.12	1.1
Other mining and quarrying	0.3	0.15	0.27	0.3
Manufacture of food products, beverages and tobacco	4.6	0.05	0.18	12.7
Manufacture of textille and leather products	0.4	0.04	0.11	0.8
Manufacture of paper and paper products	2.0	0.17	0.25	1.7
Publishing and printing	0.3	0.01	0.05	0.5
Manufacture of petroleum products	12.0	0.67	0.74	8.9
Manufacture of chemical products	22.2	0.33	0.45	23.6
Manufacture of rubber and plastic products	0.3	0.02	0.11	0.8
Manufacture of basic metals	6.5	0.49	0.62	5.1
Manufacture of fabricated metal products	0.8	0.03	0.13	1.8
Manfacture of machinery n.e.c.	0.4	0.01	0.07	1.5
Manufacture of electrical equipment	0.4	0.01	0.06	1.8
Manufacture of transport equipment	0.3	0.01	0.06	1.5
Recycling industries	0.4	0.23	0.38	0.2
Manufacture of wood and wood products	0.2	0.03	0.09	0.1
Manufacture of construction materials	3.0	0.23	0.34	1.1
Other manufacturing	0.2	0.02	0.07	0.9
Electricity supply	48.0	1.91	2.00	22.9
Gas and water supply	0.0	0.01	0.09	0.2
Construction	1.8	0.02	0.09	6.0
Wholesale trade	0.7	0.03	0.07	0.6
Retail trade, repair (excl motor vehicles)	2.1	0.02	0.06	0.5
Hotels and restaurants	2.4	0.03	0.10	2.1
Land transport	8.3	0.29	0.36	4.5
Water transport	7.4	0.79	0.85	7.0
Air transport	12.0	0.83	0.91	10.1
Supporting transport activities	0.4	0.02	0.16	2.3
Financial, business services and communication	4.2	0.01	0.04	6.3
Public administration and social security	3.0	0.03	0.11	8.5
Educaton	0.9	0.03	0.06	2.0
Health and social work activities	1.6	0.02	0.07	4.2
Sewage and refuse disposal services	6.6	0.55	0.81	1.7
Other services	1.1	0.02	0.09	2.5
Trade and transport margins	0.0	0.00	0.11	12.6
Total	168.1	0.10	0.17	168.1

Source: Statistics Netherlands (2002) and own computations

If the diagonalised matrix of the vector c were used, the result would be a matrix with elements denoting the extra emission of CO_2 by sector *i* due to an increase of final demand of sector *j* with one unit. Therefore, the matrix $\hat{c}L\hat{f}$ shows how much CO_2 was emitted by sector *i* due to final demand of sector *j*, or, in other words, how much CO_2 was emitted by sector *i* for sector *j*.

The row totals of this matrix add up to the total emission of each sector, the column totals show how much indirect CO_2 emission the sector can be held responsible for, *i.e.* how much CO_2 is emitted *for* the sector instead of *by* the sector. These figures are displayed in column five of Table 5.1. Both column four and five of Table 5.1 show that the sectors with most indirect emission of CO_2 are about the same as the sectors with most direct emission, even though the direct emission of the electricity sector is about twice as large as the indirect emission. Interestingly, the transport and trade margins show up with large emissions, reflecting the fact that transportation is responsible for a large part of the CO_2 emission. Due to lack of data, however, this could not be seen in the direct emissions.

The analysis above actually assigns the emission of CO_2 to final demand of the sectors. After all, intermediary products are only used in order to fulfil the final demand to a sector's product. Hence, the analysis above registers how much CO_2 is emitted in the entire economic system in order to fulfil the final demand of a sector. Since final demand is distinguished at four categories, it is possible to calculate for each category how much CO_2 was emitted in order to produce it. This does not only depend on the share of the categories in total final demand, but also on the sectoral compositions of the four categories. The relevant figures can be obtained by using the final demand matrix rather than total final demand. The vector c'LF contains 4 numbers indicating how much CO_2 was emitted for private consumption, government consumption, investments and exports. This shows that exports generated most CO_2 emission: it is responsible for 55% of the entire emission of CO_2 in 2000. Private consumption is responsible for 28%, government consumption for 10% and investments for 8 %. The shares of the categories in final demand are respectively 39%, 29%, 18% and 13%.

Although much CO_2 is emitted for foreign users, imports have the opposite effect, since they generate CO_2 emission in foreign countries for Dutch users. With the National Accounts data, it is possible to compute the CO_2 trade balance, analogue to Machado, Schaeffer and Worrell (2001). In the case of the Netherlands, however, the result is predictable: since there is a trade surplus, exports contain more CO_2 than imports. A more interesting analysis is the computation of the CO_2 intensity per unit of export and import. If e denotes the export coefficients, *i.e.* exports per sector divided by total exports, and m the import coefficients, the CO_2 intensity of exports respectively imports can be computed as c'Le and c'Lm. This exercise shows that in 1995 every guilder of export generated 0.30 kilo CO_2 emission, whereas every guilder of import incorporates 0.28 kilo CO_2. Exports are not only larger than imports, they are also more CO_2 intensive. Hence, the trade balance position of the Netherlands is unfavourable for domestic CO_2 emission. In 2000, however, the numbers have changed: both exports and imports incorporated 0.24 kilo CO_2. The decrease in the CO_2 intensity of exports as well as the levelling of CO_2 intensity of imports and exports are favourable for the Dutch CO_2 trade balance, but the CO_2 trade balance will still show a surplus.

Table 5.2 Decomposition of changes in CO_2 emission between 1995 and 2000, Mtonnes

	Emission coefficients	Input coefficients	Composition final demand	Level of final demand	Total
Agriculture and foresty	-1.8	-0.5	-1.1	2.4	-1.0
Fishing	-0.5	-0.4	-0.8	0.8	-0.9
Crude petroleum and natural gas production	0.3	-0.3	-0.2	0.4	0.2
Other mining and quarrying	0.1	0.0	0.0	0.1	0.2
Manufacture of food products, beverages and tobacco	-0.6	-0.1	-0.7	1.2	-0.2
Manufacture of textille and leather products	0.0	0.0	-0.1	0.1	0.0
Manufacture of paper and paper products	-0.2	0.0	-0.2	0.5	0.1
Publishing and printing	0.0	0.0	0.0	0.1	0.0
Manufacture of petroleum products	0.8	-0.9	-2.0	2.9	0.9
Manufacture of chemical products	-6.6	-0.2	-2.1	6.2	-2.7
Manufacture of rubber and plastic products	-0.1	0.0	0.0	0.1	0.0
Manufacture of basic metals	-1.4	-0.1	-0.8	1.8	-0.5
Manufacture of fabricated metal products	0.0	0.0	0.0	0.2	0.1
Manfacture of machinery n.e.c.	-0.1	0.0	0.0	0.1	0.0
Manufacture of electrical equipment	-0.3	0.0	0.1	0.1	-0.1
Manufacture of transport equipment	-0.2	0.0	0.0	0.1	-0.1
Recycling industries	0.2	0.1	0.0	0.0	0.4
Manufacture of wood and wood products	0.0	0.0	0.0	0.0	0.0
Manufacture of construction materials	-0.7	0.2	-0.1	0.7	0.0
Other manufacturing	0.0	0.0	0.0	0.0	0.0
Electricity supply	1.0	-2.3	-4.2	9.1	3.6
Gas and water supply	0.0	0.0	0.0	0.0	0.0
Construction	-0.1	0.0	0.0	0.4	0.2
Wholesale trade	-0.3	0.0	0.0	0.1	-0.1
Retail trade, repair (excl motor vehicles)	-0.4	0.2	0.1	0.4	0.3
Hotels and restaurants	-0.9	-0.1	0.1	0.5	-0.4
Land transport	-0.1	0.0	-0.3	1.6	1.2
Water transport	0.3	-0.1	-0.5	1.7	1.4
Air transport	-0.5	0.4	0.3	2.6	2.9
Supporting transport activities	-0.4	0.0	0.0	0.1	-0.3
Financial, business services and communication	-0.7	0.3	0.4	0.7	0.7
Public administration and social security	-0.1	0.0	0.0	0.3	0.2
Educaton	0.0	0.0	0.0	0.1	0.1
Health and social work activities	-0.3	0.0	0.0	0.2	-0.1
Sewage and refuse disposal services	-0.2	1.1	0.0	0.9	1.8
Other services	-0.1	0.0	0.0	0.2	0.1
Trade and transport margins	0.0	0.0	0.0	0.0	0.0
Total	-13.8	-2.7	-12.2	36.8	8.1

Source: own computations based on Statistics Netherlands 2002

Table 5.2 shows the results of the decomposition analysis. Technological and composition changes decreased the emission of CO_2 substantially, with 14 Mtonnes due to technological changes that influenced the emission coefficients directly, 3 Mtonnes due to technological changes that affected the input structures, and 12 Mtonnes due to changes in the composition of final demand. These effects are more than nullified by the effects of increasing economic growth: changes in final demand caused the emission of CO_2 to increase by almost 37 Mtonnes. Since the total increase between 1995 and 2000 was 8 Mtonnes, the increase was larger than the maximum allowed increase of 1 Mton per year computed in Section 2. Hence, the increases in this period have to be compensated for in the future in order to reach the aims of the Kyoto protocol.

The sectoral results in Table 5.2 show an interesting pattern for the changes in CO_2 emissions due to technological changes with respect to the emission coefficients. Most sectors developed cleaner technologies with less CO_2 emission per unit of output. However, a few sectors stand out with technologies that became more CO_2 extensive. The most important effects take place in the electricity sector and the oil industry. Although this seems to imply that the electricity sector switched to more emission generating techniques, the results may be due to data errors. To analyse whether this is the case, we checked the robustness of the results by repeating the analysis for the period 1995-1999. This showed that most conclusions did not change, except for the effect of changes in the CO_2 intensity for the electricity sector; instead of being responsible for 1 megaton extra CO_2, it decreased the emission of CO_2 with 2 megatons according to the 1999 figures. Clearly, the detailed sector specific results are not always very robust, which makes it dangerous to draw far-reaching conclusions on these data.[3] The conclusion for the oil industry, however, was the same for the 1999 and the 2000 data. Table 5.3 displays the results of the 1999 analysis.

Since many decomposition analyses conclude that a decrease in the energy intensity contributes substantially to lower CO_2 emission (see, *e.g.*, Ang, 1999, Sun, 1999, Schipper, Murtishaw, and Unander, 2001, Albrecht, J., D. François, and K. Schoors, 2002), it is interesting to take a look at the outcomes in Tables 5.2 and 5.3. The reduction in the input structure due to changes in inputs from the electricity sector are in both cases relatively large. Although it is tempting to conclude that these results confirm that the decrease in energy intensity is an important factor in reducing the emission of CO_2, they may also be due to an increase in imported electricity.

[3] In 1995, the Dutch electricity sector produced 58,350 million kWh electricity, using several primary energy carriers amongst which 262 PJ coal. In 1999, the respective figures were 52,994 and 211. This implies that for each million kWh the electricity sector used 0.0045 PJ coal in 1995 and 0.0040 PJ coal in 1999. The coal intensity of the (central) generation of power in the Netherlands declined thus with more than 10% in this period. (source: CBS).

Indeed, a look at the import data shows that imports of electricity increased by 73% between 1995 and 2000.

Table 5.3 Decomposition of changes in CO2 emission between 1995 and 1999, Mtonnes

	Emission coefficients	Input coefficients	Composition final demand	Level of final demand	Total
Agriculture and foresty	-1.7	-0.3	-0.7	1.6	-1.0
Fishing	-0.4	-0.2	-0.5	0.6	-0.4
Crude petroleum and natural gas production	0.2	-0.1	-0.2	0.3	0.2
Other mining and quarrying	0.0	0.0	0.0	0.0	0.1
Manufacture of food products, beverages and tobacco	-0.1	0.0	-0.5	0.8	0.2
Manufacture of textille and leather products	-0.1	0.0	-0.1	0.1	-0.1
Manufacture of paper and paper products	-0.7	0.0	-0.1	0.3	-0.5
Publishing and printing	0.0	0.0	0.0	0.0	0.0
Manufacture of petroleum products	0.9	-0.5	-1.6	2.0	0.8
Manufacture of chemical products	-2.6	0.5	-2.4	4.3	-0.2
Manufacture of rubber and plastic products	0.0	0.0	0.0	0.1	0.0
Manufacture of basic metals	-0.9	0.2	-0.7	1.2	-0.2
Manufacture of fabricated metal products	0.0	0.0	0.0	0.1	0.1
Manfacture of machinery n.e.c.	0.0	0.0	0.0	0.1	0.0
Manufacture of electrical equipment	-0.3	0.0	0.0	0.1	-0.2
Manufacture of transport equipment	-0.2	0.0	0.0	0.1	-0.1
Recycling industries	0.2	0.1	0.0	0.0	0.3
Manufacture of wood and wood products	0.0	0.0	0.0	0.0	0.1
Manufacture of construction materials	-0.6	0.2	-0.1	0.5	0.0
Other manufacturing	-0.1	0.0	0.0	0.0	0.0
Electricity supply	-2.0	-1.4	-4.1	6.8	-0.7
Gas and water supply	0.0	0.0	0.0	0.0	0.0
Construction	-0.1	0.0	0.0	0.3	0.2
Wholesale trade	-0.3	0.0	0.0	0.1	-0.1
Retail trade, repair (excl motor vehicles)	-0.4	0.2	0.0	0.3	0.1
Hotels and restaurants	-1.1	-0.1	0.1	0.4	-0.8
Land transport	-0.4	0.1	-0.1	1.2	0.8
Water transport	-0.5	0.0	-0.2	1.1	0.4
Air transport	-0.6	0.5	0.5	1.7	2.1
Supporting transport activities	-0.4	0.0	0.0	0.1	-0.3
Financial, business services and communication	-0.7	0.3	0.3	0.6	0.4
Public administration and social security	0.3	0.0	0.0	0.3	0.6
Educaton	-0.1	0.0	0.0	0.1	0.0
Health and social work activities	-0.5	0.0	0.0	0.2	-0.3
Sewage and refuse disposal services	0.4	1.0	0.0	0.7	2.1
Other services	-0.1	0.0	0.0	0.1	0.0
Trade and transport margins	0.0	0.0	0.0	0.0	0.0
Total	-12.6	0.3	-10.2	26.2	3.7

Source: own computations based on Statistics Netherlands (2002)

Table 5.4 Changes in CO_2 emission due to final demand between 1995-2000, Mtonnes

	Private consumption	Government consumption	Investments	Exports	Total
Agriculture and foresty	0.3	0.0	0.1	2.0	2.4
Fishing	0.1	0.0	0.0	0.6	0.8
Crude petroleum and natural gas production	0.1	0.0	0.0	0.3	0.4
Other mining and quarrying	0.0	0.0	0.0	0.0	0.1
Manufacture of food products, beverages and tobacco	0.2	0.0	0.0	0.9	1.2
Manufacture of textille and leather products	0.0	0.0	0.0	0.1	0.1
Manufacture of paper and paper products	0.0	0.0	0.0	0.4	0.5
Publishing and printing	0.0	0.0	0.0	0.0	0.1
Manufacture of petroleum products	0.3	0.0	0.1	2.6	2.9
Manufacture of chemical products	0.2	0.1	0.1	5.8	6.2
Manufacture of rubber and plastic products	0.0	0.0	0.0	0.1	0.1
Manufacture of basic metals	0.0	0.0	0.2	1.5	1.8
Manufacture of fabricated metal products	0.0	0.0	0.0	0.1	0.2
Manfacture of machinery n.e.c.	0.0	0.0	0.0	0.1	0.1
Manufacture of electrical equipment	0.0	0.0	0.0	0.1	0.1
Manufacture of transport equipment	0.0	0.0	0.0	0.1	0.1
Recycling industries	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
Manufacture of construction materials	0.1	0.0	0.3	0.3	0.7
Other manufacturing	0.0	0.0	0.0	0.0	0.0
Electricity supply	4.4	0.4	0.8	3.4	9.1
Gas and water supply	0.0	0.0	0.0	0.0	0.0
Construction	0.0	0.0	0.3	0.0	0.4
Wholesale trade	0.1	0.0	0.0	0.1	0.1
Retail trade, repair (excl motor vehicles)	0.1	0.0	0.1	0.2	0.4
Hotels and restaurants	0.2	0.0	0.1	0.2	0.5
Land transport	0.5	0.1	0.1	0.9	1.6
Water transport	0.1	0.0	0.0	1.6	1.7
Air transport	0.3	0.0	0.1	2.2	2.6
Supporting transport activities	0.0	0.0	0.0	0.1	0.1
Financial, business services and communication	0.3	0.0	0.1	0.3	0.7
Public administration and social security	0.0	0.3	0.0	0.0	0.3
Educaton	0.0	0.1	0.0	0.0	0.1
Health and social work activities	0.1	0.1	0.0	0.0	0.2
Sewage and refuse disposal services	0.1	0.4	0.1	0.3	0.9
Other services	0.1	0.0	0.0	0.1	0.2
Trade and transport margins	0.0	0.0	0.0	0.0	0.0
Total	7.9	1.7	2.7	24.5	36.8

Source: own computations based on Statistics Netherlands (2002)

Because the effect of final demand is by far the largest effect, it is split up in its four components. These figures are displayed in Table 5.4. It shows that most emission was generated by changes in exports. This is for a large part explained by the increase in exports (about 30%, against private consumption 20%). Again, emissions of CO_2 in the Netherlands are for a large part caused by foreign users.

6 Conclusions

The decomposition of the CO_2-data of the Netherlands gives clear answers to the questions posed in the introductory section. The electricity sector, the transportation sector, the oil industry, and the chemical industry together emit most of the Dutch carbon dioxide. As these sectors produce mainly intermediate products, they are not 'responsible' for these emissions. The emissions follow largely from production directed to exports: approximately 55% of the total domestic emission of carbon dioxide results from foreign demand for goods. Private consumption within the Netherlands is responsible for about one quarter of the Dutch emissions.

Much reduction of CO_2 emission has been achieved by decreasing the emitted CO_2 per unit of output. This points at new technologies that are in line with the intentions of the climate change policy. However, the data per sector show that this has mostly been achieved in the industry, especially in the chemical sector. Whereas reductions due to less CO_2 extensive technologies have also been achieved by many service sectors, agriculture and fishery, one industry has become more CO_2 intensive, namely the oil industry.

Shifts in the input structure did cause a decrease in the emission of CO_2 by the electricity sector. A closer look at the figures reveals that this may be due to an extreme increase in the imports of the electricity sector: between 1995 and 2000, imports increased by 73%. Since importing electricity decreases the emissions in the domestic country and increases the emission of CO_2 in foreign countries, these observations mean that emission of CO_2 by the Dutch electricity sector has been shifted to foreign countries rather than decreased by new technologies.

Knowing these factors behind the Dutch emissions of carbon dioxide, the remaining question to be answered refers to the policy implications. In the recent history, the government introduced several policy measures in order to decrease domestic emissions. Those measures comprise mainly of subsidies for investments in energy saving, voluntary agreements with firms to increase their efficiency of the use of energy, and energy taxes (Ministry of Housing, Spatial Planning and Environment, 2002). Most of these measures aim at reducing the level of energy use per unit of output. Other measures are meant to generate substitutions within the energy mix, such as granting subsidies for renewable energy, and obligating power producers to use more non-fossil energy carriers. Although the outcomes of the analysis above do not compute the effects of those climate measures, it is possible to analyse whether the outcomes are in line with the desired developments. The aggregate figures indicate that this policy works, since technological changes led to a reduction in CO_2 emissions by 18%.

Economic growth in general and growth of energy intensive sectors in particular, however, neutralises the effect of improvements in energy efficiency and in the emission coefficient. This fact makes emissions of carbon dioxide a persistent environmental problem. The latter effects are so strong that the total increase in emission of CO_2 in the period 1995–2000 was 8 Mtonnes, whereas the maximum allowed increase for reaching the targets in the Kyoto protocol is less than 1 Mton per year. Hence, the developments so far are unfavourable for reaching the targets in the Kyoto protocol. Forecasts of Dutch carbon emissions in the year 2010 also suggest a gap between expected level of emissions and the policy target (CPB/RIVM, 2002). In order to achieve more results in bringing down emissions of greenhouse gases, additional measures are needed. Those measures should affect the marginal costs of products produced by sectors emitting significant amounts of carbon dioxide. In that case, firms and consumers will reallocate their expenditures towards products produced with fewer emissions.

Since much of the emission of CO_2 is related to exports, meeting the targets of the Kyoto protocol poses an extra threat to the Dutch competitive position. Therefore, the key issue in establishing a CO_2 policy is how to minimize economic losses which would happen due to international competition. This holds especially for open economies like the Netherlands. Recently, a Dutch Commission studied the feasibility of a national scheme of emissions trading. This Commission proposed to introduce a domestic emissions trading system giving internationally 'exposed' firms a special treatment (CO_2 Trading Commission, 2002). According to that proposal, those firms should be subject to a relative cap, while other sectors sheltered from international competition should be subject to an absolute ceiling on their aggregate emissions. Kuik and Mulder (2004) conclude that such a hybrid emissions trading scheme generates high administrative costs because of the different treatment of firms. If all domestic firms are subject to a cap on the aggregate emissions, transaction costs would be much lower but the overall macroeconomic costs would be significant due to deterioration of competitiveness on international markets. Emissions trading within an international scheme appears to be the most efficient way to reduce emissions. De Groot et al. (2002) show that an international system of emissions trading reduces macroeconomic costs of Kyoto by more than 50%. For the Netherlands, the costs of realising the targets of Kyoto by means of an international emissions trading scheme are estimated at 0.2% NNI in 2010. One can conclude, therefore, that an international system of emissions trading generates sufficient incentives for changes towards less polluting products without causing much economic costs.

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Appendix A: Sector classifications

Sectors according to the 106 sector classification

1	Arable farming
2	Horticulture
3	Live stock
4	Other Agriculture
5	Service activities related to agriculture
6	Forestry and hunting
7	Fishing
8	Crude petroleum and natural gas production
9	Other mining and quarrying
10	Manufacture of meat
11	Manufacture of fish products
12	Manufacture of vegetable and fruit products
13	Manufacture of dairy prod.
14	Manufacture of animal feeds
15	Manufacture of other food products
16	Manufacture of coffee and tea
17	Manufacture of beverages
18	Manufactuure of tobacco products
19	Manufacture of textiles
20	Manufacture of wearing apparel
21	Manufacture of leather and leather products
22	Manufacture of wood and wood products
23	Manufacture of paper
24	Manufacture Paper products
25	Publishing and printing
26	Manufacture of recorded media
27	Manufacture of petroleum products; cokes and nuclear fuel
28	Manufacture of other basic chemicals and man-made fibres
29	Manufacture of inorganic basic chemicals
30	Manufacture of petrochemicals
31	Manufacture of fertilisers and nitrogen compounds
32	Manufacture of chemical products
33	Manufacture of rubber and plastic products
34	Manufacture of other non-metallic mineral products
35	Manufacture of basic metals

36	Manufacture of fabricated metal products
37	Manufacture of other machinery and equipment
38	Manufacture of domestic appliances
39	Manufacture of office machinery and computers
40	Manufacture of electrical machinery n.e.c.
41	Manufacture of radio, television and communication equipment
42	Manufacture of medical and optical equipment
43	Manufacture of motor vehicles
44	Manufacture of ships and boats
45	Manufacture of trains, trams and aircraft
46	Manufacture of other transport equipment
47	Manufacture of furniture
48	Manufacturing n.e.c.
49	Recycling
50	Electricity supply
51	Gas, steam and hot water supply
52	Collection, purification and distribution of water
53	Site preparation
54	Construction of buildings
55	Other civil engineering
56	Building installation
57	Building completion
58	Renting of construction equipment
59	Wholesale trade of motor vehicles/cycles
60	Retail trade of motor vehicles/cycles
61	Repair of motor vehicles/cycles; retail sale of fuel
62	Wholesale trade (excl. motor vehicles/cycles)
63	Retail trade and repair (excl. motor vehicles/cycles)
64	Hotels and restaurants
65	Passenger transport by road; railway transport
66	Freight transport by road
67	Transport via pipelines
68	Sea transport
69	Inland water transport
70	Air transport
71	Other supporting transport activities
72	Supporting water transport activities
73	Supporting air transport activities
74	Activities of travel agencies

75	Post and telecommunications
76	Banking
77	Insurance and pension funding
78	Activities auxiliary to financial intermediation
79	Letting services for leeses and own property
80	Other real estate activities
81	Renting of movables
82	Computer and related activities
83	Research and development
84	Legal and economic activities
85	Architectural and engineering activities
86	Advertising
87	Activities of employment agencies
88	Building-cleaning activities
89	Other business activities n.e.c.
90	Public administration; central government
91	Public administration; communities
92	Other public administration; compulsory social security activities
93	Defence activities
94	Subsidized education, universities
95	Subsidized education on a religious basis
96	Other subsidized education
97	Human health and veterinary activities
98	Social work activities
99	Sewage and refuse disposal services; corporations
100	Sewage and refuse disposal services; government
101	Other recreational, cultural and sporting activities
102	Lotteries and the like
103	Other service activities n.e.c.
104	Private households with employed persons
105	Manufacturing and services n.e.c.
106	Trade and transport margins

Sectors according to the 37 sector classification:

		Included sectors
1	Agriculture and foresty	1:6
2	Fishing	7
3	Crude petroleum and natural gas production	8
4	Other mining and quarrying	9
5	Manufacture of food products, beverages and tobacco	10:18
6	Manufacture of textille and leather products	19:21
7	Manufacture of paper and paper products	23:24
8	Publishing and printing	25:26
9	Manufacture of petroleum products	27
10	Manufacture of chemical products	28:32
11	Manufacture of rubber and plastic products	33
12	Manufacture of basic metals	35
13	Manufacture of fabricated metal products	36
14	Manfacture of machinery n.e.c.	37:38
15	Manufacture of electrical equipment	39:42
16	Manufacture of transport equipment	43:46
17	Recycling industries	49
18	Manufacture of wood and wood products	22
19	Manufacture of construction materials	34
20	Other manufacturing	47:48
21	Electricity supply	50:51
22	Gas and water supply	52
23	Construction	53:58
24	Wholesale trade	59:61
25	Retail trade, repair (excl motor vehicles)	62
26	Hotels and restaurants	63:64
27	Land transport	65:67
28	Water transport	68:69
29	Air transport	70
30	Supporting transport activities	71:74
31	Financial, business services and communication	75:89
32	Public administration and social security	90:93
33	Educaton	94:96
34	Health and social work activities	97:98
35	Sewage and refuse disposal services	99:100
36	Other services	101:105
37	Trade and transport margins	106

Final demand categories included in the analysis

Private consumption	Final consumption expenditure of households
	Non-profit institutions serving households
Government consumption	Final consumption expenditure of general government
	Social security in kind by the government
Investments	Fixed capital formation (gross)
	Changes in inventories (incl. acquisitions less disposals of valuables)
Exports	Exports of goods (fob) and services