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Environmental Structural Decomposition Analysis of Italian Emissions, 1995-2005

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Resumen

El estudio analiza la evolución de los gases de efecto invernadero (GEI) y las emisiones de acidificación para Italia durante el periodo 1995-2005. Los datos muestran que mientras las emisiones que contribuyen a la acidificación han disminuido constantemente, las emisiones de GEI han aumentado debido al aumento de dióxido de carbono. El objetivo de este estudio es poner de relieve cómo diferentes factores económicos, en particular el crecimiento económico, el desarrollo de una tecnología menos contaminante y la estructura del consumo, han impulsado la evolución de las emisiones. La metodología propuesta es un análisis de descomposición estructural (ADE), método que permite descomponer los cambios de la variable de interés entre las diferentes fuerzas y revelar la importancia de cada factor. Por otra parte, este estudio considera la importancia del comercio internacional e intenta incluir el "problema de la responsabilidad". Es decir, a través de las relaciones comerciales internacionales, un país podría estar exportando procesos de producción contaminantes sin una reducción real de la contaminación implícita en su patrón de consumo. Con este fin, siguiendo primero un enfoque basado en la "responsabilidad del productor", el ADE se aplica a las emisiones causadas por la producción nacional. Sucesivamente, el análisis se mueve hacia un enfoque basado en la "responsabilidad del consumidor" y la descomposición se aplica a las emisiones relacionadas con la producción nacional o la producción extranjera que satisface la demanda interna. De esta manera, el ejercicio permite una primera comprobación de la importancia del comercio internacional y pone de relieve algunos resultados a nivel global y a nivel sectorial.

Abstract

This study analyses the evolution of greenhouse gas (GHG) emissions and acidification emissions for Italy in the years 1995-2005. Looking at data, while emissions that contribute to the local problem of acidification have been decreasing quite constantly, GHG emissions have been showing a slight increase due to the rise of carbon dioxide. The aim is therefore to highlight how different economic factors have driven the evolution of Italian emissions. The main factors considered are economic growth, the development of a technology allowing a more environment-friendly way of production, and the structure of consumption. The methodology proposed is a structural decomposition analysis (SDA), a method that permits to decompose the changes of the variable of interest among different driving forces and to reveal the relevance of each factor. Moreover, the analysis considers the relevance of international trade and it tries to deal with the "problem of responsibility". That is, through international trade relationships a country could be exporting polluting production processes without a real reduction of the pollution implied in its consumption pattern. For this purpose, the SDA is firstly applied to the emissions caused by domestic production. This corresponds to a "production-based" approach (PBA). Successively, the analysis moves toward a "consumption-based" approach (CBA) and the decomposition is applied to emissions related to domestic production or foreign production that satisfies domestic demand. In this way the exercise allows a first check of the importance of international trade and it highlights some results at global as well at sector level that can indicate in which direction further analysis should be carried on.

JEL codes: C67, D57, Q53, Q56.

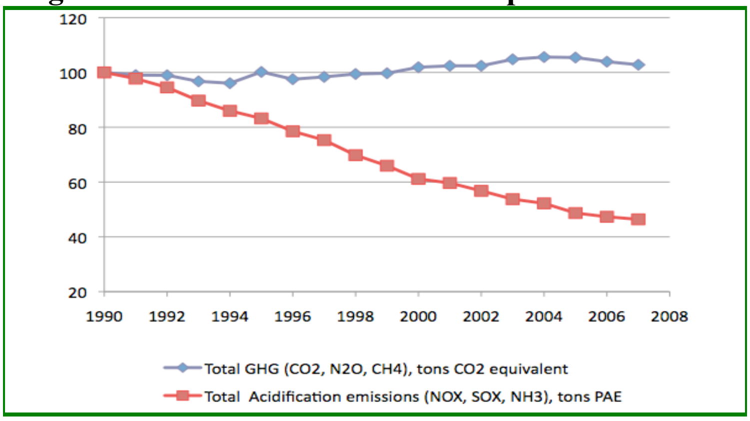
Keywords: structural decomposition analysis, NAMEA data, problem of responsibility.

1. Introduction

Atmospheric contamination is one of the pressures that human activities exert on the environment. In particular, greenhouse gas (GHG) emissions are responsible for climate change: the international policies developed since the nineties and their enforcement at national level show a widespread concern about the relevance of this phenomenon. Within the United Nation Framework Convention on Climate Change (UNFCCC), the international community established the Kyoto protocol in 1997. For the period 2008-2012, this agreement sets a reduction target of 5.2% of total GHG emissions relating to the level of emissions in 1990 for industrialized countries, 8% for European countries and 6.5% for Italy. Moreover, data of the International Energy Agency[1] reveals that Italian emissions of carbon dioxide account for the 1.92% of the world's total emissions in 1990, and for the 1.66% in 2005, ranking Italy among the world's ten largest emitters.

Within this framework, this research analyses the evolution of atmospheric emissions of the Italian productive system and its driving forces in the years 1995-2005. The emissions analysed are the three main GHGs considered global pollutants: i.e. carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) ; and three gases related to local environmental problems, such as acidification or acid rainfalls: i.e. nitrogen oxides (NO_X), sulphur oxides (SO_X), and ammonia (NH_3). A first glance at data on emissions in the Italian case (Figure 1) shows that while emissions that contribute to acidification have been decreasing quite constantly, GHG emissions have been showing a slight increase due to the weight of CO_2, which is the only emission responsible for this increase (Table 1).

Figure 1. Evolution of Italian atmospheric emissions



Source: own elaboration from Italian NAMEA data.

[1] Available at: http://www.eia.gov/countries/data.cfm

Table 1. Italian emissions

	1995	2000	2005	Variation (1995-2005)
CO_2	449,197.55	466,881.83	493,059.11	10%
N_2O	123.83	128.42	122.30	-1%
CH_4	2,102.45	2,104.47	1,887.81	-10%
NO_X	1,894.49	1,449.51	1,223.84	-35%
SO_X	1,338.75	759.95	410.26	-69%
NH_3	448.37	450.92	413.98	-8%

Source: own elaboration from 1995, 2000, and 2005 Italian NAMEA tables.
Unit: 1000 tons.

The aim of this study is to analyze the evolution of GHG and acidification emissions, and to define to what degree different economic factors have counted for such different trends. For doing so, we will perform a structural decomposition analysis (SDA). This method developed in the framework of IO analysis permits to decompose the changes of the variable of interest among different driving forces and to reveal the relevance of each factor. The knowledge of the role of different driving forces is helpful to figure out effective political instruments that would permit to delink economic growth and environmental pressures and to reach the emissions reduction targets. Generally, changes in emissions are mainly affected by the development of a technology allowing a more environment-friendly way of production, changes in the volume of consumption stimulated by economic growth, and changes in consumers' preferences revealed by the structure of goods and services consumption. Therefore, these will be the three factors considered in this study.

Moreover, another important characteristic of a country's production and consumption system is the relevance of international trade. By considering how international trade affects emissions, the analysis deals with the "problem of responsibility": the idea is that if international flows of goods and services are not adequately considered, the possibility that a country could be exporting polluting production processes is omitted from the analysis, and this does not mean a real reduction of the pollution implied in its consumption pattern. This concern moves the analysis to look at things from a different point of view, which recognizes the importance of the globalisation process and that investigates more deeply not only the environmental pressures that the national production system implies, but also those who should be considered responsible for these pressures. Munksgaard and Pedersen (2001) and Baiocchi and Minx (2010) suggest that international trade should be considered at the time of establishing equitable and feasible reduction targets, while the UNFCCC still applies a production-based accounting perspective in setting the reduction targets of emissions for different countries. Due to its balance trade structure, it seems important to include the role of international trade and the problem of responsibility in the analysis of Italian emissions. On the one side the existence of little natural endowment makes international trade a key element for Italian growth, which depends on a systematic current account deficit. On the other side, as Viviani (2010) highlights, Italy could be particularly interested in the problem of responsibility due to its substantial energy-intensive manufacturing base. Tables 2 and 3 show data on import and export flows for the five most relevant sectors as regards the Italian current account balance (for the year 1995) and data on CO_2 emissions for the five most polluting sectors: it is worth noticing that some of the relevant sectors for international trade are also among the most polluting sectors.

Table 2. Export and Import for the five most trade-relevant sectors.

Export					Import				
	1995	2000	2005	Variation (95-05)		1995	2000	2005	Variation (95-05)
Manufacture of machinery and equipment	45,018.52	49,505.73	54,195.04	20%	Manufacture of chemicals	25,150.04	33,452.07	42,039.79	67%
Manufacture of motor vehicles	15,949.22	19,000.26	19,761.13	24%	Manufacture of motor vehicles	17,579.79	28,260.61	33,329.02	90%
Wholesale and retail trade*	15,879.40	19,731.17	21,635.09	36%	Manufacture of basic metals*	17,123.77	22,333.18	23,175.39	35%
Manufacture of chemicals	15,776.88	23,448.99	29,204.65	85%	Manufacture of food products, beverages, tobacco	16,312.99	17,200.46	18,846.33	16%
Manufacture of furniture	14,565.47	16,109.18	12,619.75	-13%	Manufacture of machinery and equipment	15,717.79	20,473.83	20,459.51	30%

Source: own elaboration from 1995, 2000, 2005 Italian IO tables.
Unit: millions of euro.
*Relevant sectors for CO_2 emissions.

Table 3. CO_2 emissions for the five most polluting sectors.

	CO_2 emissions			
	1995	2000	2005	Variation (1995-2005)
Electricity, gas and water supply	114,708.52	122,674.76	135,359.58	18%
Manufacture of other non-metallic mineral products	37,774.94	43,324.31	45,258.93	20%
Manufacture of basic metals	24,053.09	19,591.33	18,901.74	-21%
Manufacture of coke, refined petroleum products and nuclear fuel	23,145.84	22,915.96	24,259.08	5%
Wholesale and retail trade	21,501.67	18,765.19	19,415.57	-10%

Source: own elaboration from 1995, 2000, 2005 Italian NAMEA tables.
Unit: 1000 tons.

Literature introduces different concepts in order to deal with the assignment of responsibility, such as the "ecological deficit", the "footprint" approach, or the life-cycle analysis. In input-output (IO) framework, a lot of studies propose the use of the environmental balance of trade that consists in the difference between emissions attributed to exports and emissions attributed to imports (for a theoretical presentation and detailed literature reviews see Wiedmann *et al.* 2007, Hoekstra *et al.* 2008, Peters 2008, Peters and Hertwich 2009, Serrano and Dietzenbacher 2010). These studies highlight that there are two main approaches for the computation of the environmental balance of trade: through "single-region input-output models" or through "multi-region input-output models" (MRIO). The first approach requires fewer data but it implies to calculate the emissions embodied in imports under the assumption that foreign production uses the same technology used by domestic production (i.e. the so-called "domestic technology assumption" (DTA)). From a different perspective, this assumption corresponds to considering how many emissions there would be if goods and services imported were produced internally. In the MRIO approach, technology does not have to be the same for different countries and moreover it permits to capture all the forward and backward effects that international trade implies. Unfortunately, this second approach requires completeness and consistency of international databases, which are sometimes difficult to get to.

In literature there are few studies that deal with the problems of international trade and responsibility through a SDA. Most of the analyses take into account the relevance of international trade as one of the factors considered in the decomposition. Chen and Wu (1994) study the sources of change in industrial electricity use in the Taiwan economy for the period 1976-1986. They propose a SDA and they consider fourteen mutually exclusive underlying driving forces, among which they include the export level, the export composition and the import substitution. They find that the effect of export demand is stronger than the effect of domestic demand in the positive variation of energy use, while import substitution would slightly increase emissions. Jacobsen (2000) proposes a SDA in order to consider the relation between trade pattern and energy consumption of the Danish manufacturing industry for the period 1966-1992. The SDA considers six components, three of which are trade-related (imported share of final demand, imported share of intermediate demand and exports of goods and services). He works out the net effect of trade, and he finds that changes in the structure of foreign trade toward less energy-intensive exports does not lead to a reduced energy demand as it is supposed to do. De Haan (2001) proposes an alternative way of looking at the role of international trade, by using a comparison between two different SDA. He studies the case of the Netherlands CO_2 emissions for the period 1987-1998. He firstly proposes an estimation of CO_2 pollution classified according to its origin (domestic production, domestic consumption, import), then he decomposes emissions attributed to different destination categories (domestic consumption, domestic capital formation, export), and for any SDA he distinguishes between demand effect and production effect. He finds that the CO_2 attributed to export is higher than the CO_2 attributed to import, and that demand effect has the same positive effect on emission change, while production- or technological- effect has a stronger positive effect for export. Peters *et al.* (2007) analyse China's CO_2 emissions from 1992 to 2002. Among the driving forces they include net trade, and they find it has a small effect on total emissions due to equal growth in emissions related to export and in emissions avoided with import. Wu *et al.* (2007) look into the factors that cause the increase of pollution in Taiwan, a highly exported-oriented country that has experienced a strong growth in the considered period (1989-2001). They consider fourteen factors, among which they include export level, export structure and import coefficients. They find that change in export level increases industrial CO_2 emissions by 72.1%. Guan *et al.* (2008) develop three different scenarios for considering Chinese CO_2 emissions from Chinese economic reforms (1980) to 2030. They include international trade by decomposing final demand among different final users. They find a rough balance between emissions from the production of exports and emissions avoided by imports. Lim *et al.* (2009) propose a SDA for industrial CO_2 emissions for energy use in Korea for the period 1990-2003, and they consider eight driving forces: two emission coefficients (energy and carbon intensity), economic growth, and five structural changes (domestic final demand, export, import of final goods, import of intermediate goods, production technology). One important conclusion is that the importance of exports has steeply risen since 2000. Baiocchi and Minx (2010) propose a SDA with a MRIO approach for the United Kingdom between 1992 and 2004. They find that recent emissions reductions partially reflect a change in the international division of global production.

As regards the Italian case, few studies propose the analysis of atmospheric emissions using a SDA. Alcantara and Duarte (2004) use a SDA for a comparison among European countries (instead of among different periods of time) for the year 1995. They identify the sources of the differences in the energetic intensities of

European Union countries for fifteen different economic sectors. Italy is found to be a country with low energy intensity but with a high impact of its production processes. Campanale (2007) proposes an IDA for the evolution of CO_2 emissions and acidification emissions during the period 1992-2003, and SDA of CO_2 emissions for the period 1995-2000. In particular, SDA considers three factors: the Leontief effect, emissions intensity and the final demand effect. He finds that the positive final demand change is offset by a negative change in the intensity of emissions, though a positive Leontief effect causes emissions to increase. Mazzanti and Montini (2009) study regional-national disparities in environmental efficiency through a shift-share analysis for the region of Lazio for the year 2000. They find that Lazio region achieves higher environmental performance compared with the rest of Italy[2].

In this work, we propose a comparison of two different SDA. The first decomposition is applied to the emissions caused by domestic production, which includes domestic production for internal demand and for export while it does not consider imports. In general, when the analysis considers emissions related to domestic production, it is called "production-based approach" (PBA). Successively, the analysis moves toward a "consumption-based approach" (CBA) and the focus is on emissions due to the production of all goods and services domestically required, regardless of where they are produced. The decomposition is indeed applied to emissions related to domestic production or foreign production that satisfies domestic demand. In this second case, the emissions attributed to export are excluded, while we include the emissions attributed to import. The shift from a PBA to a CBA leads to re-allocate the responsibility of emissions considering consumption activities and not only domestic production activities. The results obtained with the two SDA are compared. In this way the exercise allows a first check of the importance of international trade in the evolution of Italian emissions and it highlights some results at global as well at sector level that can indicate in which direction further analysis should be carried on.

2. Method and data

2.1. Model

In this study we follow the single-region IO model used by Serrano and Roca (2008)[3] in which the trade relationships between a small open country and the rest of the world are considered. As a single-region model it extremely simplifies the reality since the rest of the world is assumed to use the same technology as the small country, i.e. it applies the DTA. In that case the small open economy is represented by the following expressions[4]:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A}_d)^{-1}(\mathbf{y}_d + \mathbf{e}) \tag{1}$$

$$\mathbf{m} = \mathbf{A}_m \mathbf{x} + \mathbf{y}_m \tag{2}$$

[2]A research in progress of Femia and Campanale (2010) was presented in June 2010 at the "Footprint Forum 2010". The authors quantify the carbon footprint from a consumption perspective and propose a SDA that includes also import. This work is not published and only an abstract is available.

[3] For a general and detailed formulation for a MRIO model see Serrano and Dietzenbacher (2010).

[4] Matrices are indicated by bold, upright capital letters; vectors by bold, upright lower case letters; and scalars by italicized lower case letters. Vectors are columns by definition, so that row vectors are obtained by transposition, indicated by a prime. A circumflex indicates a diagonal matrix with the elements of any vector on its diagonal and all other entries equal to zero. The notation **i** is used to represent a column vector of 1's of appropriate dimensions.

Where $\mathbf{x}$ is domestic gross output, $\mathbf{I}$ is the identity matrix, $\mathbf{A_d}$ is the matrix of domestic input coefficients, $\mathbf{y_d}$ is domestic final demand (that comprises domestic private consumption by household, domestic public consumption by government, and domestic investment), and $\mathbf{e}$ exports. Expression (2) shows the required total imports $\mathbf{m}$ of this economy, no matter if they are used as intermediate inputs $\mathbf{A_m x}$ or as final demand $\mathbf{y_m}$[5].

The matrix $(\mathbf{I} - \mathbf{A_d})^{-1}$ is the well-known Leontief inverse $\mathbf{L}$ and its element l_{ij} gives the (extra) output in sector *i* that is necessary for one (extra) monetary unit of final demand in sector *j*. Pre-multiplying this matrix by the diagonal matrix $\hat{\mathbf{w}}$ of atmospheric emission coefficients of any pollutant, we can estimate, for instance, the pollution associated with the domestic final demand of this economy $\mathbf{p_d}$ as:

$$\mathbf{p_d} = \hat{\mathbf{w}}(\mathbf{I} - \mathbf{A_d})^{-1}\mathbf{y_d} \tag{3}$$

The technology of an open economy is determined by the matrix of total input coefficients $\mathbf{A_t}$, given by $\mathbf{A_t} = \mathbf{A_d} + \mathbf{A_m}$. Since total supply should equal total demand, the equilibrium of this economy is given by:

$$\mathbf{x} + \mathbf{m} = \mathbf{A_t x} + \mathbf{y_t} \tag{4}$$

Expressions (3) and (4) together allow us to differentiate the atmospheric pollution associated with both perspectives, PBA and CBA. Thus, the solution of this economy taking into account only those goods and services produced inside the country regardless of where they will be consumed is given by:

$$\mathbf{p_{PBA}} = \hat{\mathbf{w}}(\mathbf{I} - \mathbf{A_d})^{-1}(\mathbf{y_d} + \mathbf{e}) \tag{5}$$

On the other hand, the solution of this economy taking into account goods and services consumed inside the country regardless of where they have been produced is given by:

$$\mathbf{p_{CBA}} = \hat{\mathbf{w}}(\mathbf{I} - \mathbf{A_t})^{-1}(\mathbf{y_d} + \mathbf{y_m}) \tag{6}$$

As it has been formally demonstrated by Serrano and Dietzenbacher (2010), from expressions (5) and (6) is easy to see the equivalence of comparing accounting emissions from the PBA and CBA and of comparing emissions embodied in exports and imports (the so-called trade emission balance).

Expression (5) can be simplified in the following way:

$$\mathbf{p_{PBA}} = \mathbf{Fy} = \mathbf{F}[\mathbf{y}/(\mathbf{i'y})][\mathbf{i'y}] = \mathbf{Fsv} \tag{7}$$

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[5] Matrices of domestic input coefficients $\mathbf{A_d}$ or imported input coefficients $\mathbf{A_m}$, are defined as $\mathbf{A_d} = \mathbf{Z_d}(\hat{\mathbf{x}})^{-1}$ and $\mathbf{A_m} = \mathbf{Z_m}(\hat{\mathbf{x}})^{-1}$; where $\mathbf{Z_d}$ and $\mathbf{Z_m}$ are the intermediate inter-industry deliveries matrices. $\mathbf{Z_d}$ gives the deliveries from sector *i* to sector *j* within the country, and $\mathbf{Z_m}$ gives the deliveries from the rest of the world's sector *i* to the country's sector *j*.

Where $\mathbf{F}$ is the emission multiplier from the PBA $\mathbf{F} = \hat{\mathbf{w}}(\mathbf{I} - \mathbf{A_d})^{-1}$ and $\mathbf{y}$ is the summation of domestic final demand and foreign final demand $\mathbf{y} = \mathbf{y_d} + \mathbf{e}$. Notice that in expression (7) $\mathbf{y}$ is divided into a structure component ($\mathbf{s}$) and a volume component ($\mathbf{v}$). Moreover, $\mathbf{F}$ is the total emission intensity matrix, which depends on both the vector of atmospheric emission coefficients $\mathbf{w'}$ and the Leontief inverse matrix $\mathbf{L}$.

Similarly for expression (6) we have:

$$\mathbf{P_{CBA}} = \widetilde{\mathbf{F}}\widetilde{\mathbf{y}} = \widetilde{\mathbf{F}}[\widetilde{\mathbf{y}}/(\mathbf{i'}\widetilde{\mathbf{y}})][\mathbf{i'}\widetilde{\mathbf{y}}] = \widetilde{\mathbf{F}}\widetilde{\mathbf{s}}\widetilde{\mathbf{v}} \tag{8}$$

Where $\tilde{\mathbf{F}}$ is the emission multiplier from the CBA $\tilde{\mathbf{F}} = \hat{\mathbf{w}}(\mathbf{I} - \mathbf{A_t})^{-1}$, $\widetilde{\mathbf{y}}$ is the total inside final demand $\widetilde{\mathbf{y}} = \mathbf{y_d} + \mathbf{y_m}$, and $\widetilde{\mathbf{s}}$ and $\widetilde{\mathbf{v}}$ are the structure and volume components of the inside final demand, respectively.

SDA considers the variation of the variable of interest between two different points of time in terms of variation of different underlying forces. In mathematical terms, this relation can be expressed as an approximation in discrete time of a total differentiation that permits to derive the effects on the dependent variable of changes in the determinants. In the case of PBA this can be expressed by:

$$\Delta\mathbf{P_{PBA}} = \mathbf{P^1_{PBA}} - \mathbf{P^0_{PBA}} = \mathbf{F^1_d s^1 v^1} - \mathbf{F^0_d s^0 v^0} = \mathbf{ef\_F} + \mathbf{ef\_s} + \mathbf{ef\_v} \tag{9}$$

Where $\mathbf{ef\_F}$ captures the joint effect of the vector of direct emissions coefficients $\mathbf{w'}$ and the Leontief inverse $\mathbf{L}$ and it can be considered as the eco-technological effect, $\mathbf{ef\_s}$ represents the variation in the final demand structure while $\mathbf{ef\_v}$ captures the effect of variations in the final demand volume.

There are several ways of decomposing the above expression. The existence of more techniques mainly depends on the "index number problem" and as Rose and Casler (1996) point out it arises from the use of discrete data and this implies that the measure of the sources of changes is not unique. In this study the decomposition methodology proposed by Sun (1998) is used: he suggests to calculate the decomposition using the Laspeyres index and to distribute the residual term in equal part among the different factors[6]. This decomposition leads to a complete decomposition without a residual term. In the case of PBA the method proposed by Sun takes the following form:

$$\begin{cases} \mathbf{eff\_F} = (\Delta\mathbf{F}\mathbf{s^0}\mathbf{v^0}) + \frac{1}{2}(\Delta\mathbf{F}\Delta\mathbf{s}\mathbf{v^0}) + \frac{1}{2}(\Delta\mathbf{F}\mathbf{s^0}\Delta\mathbf{v}) + \frac{1}{3}(\Delta\mathbf{F}\Delta\mathbf{s}\Delta\mathbf{v}) \\ \mathbf{eff\_s} = (\mathbf{F^0}\Delta\mathbf{s}\mathbf{v^0}) + \frac{1}{2}(\Delta\mathbf{F}\Delta\mathbf{s}\mathbf{v^0}) + \frac{1}{2}(\mathbf{F^0}\Delta\mathbf{s}\Delta\mathbf{v}) + \frac{1}{3}(\Delta\mathbf{F}\Delta\mathbf{s}\Delta\mathbf{v}) \\ \mathbf{eff\_v} = (\mathbf{F^0}\mathbf{s^0}\Delta\mathbf{v}) + \frac{1}{2}(\Delta\mathbf{F}\mathbf{s^0}\Delta\mathbf{v}) + \frac{1}{2}(\mathbf{F^0}\Delta\mathbf{s}\Delta\mathbf{v}) + \frac{1}{3}(\Delta\mathbf{F}\Delta\mathbf{s}\Delta\mathbf{v}) \end{cases} \tag{10}$$

[6] It is possible to show that this solution is equal to the mean of the (n!) possible decomposition forms proposed by Dietzenbacher and Los (1998).

For the CBA we have similar expressions.

2.2. Database

The main databases required are the Italian IO tables of the "System of National Accounts" and the "Environmental Satellite Accounts of Air Emissions".

The Italian National Statistical Institute (ISTAT) offers a set of IO tables (ISTAT 2010a)[7] that includes symmetrical IO tables (SIOT) at basic current prices for the years 1995, 2000, and 2005. Two different symmetrical IO tables are available, both with dimension 59x59: the "commodity-by-commodity" SIOT, and the "industry-by-industry" SIOT. The set of IO tables also includes for the mentioned years the use and the symmetrical tables for imports.

The "Satellite Accounts" is the part of accounts that registers the flows between economy and environment- also named NAMEA (National Accounting Matrix including Environmental Accounts) system. Since February 2010 NAMEA tables have been available for Italy (ISTAT 2010b) for the period 1990-2007. The number of industries available for the years 1995-2007 is 51. Nineteen atmospheric pollutants are reported in physical units[8]. Data on emissions are split between emissions caused by economic activities and emissions caused directly by household (mainly due to heating and transport).

This study uses the "commodity-by-commodity" SIOTs that are estimated under the "industry technology" assumption[9]. Under the "industry technology" assumption, each industry has its specific way of production, the same for primary as well as for secondary products: all products produced by an industry are produced with the same input structure. This assumption best applies to cases where several products are produced in a single production process (as in the cases of by-production or joint production). Non-characteristic production is indeed transferred according to the input structure of the industry that actually produces the secondary products[10].

For a comparison among different years, IO tables should be considered in constant prices, because changes in price may alter the quantity changes attributed to variables of interest. Taking into account the available data (ISTAT 2010c), we have estimated the 1995 and 2005 SIOTs at 2000 constant prices applying the double-deflation method. The dimension of the three SIOT at constant prices is 38x38, due to the available desegregation of value added data at constant prices (see appendix A for a sectors' complete list).

[7] The used classification is the "National Classification of Economic Activities" (NACE) *Rev 1.1* (Eurostat 2002), for industries, and "Classification of Product by Activities" (CPA) (Eurostat 2008a), for products.
[8] In tonnes: carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), nitrogen oxides (NO_x), sulphur oxides (SO_x), ammonia (NH_3), composed organic volatile not methanic (COVNM), carbon monoxide (CO), particulate PM10, particulate PM25. In kilograms: arsenic (As), cadmium (Cd), chrome (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), selenium (If) and zinc (Zn).
[9] For a complete explanation of different methods and assumption for the construction of IO tables from SUT, see Miller and Blair (2009), cap. 5, and Eurostat (2008b), cap. 11.
[10] Symmetrical IO tables have been estimated from SUT for the years 1995, 2000 and 2005. Though results are similar to data made available by ISTAT, IO tables used for the SDA are the one proposed by ISTAT because they are obtained from SUT with a higher level of desegregation (101 industries instead of 59).

As regards NAMEA data, the analysis considers three GHG gases (CO_2, N_2O, CH_4) and three acidification gases (NO_X, SO_X, NH_3). Moreover, two indices are included. For a synthetic measure of greenhouse effect (GHGeq), GHG gases are converted into CO_2-equivalent using the Global Warming Potential (GWP) as suggested in Femia and Campanale (2009)[11]. Similarly, for acidifying effect (Acid), acidification gases are converted on the base of their Potential Acid Equivalent (PAE)[12]. Moreover, the ISTAT offers NAMEA data on emissions in a coherent way with the structure of supply and use tables where secondary production is considered. In the case of a 'commodity-by-commodity" SIOT they indeed need to be transformed following the same structure. Hence, in this study data on emissions are estimated under the hypothesis of "industry technology" for 1995, 2000 and 2005.

3. Empirical analysis

In this section we present the SDA results for the period 1995-2000 and 2000-2005. The analysis of two different sub-periods makes it possible to highlight if the weight of the considered factors has been constant during the whole period or if their relevance has changed. Results for the whole economy from both approaches, the PBA and the CBA, are shown in section 3.1., whereas section 3.2. analyses the sector-based results.

3.1. SDA for the economy

3.1.1. Production-based approach

Tables 4 and 5 show the decomposition of emission variation for Italy in both sub-periods considered for the whole economy. Table 4 considers the change of GHG emissions and GHG index, while Table 5 considers the emissions related to acidification gases.

Table 4. Percentage change of GHG emissions (and GHG index) and decomposition (PBA)

		1995-2000				2000-2005			
		CO_2	N_2O	CH_4	GHGeq	CO_2	N_2O	CH_4	GHGeq
Eco-technological effect	(ef_F/P_0)	-11.18	-11.22	-12.16	-11.28	2.06	-8.26	-13.49	-0.34
Final use structure effect	(ef_s/P_0)	2.03	2.69	1.35	2.02	-0.59	0.76	-0.74	-0.49
Final use level effect	(ef_v/P_0)	10.97	10.99	10.88	10.96	4.35	4.15	4.01	4.30
Total effect*	($\Delta P/P_0$)	1.83	2.47	0.06	1.71	5.82	-3.34	-10.22	3.47

Source: own elaboration from 1995, 2000, 2005 Italian NAMEA and IO tables.
Unit: %.
*: The sum does not perfectly fit because of decimal approximations.

The main trends are common for both groups of gases. One the one hand the eco-technological effect would have brought emissions to decrease in both periods, but the increase in the volume of final demand boosted an increase in emissions, offsetting –sometimes totally sometimes partially- the effect of eco-technology. In general the final use structure effect caused emissions to increase in the first period while improved in the second period, but in both cases this effect is less relevant than the other two.

[11] Conversion factors to CO_2- equivalent: CO_2: 1; N_2O: 310; CH_4: 21.
[12] Conversion factors to PAE: SO_X: 1/32; NO_X: 1/46; NH_3: 1/17.

As for the analysis of GHG emissions, as regards CO_2, while in the first period the eco-technological effect change is negative and strong (-11.2%), in the years 2000-2005 it becomes positive (2.1%). Although the increase of final use level effect is less relevant than in the first period, the total change is a growth of CO_2 emissions of 5.8%. As regards N_2O emissions, in the first period there is a positive variation of total emissions: technological improvement is not strong enough to compensate the positive variation of final use structure and volume effects. For CH_4 emissions, the analysis reveals, in the first period, a global variation near to zero due to an offset between the eco-technological effect and the final use level. An interesting result is that for both N_2O and CH_4, the better performance that characterizes the second sub-period is not due to a better eco-technology, but it is due to a cleaner demand, in both its component, i.e. structure and volume, with great relevance of the decrease caused by changes in final use volume.

The GHG index has the same trends as CO_2 emissions, although the eco-technological change in the second period has a negative sign thanks to N_2O and CH_4 technological improvement. Nonetheless, in both periods the total change of GHG index is an increase of emissions, more relevant in the second period.

Table 5. Percentage change of acidification emissions (and acidification index) and decomposition (PBA)

		1995-2000				2000-2005			
		NO_X	SO_X	NH_3	Acid	NO_X	SO_X	NH_3	Acid
Eco-technological effect	(ef_F/P_0)	-35.02	-55.20	-15.26	-38.12	-11.74	-47.14	-10.30	-22.57
Final use structure effect	(ef_s/P_0)	0.90	3.45	1.32	2.06	-0.90	-2.54	-1.39	-1.60
Final use level effect	(ef_v/P_0)	9.62	8.70	10.70	9.53	4.05	3.27	4.06	3.80
Total effect*	($\Delta P/P_0$)	-24.50	-43.05	-3.24	-26.53	-8.60	-46.40	-7.63	-20.37

Source: own elaboration from 1995, 2000, 2005 Italian NAMEA and IO tables.
Unit: %.
*: The sum does not perfectly fit because of decimal approximations

As regards acidifying gases (NO_X, SO_X, NH_3), the general decrease of emissions level during the years 1995-2000 is mainly due to a strong technological improvement, in particular for NO_X (-35%) and SO_X (-55%), only partially offset by a positive final use volume variation (close to 10%) and a positive but very small final use structure variation (between 0.8 and 3.5%).

In the years 2000-2005 the decrease of emissions continues to be very important in the case of SO_X (-47.5%). Also in this case, the driving factor is a strong eco-technological improvement. The decrease of NO_X emissions is a quarter of the decrease of the first period, due to a downfall in technological improvement. The decrease of NH_3 emissions is higher in the second period. Also in this case it is not due to a further technological improvement (eco-technological effect is actually less relevant during the years 2000-2005). It is due to the decrease of the positive final use level effect variation and to the variation of final use structure effect that in the second period becomes negative.

The main difference between the two groups of gases seems to be a stronger eco-technological improvement in the case of acidification emissions, although in both cases it is worth noticing that eco-technological improvements are more effective in the first sub-period, while in the second sub-period the negative effect of the final use volume decreases.

3.1.2. Consumption-based approach

Tables 6 and 7 show the results of SDA with the CBA. In general, the different approaches reveal common trends, but some differences in results are worth noticing.

Table 6. Percentage change of GHG emissions (and GHG index) and decomposition (CBA)

		1995-2000				2000-2005			
		CO_2	N_2O	CH_4	GHGeq	CO_2	N_2O	CH_4	GHGeq
Eco-Technological effect	(ef_F/P_0)	-9.87	-9.49	-8.25	-9.64	4.32	-5.43	-7.05	2.09
Final use structure effect	(ef_s/P_0)	2.25	0.56	1.69	2.02	-1.81	-0.44	-3.83	-1.92
Final use level effect	(ef_v/P_0)	11.23	11.15	11.28	11.23	4.26	4.08	3.98	4.21
Total effect*	$(\Delta P/P_0)$	3.61	2.22	4.71	3.61	6.76	-1.79	-6.90	4.38

Source: own elaboration from 1995, 2000, 2005 Italian NAMEA.
Unit: %.
*: The sum does not perfectly fit because of decimal approximations.

Table 7. Percentage change of acidification emissions (and acidification index) and decomposition (CBA)

		1995-2000				2000-2005			
		NO_X	SO_X	NH_3	Acid	NO_X	SO_X	NH_3	Acid
Eco-Technological effect	(ef_F/P_0)	-34.54	-54.90	-15.24	-37.10	-10.73	-47.33	-9.37	-21.54
Final use structure effect	(ef_s/P_0)	1.25	2.73	0.09	1.51	-1.13	-3.50	-1.52	-2.01
Final use level effect	(ef_v/P_0)	9.82	8.81	10.80	9.70	3.96	3.16	3.97	3.72
Total effect*	$(\Delta P/P_0)$	-23.47	-43.36	-4.34	-25.89	-7.90	-47.67	-6.92	-19.83

Source: own elaboration from 1995, 2000, 2005 Italian NAMEA.
Unit: %.
*: The sum does not perfectly fit because of decimal approximations.

As regards CO_2 emissions, in both periods the increase of emissions is stronger if we consider the CBA, mainly due to a less effective eco-technological effect, only partially compensated by a better evolution of final use structure in the second period. As regards N_2O emissions, though in the first period the two different approaches give similar results, the different factors have different weights: with the CBA the eco-technological improvement is less strong while the final use structure effect seems to be better. Also in the second period technological improvement is less relevant within the CBA. The case of CH_4 emissions is the one where results more strongly differ between PBA and CBA. The technological improvement is less relevant under the CBA, and although in the second period the structure of final use seems better, the final result under the CBA is a positive variation of emissions in the first period and a less important emission reduction in the second period.

For acidification emissions differences between the two different approaches are not relevant. Only in the second period for NO_X and NH_3 the CBA reveals a worse variation of technology, while it reveals a better structure of final use for SO_X.

Although at global level the trend of evolution of emissions is similar for both groups of gases, in general under the CBA the eco-technological effect seems to be less effective in the reduction of emissions level, while the structure of final use improves. Moreover, results differ most for GHG emissions.

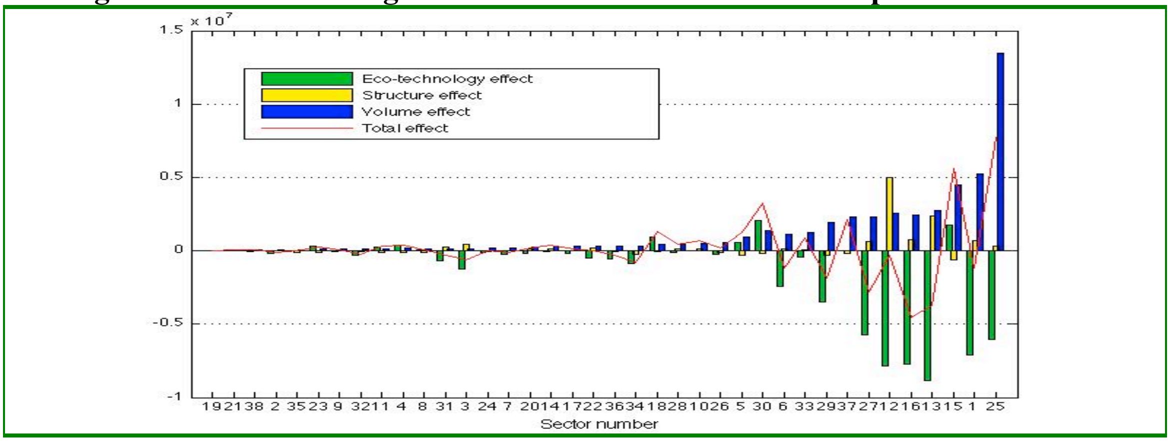
3.2. Sector-based results

The analysis of the results at a sector-based level can enrich the information found so far in two different ways. Firstly, it permits to find some explanations to the trends and the differences that the analyses at a global level have underlined. Secondly, while some sectors' peculiarities could remain hidden in the global analysis, a sector-based approach can help to highlight them. Numeric results are shown in appendixes B and C[13].

3.2.1. Production-based approach

Figures 2-5 show the results of SDA at sector level[14] for GHG emissions index and for acidification emissions index in the two sub-periods considered. Sectors are ordered according to the absolute level of emissions in the base year, so that we can graphically highlight the relation between the level of pollution, changes in emissions and changes in the driving factors. In appendix B the numeric results for all gases are reported.

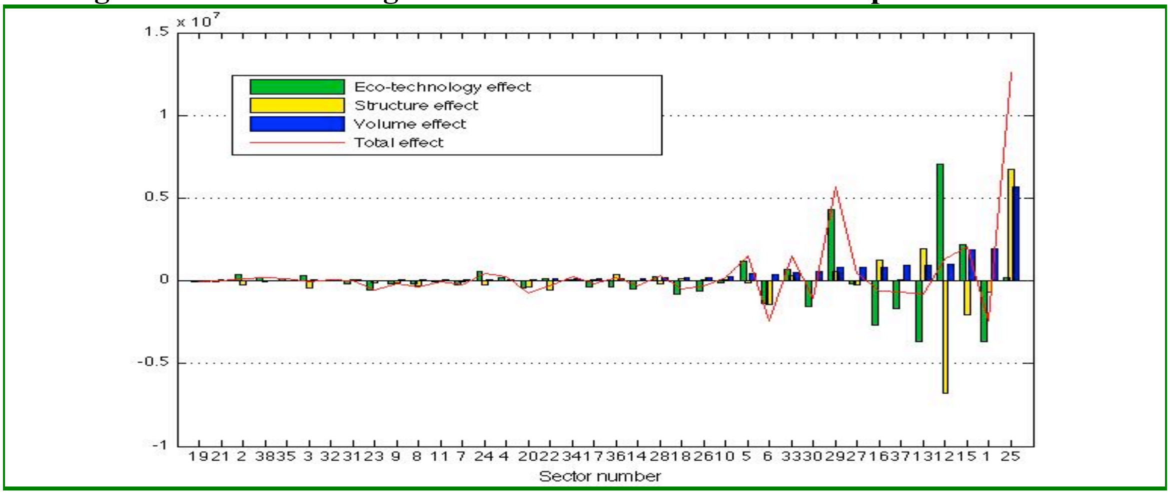
Figure 2. SDA for changes in GHG emissions index for the period 1995-2000



Source: own elaboration from 1995, 2000 Italian NAMEA and IO tables.

[13] In appendix B and C, for each gas the total emissions of economy are used as reference, such that the sum per column gives the same result as the analysis of economy as a whole.
[14] For the correspondence between numbers and sectors, see appendix A.

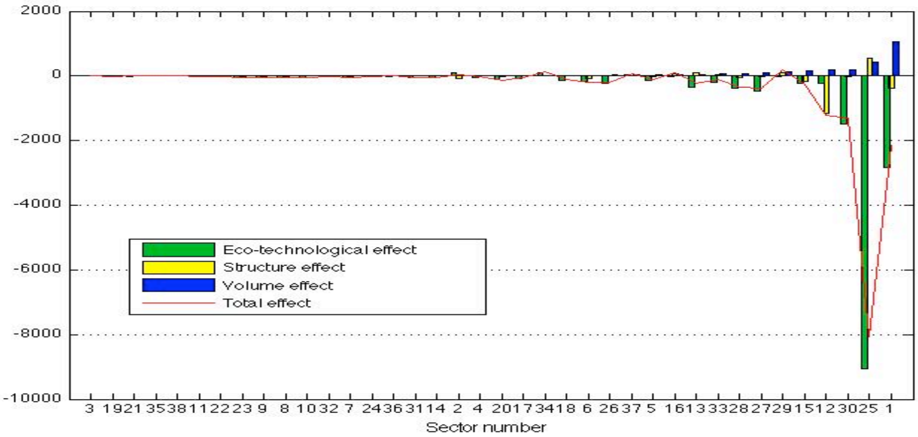
Figure 3. SDA for changes in GHG emissions index for the period 2000-2005



Source: own elaboration from 2000, 2005 Italian NAMEA and IO tables.

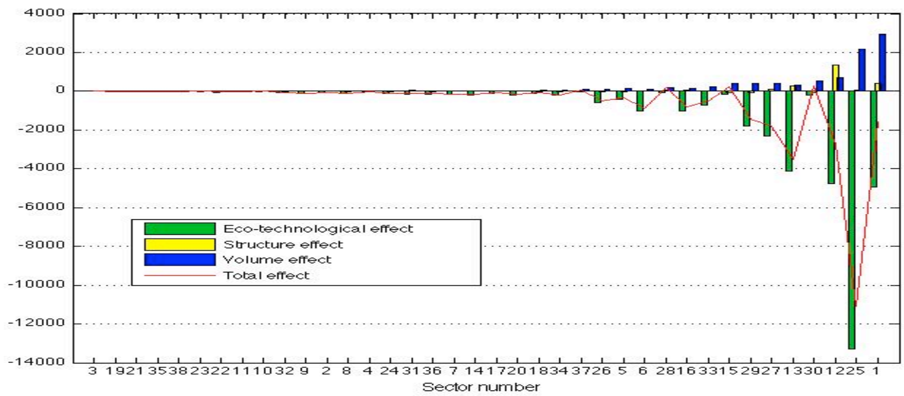
As regards GHG emissions, in case of CO_2, the main responsible for emission increase is sector 25 ('Electricity'), in the first sub-period due to an important effect of final use volume, in the second sub-period due to a worsening eco-technological effect and a worsening final use structure. Moreover, while in the first sub-period there are three sectors that help emissions to decrease through an important eco-technological improvement- 13 ('Manufacture of chemicals'), 16 ('Manufacture of basic metals) and 27 ('Wholesale and retail trade')- their relevance and their eco-technological performance gets worse in the second sub-period. Finally, another interesting result is that for sector 12 ('Manufacture of coke') the final use structure effect is significantly relevant: on the one side it offsets the eco-technological improvement in the first sub-period, but on the other side it keeps the emission increase low in the second sub-period, when a bad eco-technological performance would have brought a strong emission increase. For N_2O, the most relevant sector for the emission decrease is sector 1 ('Agriculture, hunting and forestry'), due to the technological effect. Sector 13 ('Manufacture of chemicals') has the worse performance. In the first period, it has a positive final use structure variation and a positive final use volume variation that more than compensate technological improvement and the total effect is an increase in emissions; in the years 2000-2005 it gets better thanks to eco-technological improvements. The main result for CH_4 is a strong negative eco-technological effect variation (-5.7%) for sector 1 ('Agriculture, hunting and forestry'). Also in this case the technological improvement is quite totally compensated by a positive final use volume change in the first period, while in the second period it causes a reduction of emissions change. Sector 37 ('Sewage and refuse disposal, sanitation and similar activities, other service activities') is also relevant. While in the first period there is an increase of emissions mainly caused by a strong positive final use volume change, in the second period the sector reveals a strong technological improvement (-7.5%) that causes the emissions to fall down.

Figure 4. SDA for changes in acidification emissions index for the period 1995-2000



Source: own elaboration from 1995, 2000 Italian NAMEA and IO tables.

Figure 5. SDA for changes in acidification emissions index for the period 2000-2005



Source: own elaboration from 2000, 2005 Italian NAMEA and IO tables

As regards acidifying index, a first difference that graphics highlight is that important changes in emissions are concentrated on few relevant sectors. Another important result is that for both NO_X and SO_X the main responsible for emission decrease is sector 25 ('Electricity'), thanks to an important improvement in eco-technology. This result, which could seem in contrast with the role of the same sector for CO_2 emissions, might be explained by considering the important substitution between oil and gas that characterized the Italian electricity industry in the considered period. For NO_X emissions, during the period 1995-2000 the decrease of emissions is driven, through a strong technological improvement, by sectors 13 ('Manufacture of chemicals'), 25 ('Electricity'), 27 ('Wholesale and retail trade'), and 29 ('Land transport'). During the second period the sectors that continue to show a negative eco-technological effect change strong enough to cause an emissions reduction are sectors 25 ('Electricity) and 30 ('Water-air transport'), although the first one reduces to one third its contribution (from -11% to -3.6%). For SO_X, sectors 12 ('Manufacture of coke'), 13 ('Manufacture of chemicals') and 25 ('Electricity') are the most relevant sectors for the reduction of emissions, due also in this case by a technological improvement. While the contribution of sectors 12 ('Manufacture of coke') and 13

(‘Manufacture of chemicals’) is less effective in the second, the eco-technological effect change sector 25 (‘Electricity’) is closed to -35%, and though final use volume and structure have positive changes the total effect is a decrease of emissions of 31%. The general decrease of ammonia (NH_3) is quite totally due to sector 1 (‘Agriculture, hunting and forestry’) for both periods. As in the case of the analysis of economy considered as a whole, though the technological improvement is most relevant in the first period (from -15% to -9.3%), the important reduction of the positive final use volume effect variation causes a higher reduction of emissions in the second period.

3.2.2. Consumption-based approach

As in the analysis of economy as a whole, also the SDA at the sector-based level reveals trends that are quite similar under the two different approaches, though for some sectors the analyses show different results. In appendix C the numeric results for all gases are reported. Appendix D presents a graphic comparison between PBA results and CBA results for each gas.

In some cases, differences between PBA and CBA results highlighted for the whole economy were traced back to few main relevant sectors. As for differences in the evolution of N_2O, the main responsible of a worse performance under the CBA is sector 13 (‘Manufacture of chemicals’), with a less effective technology for both periods, compensated only in the first period by a better final use structure. For the different results regarding CH_4, most responsibility lies with sector 3 (‘Mining of energy producing materials’), whose technology is worse under CBA in both periods, while final use structure is worse in the first period but it improves in the second period. As for NH_3, it’s worth noticing the role of sector 1 (‘Agriculture’) that, in the second period, is less effective in the reduction of emissions under the CBA due to a worst eco-technological effect. Finally, in CBA, sector 12 (‘Manufacture of coke’) is the main responsible for the stronger reduction of SO_X emissions in the second period, thanks to a better technology and a better structure of final use.

In other cases -as the case of the worse performance for CO_2 and NO_X under the CBA- is not possible to trace back differences only to few sectors because differences are spread among many sectors of the economy.

Finally the analysis at a sector-based level is able to highlight some differences hidden in the analysis at a global level, as the better technological performance of sector 13 (‘Manufacture of chemicals’) in the first period regarding SO_X emissions under the CBA, or the worse NO_X emissions change for sector 30 (‘Water-air transport’) under the CBA because of a worsening in both the structure of final demand and technology.

Figure 6 summarizes the main results for the most relevant sectors in the evolution of emissions for both approaches considered. In general, the two SDA proposed at a sector level highlight some differences in responsibilities if the approach is based on production or if it is based on consumption, but at a global level, in the case of Italy, the “pollution haven hypothesis” and the migration of highly pollution intensive industries abroad do not seem strongly relevant.

Figure 6. Sector with relevant influence on the evolution of emissions,1995-2005

1: Agriculture, hunting and forestry (A1-2)

NO_X In the first period it reveals a technological improvement but it is compensated by the increase of final use volume.

NH_3 It is the most important sector in the negative total emissions variation, that is higher in the second period for the important reduction of the final use volume effect.

N_2O Also in this case it is the most important sector. In both periods there is a strong technological improvement. The reduction of total emissions level in the second period is also due to the end of positive final use structure and the decrease of the positive volume variation.

CH_4 It is the most important sector in the reduction of the emissions and the path is the same as for NH_3 and N_2O emissions.

3: Mining and quarrying of energy producing materials (C10-12)

CH_4 Results change depending on the different approach. In both periods the responsibility in the increase of emissions is higher if we consider the CBA. In the first period this is due to a worse performance of all the factors considered, while in the second period there is a strong positive eco-technological effect change.

12: Manufacture of coke, refined petroleum products and nuclear fuel (D23)

SO_X In both periods there is a strong negative total emissions variation that corresponds in the first period to technological improvement (-10.5%), while in the years 2000-2005 it is explained by a strong negative final use structure effect variation.

CO_2 While in the first period the sector contributes to the reduction of emissions through an eco-technological improvement, in the second period though the final use structure variation becomes negative, the eco-technological effect variation as well as the total effect variation have positive sign.

It is the only sector that shows a better path if we consider the CBA for both SO_X and CO_2 emissions.

13: Manufacture of chemicals, chemical products and man-made fibres (D24)

SO_X It is a relevant sector for the decrease of emissions brought about by technological improvement for both periods, although the result is quite less effective in the years 2000-2005.

CO_2 Its contribution to the decrease of emissions is relevant just in the first period.

N_2O In the first period, even with technological improvement, positive final use structure and volume cause emissions to growth, while in the second period the different factors offset each other. In the consumption-based approach, the responsibility for the growth of emissions in the first period is caused by a worse technological effect and not by the final use structure effect.

25: Electricity, gas and water supply (E40-41)

NO_X In both period it is one of the most relevant sectors for the decrease of emissions, though in the years 2000-2005 its contribution falls from -11% to -3.6%.

SO_X It contributes to the decrease of emissions through technological improvements in both periods, counting in the second one for a reduction of emissions close to 30%.

CO_2 Though in the years 1995-2000 there is a negative technological effect variation, it is offsets by a positive final use structure effect variation that causes emissions to increase. In the second period the technological improvement ceases to exist.

27: Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods (G50-52)

NO_X It contributes to the decrease of emissions in a relevant way only in the first period.

CO_2 As for NO_X emissions, its contribution to the reduction of emissions due to a technological improvement is relevant only in the first period.

29: Land transport; transport via pipeline (I60)

NO_X In the first period it is a relevant sector for the decrease of emissions due to a technological improvement.

30: Water transport, Air transport, Supporting and auxiliary transport activities; activities of travel agencies (I61-63)

NO_X While in the first period it causes an increase of emissions and it is the sector that shows the worst relation between absolute level of emissions in 1995 and emissions variation, in the second period it is the only sector with sector 25 that becomes relevant for the decrease of emissions due to a technological improvement.

Its evolution in the first period is worse if we considered the consumption-based approach because of a positive final use structure variation.

37: Sewage and refuse disposal, sanitation and similar activities; Activities of membership organizations; Other service activities (O90, O91, O93)

CH_4 While in the first period there is a positive final use effect variation that causes emissions to increase, in the years 2000-2005 a strong technological improvement contributes to a relevant decrease of emissions.

4. Final remarks

In this work, the interest was to highlight through SDA how different economic factors have driven the evolution of Italian emissions during the years 1995-2005, for three GHG gases (CO_2, N_2O, CH_4) and three acidification gases (NO_X, SO_X, NH_3). The driving forces that are considered relevant are eco-technological effect, final demand structure and final demand volume.

The exercise tries to incorporate the difference between the PBA, that considers the emissions caused by the production process and it includes exported goods, and the CBA, that analyses the emissions caused by domestic and foreign production for internal demand and indeed it includes import but it does not consider export. Anyway, it is necessary to recognise that the comparison proposed has two main limitations. First, as single-region IO model, the use of the domestic technology assumption is needed, and this could be sometimes unrealistic. Second, the interpretation of the comparison is not immediate. The PBA considers the emissions related to the actual productive processes and it compares the role of technology and domestic input structure against the role of the demand that such productive system satisfies. The CBA compares the role of technology by including also imported inputs against the role of the total domestic demand. If for the one side the two analyses permit to reveal the role of the different factors under the different viewpoints- i.e. the production one and the consumption one- for the other side the comparison of the role of the same factor under the different approaches is less relevant if we consider that also the other factors are changing. However, the analysis gives a lot of information on the importance of different forces underlying the evolution of emissions for the different sectors considered, and it is a useful instrument in order to highlight the critical sectors for the achievement of the emissions reduction targets.

In general, for both periods, a negative eco-technological effect reduces the growth of emissions that otherwise the increase of the final use volume effect would cause. In the second period technological effect is less effective, while the decrease of the positive final use effect variation and a negative final use structure variation become more relevant for the decrease or the retention of emissions. If for the one side this result reveals the importance of eco-technological effect in reducing the emissions, for the other side it also underlines the role of final demand in causing emissions to increase, and this should be taken into account in order to figure out adequate policies for reaching the emission reduction targets.

The main difference between CO_2 emissions and all the other gases is the absence of an important technological improvement, in particular for the second period, when for CO_2 the technological component becomes responsible of the increase of emissions.

These general trends can considerably change depending to the sector considered. Moreover, the analysis at a sector-based level reveals the crucial role of some sector for the reduction of acidification emissions (agriculture, refusal disposal, land and water transport, energy sector, manufacture of coke and chemicals). Another interesting result is the different responsibility of sector 25 ('Energy') for the evolution of the different gases considered.

The two different analyses proposed (PBA and CBA) give similar results, although some differences at global as well as at sector-based level are relevant. Most of all, as regards the analysis of economy as a whole, for N_2O the increase of emissions is stronger in the first period if we consider a CBA, and the improvement of CH_4 emissions is less relevant. For acidification emission there are less differences. Moreover, at sector level, some sectors reveal different responsibility depending on the approach considered, in particular 'Agriculture, hunting and forestry', 'Mining of energy producing materials', 'Manufacture of coke', and 'Manufacture of chemicals'. We can finally conclude that the intent to analyze the evolution of emissions from different perspective (PBA and CBA) reveals some differences and it seems to be useful for quantifying the responsibility of different sectors and different economic factors. Anyway, results seem to show equilibrium in the balance of emissions for Italy between 1995 and 2005.

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Appendix A. Economic Sectors

N°	NACE rev 1.1	Economic Activities
1	A1-A2	Agriculture, hunting and forestry
2	B5	Fishing
3	C10-C12	Mining and quarrying of energy producing materials
4	C13- C14	Mining and quarrying, except of energy producing materials
5	D15-D16	Manufacture of food products, beverages and tobacco
6	D17	Manufacture of textiles
7	D18	Manufacture of wearing apparel; dressing and dyeing of fur
8	D19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
9	D20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
10	D21	Manufacture of pulp, paper and paper products
11	D22	Publishing, printing and reproduction of recorded media
12	D23	Manufacture of coke, refined petroleum products and nuclear fuel
13	D24	Manufacture of chemicals, chemical products and man-made fibres
14	D25	Manufacture of rubber and plastic products
15	D26	Manufacture of other non-metallic mineral products
16	D27	Manufacture of basic metals
17	D28	Manufacture of fabricated metal products, except machinery and equipment
18	D29	Manufacture of machinery and equipment n.e.c.
19	D30	Manufacture of office machinery and computers
20	D31-D32	Manufacture of electrical machinery and apparatus n.e.c., Manufacture of radio, television and communication equipment and apparatus
21	D33	Manufacture of medical, precision and optical instruments, watches and clocks
22	D34	Manufacture of motor vehicles, trailers and semi-trailers
23	D35	Manufacture of other transport equipment
24	D36-D37	Manufacture of furniture; manufacturing n.e.c., recycling
25	E40-E41	Electricity, gas and water supply
26	F45	Construction
27	G50-G52	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods
28	H55	Hotels and restaurants
29	I60	Land transport; transport via pipelines
30	I61-I63	Water transport, Air transport, Supporting and auxiliary transport activities; activities of travel agencies
31	I64	Post and telecommunications
32	J65-J67	Financial intermediation
33	K70-K74	Real estate, renting and business activities
34	L75	Public administration and defence; compulsory social security
35	M80	Education
36	N85	Health and social work
37	O90,O91,O93	Sewage and refuse disposal, sanitation and similar activities, Activities of membership organizations n.e.c., Other service activities
38	O92	Recreational, cultural and sporting activities

Appendix B. Sector-based SDA, production-based approach

Table B.1. Sector-based SDA, 1995-2000

	CO_2				N_2O				CH_4				NO_X				SO_X				NH_3			
	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0
1	-0.46	0.03	0.23	-0.20	-8.12	0.91	6.93	-0.27	-5.75	0.56	4.26	-0.93	-2.03	0.12	0.88	-1.04	-0.76	0.01	0.05	-0.70	-15.20	1.34	10.18	-3.68
2	-0.06	0.01	0.02	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.17	0.03	0.07	-0.08	-0.07	0.00	0.00	-0.06	0.00	0.00	0.00	0.00
3	-0.07	0.03	0.01	-0.03	0.00	0.00	0.00	0.00	-2.28	0.85	0.26	-1.16	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.09	-0.03	0.05	0.11	0.04	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.09	-0.03	0.04	0.11	-0.19	-0.02	0.03	-0.18	0.00	0.00	0.00	0.00
5	0.19	-0.07	0.23	0.35	-0.03	-0.04	0.14	0.07	-0.14	-0.05	0.18	-0.01	-0.24	-0.05	0.15	-0.14	-0.69	-0.03	0.09	-0.62	-0.22	-0.05	0.15	-0.11
6	-0.67	0.04	0.31	-0.33	-0.11	0.01	0.06	-0.04	-0.04	0.00	0.02	-0.01	-0.53	0.01	0.11	-0.41	-2.09	0.02	0.19	-1.88	0.01	0.00	0.00	0.01
7	-0.08	0.00	0.05	-0.03	0.01	0.00	0.01	0.02	0.00	0.00	0.00	0.00	-0.12	0.00	0.04	-0.08	-0.32	0.00	0.03	-0.30	0.01	0.00	0.00	0.01
8	0.02	-0.04	0.04	0.02	-0.01	-0.01	0.01	-0.01	0.01	-0.02	0.02	0.01	-0.12	-0.03	0.03	-0.12	-0.23	-0.02	0.02	-0.23	0.01	0.00	0.00	0.01
9	-0.02	0.00	0.04	0.01	-0.01	0.00	0.01	-0.01	0.00	0.00	0.00	0.00	-0.10	0.00	0.03	-0.07	-0.23	0.00	0.02	-0.21	0.00	0.00	0.00	0.00
10	-0.01	0.04	0.15	0.19	0.03	0.01	0.02	0.05	0.01	0.00	0.01	0.02	0.01	0.01	0.03	0.05	-0.07	0.00	0.01	-0.05	0.00	0.00	0.00	0.00
11	0.07	-0.03	0.04	0.08	0.02	-0.01	0.01	0.02	0.00	0.00	0.00	0.00	-0.02	-0.02	0.02	-0.01	-0.10	-0.01	0.01	-0.09	0.00	0.00	0.00	0.01
12	-2.15	1.38	0.71	-0.06	-0.18	0.10	0.05	-0.02	-0.36	0.14	0.07	-0.16	-1.56	0.59	0.30	-0.67	-10.54	2.82	1.46	-6.26	0.00	0.00	0.00	0.00
13	-2.22	0.47	0.54	-1.21	-2.24	1.79	2.03	1.58	-0.35	0.11	0.13	-0.11	-2.59	0.21	0.24	-2.13	-8.13	0.54	0.61	-6.97	-0.03	0.01	0.01	-0.02
14	-0.01	0.03	0.09	0.11	0.00	0.01	0.02	0.02	0.00	0.00	0.00	0.00	-0.14	0.02	0.05	-0.08	-0.39	0.01	0.04	-0.34	0.01	0.00	0.00	0.01
15	0.49	-0.16	1.24	1.56	0.02	-0.03	0.23	0.22	0.00	0.00	0.01	0.01	-0.21	-0.11	0.81	0.49	-0.18	-0.05	0.40	0.16	0.01	0.00	0.00	0.01
16	-2.14	0.22	0.67	-1.26	-0.12	0.01	0.04	-0.08	-0.10	0.01	0.03	-0.06	-1.15	0.06	0.19	-0.91	-1.60	0.08	0.26	-1.26	0.00	0.00	0.00	0.00
17	-0.05	0.00	0.08	0.04	-0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	-0.19	0.00	0.08	-0.11	-0.14	0.00	0.02	-0.12	0.01	0.00	0.00	0.02
18	0.26	-0.02	0.13	0.37	0.03	0.00	0.02	0.05	0.01	0.00	0.01	0.02	-0.03	-0.01	0.09	0.04	-0.30	-0.01	0.04	-0.26	0.02	0.00	0.00	0.02
19	0.00	-0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.01	0.01	-0.02	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
20	-0.05	0.04	0.07	0.06	0.00	0.00	0.01	0.02	-0.04	0.01	0.01	-0.02	-0.19	0.03	0.05	-0.12	-0.34	0.02	0.04	-0.28	0.01	0.00	0.00	0.01
21	0.01	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.01	0.00	-0.02	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
22	-0.14	0.06	0.08	0.00	-0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-0.11	0.02	0.03	-0.05	-0.06	0.00	0.00	-0.05	0.00	0.00	0.00	0.00
23	0.08	-0.03	0.03	0.08	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.06	-0.03	0.03	0.06	-0.05	-0.01	0.01	-0.05	0.00	0.00	0.00	0.00
24	0.00	-0.02	0.05	0.03	-0.04	-0.01	0.01	-0.03	-0.25	-0.01	0.03	-0.23	-0.12	-0.02	0.05	-0.09	-0.21	-0.01	0.02	-0.20	-0.01	0.00	0.00	0.00
25	-1.47	0.08	3.63	2.25	-0.13	0.00	0.10	-0.03	-1.89	0.03	1.33	-0.53	-12.75	0.04	1.66	-11.05	-22.80	0.10	4.06	-18.65	0.00	0.00	0.00	0.01
26	-0.05	-0.03	0.15	0.07	-0.14	-0.01	0.03	-0.12	-0.07	-0.01	0.04	-0.04	-0.78	-0.05	0.20	-0.63	-0.79	-0.02	0.11	-0.71	0.00	0.00	0.00	0.00
27	-1.57	0.18	0.62	-0.77	-0.32	0.05	0.16	-0.11	-0.19	0.02	0.08	-0.09	-5.40	0.30	1.06	-4.03	-1.42	0.04	0.14	-1.24	-0.04	0.01	0.02	-0.01
28	-0.04	0.04	0.11	0.10	0.08	0.02	0.07	0.17	0.04	0.01	0.03	0.09	-0.24	0.10	0.29	0.15	-0.07	0.06	0.19	0.18	0.13	0.03	0.08	0.23
29	-0.93	-0.08	0.54	-0.48	-0.19	-0.01	0.06	-0.14	-0.25	-0.01	0.03	-0.22	-3.85	-0.18	1.16	-2.87	-1.40	-0.02	0.10	-1.31	-0.02	0.00	0.01	-0.01
30	0.57	-0.04	0.38	0.90	0.05	0.00	0.03	0.08	-0.01	0.00	0.00	0.00	0.20	-0.11	0.92	1.01	-0.65	-0.07	0.59	-0.13	0.00	0.00	0.00	0.00
31	-0.18	0.06	0.04	-0.08	-0.02	0.01	0.00	-0.01	-0.01	0.00	0.00	-0.01	-0.39	0.12	0.07	-0.20	-0.12	0.01	0.01	-0.09	0.00	0.00	0.00	0.00
32	-0.09	-0.02	0.03	-0.07	-0.02	0.00	0.00	-0.02	-0.01	0.00	0.00	-0.01	-0.21	-0.02	0.05	-0.18	-0.05	0.00	0.00	-0.05	0.00	0.00	0.00	0.00
33	-0.13	0.01	0.33	0.22	-0.18	0.00	0.10	-0.08	0.21	0.00	0.06	0.27	-0.97	0.02	0.55	-0.40	-1.02	0.00	0.10	-0.92	0.03	0.00	0.01	0.04
34	-0.24	-0.07	0.09	-0.22	-0.08	-0.02	0.02	-0.07	-0.01	0.00	0.00	-0.01	-0.61	-0.09	0.12	-0.58	-0.07	-0.01	0.02	-0.07	0.01	0.00	0.00	0.02
35	0.00	-0.03	0.02	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.02	0.02	-0.04	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
36	-0.19	-0.02	0.07	-0.14	0.44	-0.05	0.24	0.62	-0.02	0.00	0.00	-0.02	-0.37	-0.02	0.07	-0.32	-0.06	0.00	0.01	-0.05	-0.01	0.00	0.00	-0.01
37	0.07	-0.01	0.07	0.14	0.06	-0.04	0.55	0.56	-0.66	-0.30	4.23	3.27	-0.05	-0.01	0.08	0.03	-0.03	0.00	0.01	-0.02	0.00	-0.01	0.21	0.19
38	-0.01	0.01	0.02	0.02	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.07	0.02	0.03	-0.02	-0.03	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
Tot	-11.17	2.03	10.97	1.83	-11.22	2.69	10.99	2.47	-12.16	1.35	10.88	0.06	-35.02	0.90	9.62	-24.50	-55.20	3.45	8.70	-43.05	-15.26	1.32	10.70	-3.24

Table B.2. Sector-based SDA, 2000-2005

	CO_2				N_2O				CH_4				NO_X				SO_X				NH_3			
	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0
1	0.00	-0.03	0.09	0.06	-5.14	-0.89	2.55	-3.48	-4.06	-0.55	1.57	-3.03	-1.86	-0.14	0.39	-1.61	-0.14	0.00	0.00	-0.14	-9.34	-1.35	3.86	-6.83
2	0.10	-0.07	0.01	0.04	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	-0.01	0.45	-0.33	0.04	0.16	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01
3	0.06	-0.04	0.00	0.03	0.00	0.00	0.00	0.00	0.26	-0.71	0.06	-0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.04	0.00	0.02	0.06	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	-0.04	0.00	0.02	-0.02	-0.12	0.00	0.01	-0.10	0.00	0.00	0.00	0.00
5	0.37	-0.03	0.11	0.44	-0.19	-0.02	0.05	-0.15	-0.10	-0.02	0.07	-0.05	0.02	-0.02	0.08	0.08	-0.39	-0.01	0.03	-0.37	-0.23	-0.02	0.05	-0.19
6	-0.34	-0.38	0.10	-0.63	-0.32	-0.05	0.01	-0.36	-0.05	-0.03	0.01	-0.07	0.05	-0.16	0.04	-0.07	-0.73	-0.14	0.04	-0.83	-0.01	0.00	0.00	-0.01
7	-0.06	-0.02	0.02	-0.06	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.10	-0.02	0.02	-0.10	-0.10	-0.01	0.00	-0.10	-0.01	0.00	0.00	-0.01
8	-0.04	-0.07	0.01	-0.10	-0.01	-0.01	0.00	-0.02	-0.01	-0.03	0.01	-0.04	-0.05	-0.06	0.01	-0.10	-0.10	-0.03	0.01	-0.12	-0.01	0.00	0.00	-0.01
9	-0.04	-0.02	0.01	-0.06	-0.02	0.00	0.00	-0.02	0.00	0.00	0.00	0.00	-0.09	-0.02	0.01	-0.10	-0.07	-0.01	0.00	-0.08	-0.01	0.00	0.00	-0.01
10	-0.02	0.02	0.06	0.06	-0.10	0.00	0.01	-0.09	-0.04	0.00	0.00	-0.03	-0.06	0.00	0.02	-0.04	-0.13	0.00	0.00	-0.12	0.00	0.00	0.00	0.00
11	-0.01	-0.02	0.02	-0.02	-0.03	0.00	0.00	-0.03	0.00	0.00	0.00	0.00	-0.03	-0.01	0.01	-0.03	-0.04	0.00	0.00	-0.04	-0.01	0.00	0.00	-0.01
12	1.94	-1.85	0.28	0.37	0.16	-0.14	0.02	0.04	-0.02	-0.14	0.02	-0.13	0.04	-0.79	0.12	-0.63	-1.10	-4.13	0.64	-4.59	0.01	0.00	0.00	0.01
13	-0.77	0.35	0.17	-0.24	-2.27	1.65	0.81	0.19	-0.12	0.10	0.05	0.02	0.16	0.13	0.07	0.36	-1.68	0.23	0.11	-1.34	-0.05	0.01	0.00	-0.04
14	-0.13	0.01	0.03	-0.09	-0.03	0.00	0.01	-0.02	0.00	0.00	0.00	0.00	-0.10	0.00	0.02	-0.08	-0.13	0.00	0.01	-0.12	-0.01	0.00	0.00	-0.01
15	0.57	-0.55	0.52	0.53	0.36	-0.10	0.10	0.35	0.01	0.00	0.00	0.01	-0.96	-0.44	0.41	-0.99	-0.05	-0.29	0.27	-0.07	-0.01	0.00	0.00	-0.01
16	-0.75	0.34	0.23	-0.19	0.00	0.02	0.01	0.03	0.12	0.02	0.01	0.15	0.04	0.11	0.07	0.23	-0.11	0.20	0.13	0.22	-0.01	0.00	0.00	-0.01
17	-0.10	0.02	0.03	-0.05	-0.02	0.00	0.01	-0.01	0.00	0.00	0.00	0.00	-0.21	0.02	0.03	-0.15	-0.05	0.01	0.01	-0.04	-0.02	0.00	0.00	-0.02
18	-0.22	0.04	0.05	-0.13	-0.03	0.00	0.01	-0.02	-0.04	0.00	0.00	-0.03	-0.24	0.03	0.04	-0.17	-0.31	0.01	0.01	-0.29	-0.03	0.00	0.00	-0.03
19	-0.01	-0.01	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	-0.02	0.00	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	-0.12	-0.10	0.03	-0.20	-0.01	-0.01	0.00	-0.02	-0.06	-0.01	0.00	-0.07	-0.09	-0.08	0.02	-0.15	-0.34	-0.05	0.01	-0.37	-0.01	0.00	0.00	-0.02
21	-0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.04	-0.15	0.03	-0.08	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.02	-0.07	0.01	-0.03	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
23	-0.14	-0.03	0.01	-0.16	-0.01	0.00	0.00	-0.02	0.00	0.00	0.00	0.00	-0.18	-0.03	0.01	-0.20	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00
24	0.08	-0.05	0.02	0.04	0.09	-0.02	0.01	0.07	0.58	-0.06	0.02	0.54	-0.02	-0.06	0.02	-0.06	-0.03	-0.01	0.00	-0.04	0.02	0.00	0.00	0.02
25	0.21	1.79	1.51	3.51	0.13	0.05	0.04	0.22	-1.43	0.60	0.50	-0.34	-4.65	0.55	0.45	-3.65	-34.26	1.77	1.41	-31.08	0.01	0.00	0.00	0.01
26	-0.15	0.02	0.06	-0.07	0.02	0.00	0.01	0.03	-0.17	0.00	0.01	-0.16	-0.08	0.03	0.09	0.03	-0.88	0.01	0.03	-0.85	-0.01	0.00	0.00	-0.01
27	0.01	-0.06	0.22	0.18	-0.14	-0.01	0.06	-0.10	-0.39	-0.01	0.02	-0.38	-1.04	-0.10	0.41	-0.73	-0.70	-0.01	0.04	-0.68	-0.18	0.00	0.01	-0.18
28	0.05	-0.04	0.04	0.06	0.18	-0.03	0.03	0.18	0.09	-0.01	0.02	0.09	-0.45	-0.12	0.15	-0.43	-1.34	-0.09	0.11	-1.32	0.20	-0.03	0.04	0.21
29	1.17	0.15	0.23	1.55	0.18	0.02	0.03	0.22	-0.03	0.01	0.01	-0.02	0.36	0.35	0.54	1.25	-0.40	0.01	0.01	-0.38	-0.05	0.00	0.00	-0.05
30	-0.43	-0.01	0.16	-0.28	-0.06	0.00	0.01	-0.05	0.00	0.00	0.00	0.00	-2.69	-0.01	0.46	-2.24	-3.61	-0.01	0.33	-3.29	-0.01	0.00	0.00	-0.01
31	-0.04	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.21	0.06	0.03	-0.12	-0.03	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
32	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.06	0.01	0.02	-0.03	-0.02	0.00	0.00	-0.02	-0.01	0.00	0.00	-0.01
33	0.24	0.08	0.14	0.46	0.00	0.02	0.04	0.06	-0.45	0.01	0.02	-0.42	-0.44	0.16	0.27	-0.01	-0.35	0.01	0.02	-0.31	-0.11	0.00	0.00	-0.11
34	0.00	0.02	0.03	0.06	0.10	0.01	0.01	0.11	0.00	0.00	0.00	0.00	0.48	0.04	0.06	0.58	-0.05	0.01	0.01	-0.04	-0.03	0.00	0.00	-0.03
35	0.04	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.01	0.04	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
36	0.01	0.08	0.03	0.11	-0.98	0.28	0.09	-0.60	-0.01	0.00	0.00	0.00	-0.03	0.08	0.03	0.07	-0.03	0.01	0.00	-0.01	-0.02	0.00	0.00	-0.01
37	0.46	0.00	0.04	0.50	-0.12	0.01	0.22	0.12	-7.54	0.10	1.59	-5.85	0.28	0.00	0.05	0.33	0.18	0.00	0.01	0.19	-0.32	0.01	0.08	-0.23
38	0.05	-0.01	0.01	0.05	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02	-0.01	0.02	0.02	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
Tot	2.06	-0.59	4.35	5.82	-8.26	0.76	4.15	-3.34	-13.49	-0.74	4.01	-10.22	-11.74	-0.90	4.05	-8.60	-47.14	-2.54	3.27	-46.40	-10.30	-1.39	4.06	-7.63

Appendix C. Sector-based SDA, consumption-based approach

Table C.1. Sector-based SDA, 1995-2000

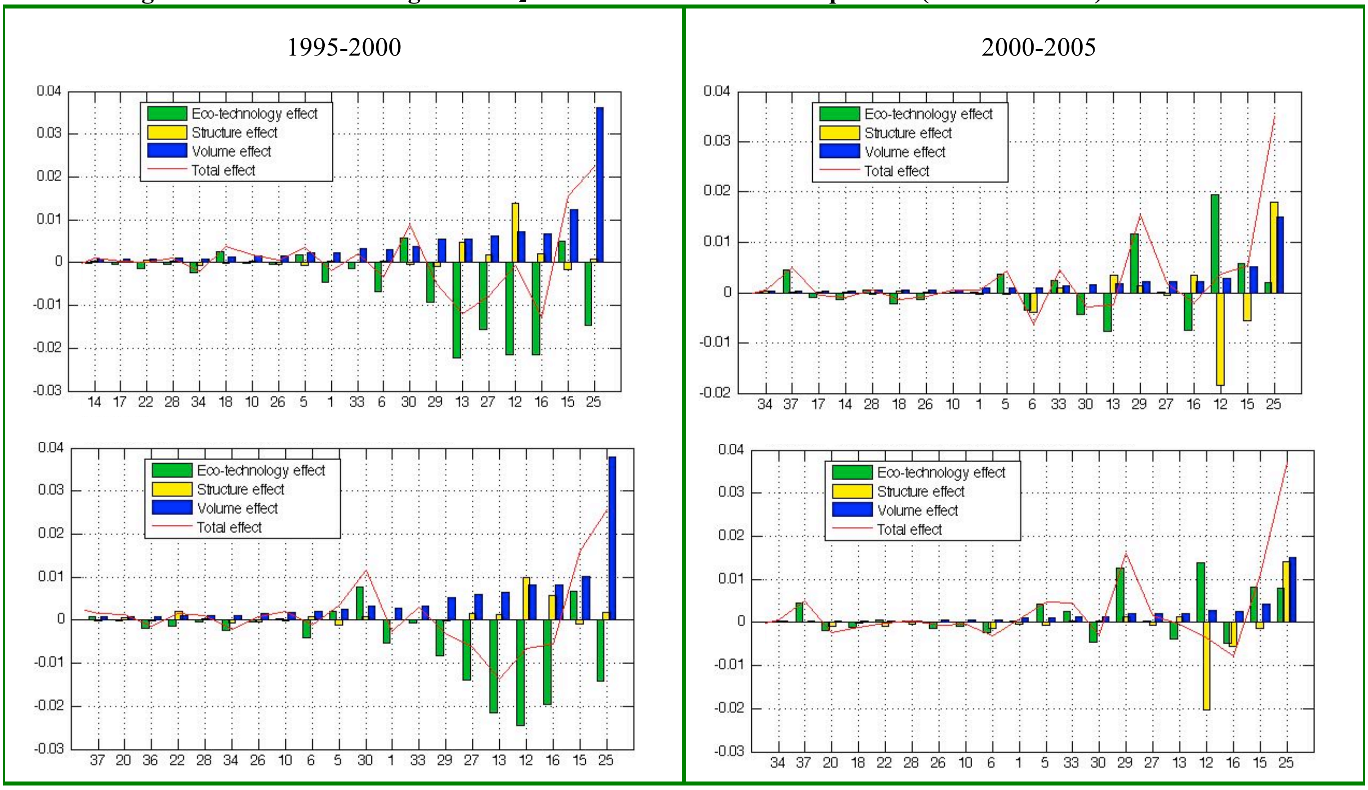
	CO_2				N_2O				CH_4				NO_X				SO_X				NH_3			
	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0
1	-0.54	0.00	0.28	-0.26	-8.32	0.10	7.22	-1.00	-5.60	0.06	4.22	-1.33	-2.40	0.01	1.06	-1.33	-0.86	0.00	0.06	-0.80	-15.19	0.14	10.33	-4.72
2	-0.06	0.01	0.03	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.17	0.05	0.09	-0.04	-0.08	0.00	0.01	-0.07	0.00	0.00	0.00	0.00
3	0.07	0.07	0.06	0.21	0.00	0.00	0.00	0.01	0.39	1.84	1.60	3.82	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.11	-0.02	0.06	0.16	0.05	0.00	0.01	0.05	0.00	0.00	0.00	0.00	0.12	-0.02	0.06	0.16	-0.26	-0.01	0.04	-0.23	0.00	0.00	0.00	0.00
5	0.20	-0.11	0.26	0.35	-0.04	-0.06	0.14	0.04	-0.13	-0.07	0.17	-0.03	-0.27	-0.07	0.17	-0.17	-0.73	-0.04	0.10	-0.67	-0.20	-0.06	0.14	-0.12
6	-0.42	0.08	0.21	-0.12	-0.06	0.01	0.04	-0.01	-0.02	0.00	0.01	0.00	-0.35	0.03	0.07	-0.25	-1.36	0.04	0.12	-1.19	0.00	0.00	0.00	0.00
7	-0.05	0.00	0.04	-0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	-0.09	0.00	0.04	-0.06	-0.25	0.00	0.02	-0.23	0.00	0.00	0.00	0.00
8	0.03	-0.02	0.03	0.03	0.00	0.00	0.00	0.00	0.01	-0.01	0.01	0.01	-0.06	-0.02	0.02	-0.06	-0.13	-0.01	0.01	-0.13	0.00	0.00	0.00	0.00
9	-0.01	-0.01	0.04	0.02	-0.01	0.00	0.01	-0.01	0.00	0.00	0.00	0.00	-0.09	-0.01	0.03	-0.07	-0.22	0.00	0.02	-0.20	0.00	0.00	0.00	0.00
10	0.04	-0.01	0.17	0.20	0.03	0.00	0.02	0.05	0.01	0.00	0.01	0.02	0.02	0.00	0.03	0.05	-0.07	0.00	0.01	-0.06	0.00	0.00	0.00	0.00
11	0.07	-0.03	0.04	0.08	0.02	0.00	0.01	0.02	0.00	0.00	0.00	0.00	-0.01	-0.02	0.02	0.00	-0.09	-0.01	0.01	-0.09	0.00	0.00	0.00	0.00
12	-2.45	1.00	0.81	-0.64	-0.18	0.06	0.05	-0.06	-0.34	0.08	0.07	-0.19	-1.79	0.43	0.35	-1.01	-11.51	1.98	1.62	-7.91	0.00	0.00	0.00	0.00
13	-2.15	0.14	0.65	-1.36	-0.67	0.46	2.17	1.96	-0.25	0.03	0.13	-0.09	-2.91	0.06	0.29	-2.55	-8.86	0.15	0.71	-8.00	-0.03	0.00	0.01	-0.02
14	0.04	0.02	0.07	0.13	0.01	0.00	0.01	0.03	0.00	0.00	0.00	0.00	-0.10	0.01	0.04	-0.05	-0.30	0.01	0.03	-0.26	0.00	0.00	0.00	0.01
15	0.68	-0.08	1.02	1.62	0.06	-0.01	0.16	0.21	0.00	0.00	0.01	0.01	0.01	-0.06	0.68	0.63	-0.06	-0.03	0.32	0.23	0.00	0.00	0.00	0.01
16	-1.95	0.58	0.82	-0.55	-0.10	0.03	0.04	-0.04	-0.08	0.02	0.03	-0.03	-1.23	0.16	0.23	-0.84	-1.63	0.22	0.30	-1.11	0.00	0.00	0.00	0.00
17	-0.02	0.03	0.07	0.08	-0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	-0.14	0.02	0.07	-0.05	-0.11	0.01	0.02	-0.08	0.01	0.00	0.00	0.01
18	0.20	0.02	0.08	0.30	0.02	0.00	0.01	0.03	0.01	0.00	0.01	0.02	0.00	0.01	0.06	0.07	-0.17	0.01	0.03	-0.14	0.01	0.00	0.00	0.01
19	0.00	0.01	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.02	0.01	0.01	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
20	-0.01	0.06	0.08	0.13	0.01	0.01	0.01	0.02	-0.03	0.01	0.01	-0.01	-0.19	0.04	0.06	-0.09	-0.34	0.03	0.05	-0.26	0.01	0.00	0.00	0.01
21	0.02	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.01	0.00	-0.02	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
22	-0.13	0.20	0.10	0.16	-0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	-0.12	0.08	0.04	0.00	-0.06	0.01	0.01	-0.05	0.00	0.00	0.00	0.00
23	0.08	-0.03	0.03	0.08	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.06	-0.03	0.02	0.06	-0.03	-0.01	0.01	-0.03	0.00	0.00	0.00	0.00
24	0.01	-0.01	0.03	0.03	-0.02	0.00	0.01	-0.02	-0.15	-0.01	0.02	-0.13	-0.08	-0.01	0.04	-0.06	-0.14	0.00	0.01	-0.14	0.00	0.00	0.00	0.00
25	-1.42	0.18	3.80	2.56	-0.12	0.00	0.09	-0.02	-1.60	0.06	1.16	-0.38	-13.30	0.09	1.76	-11.46	-22.70	0.20	4.12	-18.39	0.00	0.00	0.00	0.01
26	-0.04	-0.03	0.15	0.08	-0.12	-0.01	0.03	-0.10	-0.05	-0.01	0.03	-0.03	-0.79	-0.04	0.21	-0.63	-0.77	-0.02	0.10	-0.69	0.00	0.00	0.00	0.00
27	-1.38	0.15	0.59	-0.64	-0.25	0.04	0.14	-0.07	-0.14	0.02	0.06	-0.06	-5.01	0.27	1.03	-3.71	-1.28	0.03	0.13	-1.11	-0.03	0.00	0.02	0.00
28	-0.04	0.04	0.11	0.11	0.07	0.02	0.06	0.16	0.04	0.01	0.03	0.08	-0.24	0.10	0.31	0.17	-0.07	0.06	0.19	0.19	0.12	0.02	0.07	0.21
29	-0.82	-0.01	0.53	-0.30	-0.16	0.00	0.05	-0.10	-0.19	0.00	0.03	-0.17	-3.59	-0.03	1.15	-2.46	-1.29	0.00	0.10	-1.20	-0.02	0.00	0.01	-0.01
30	0.76	0.07	0.34	1.17	0.06	0.01	0.03	0.09	0.00	0.00	0.00	0.00	0.80	0.18	0.84	1.83	-0.17	0.11	0.51	0.45	0.00	0.00	0.00	0.00
31	-0.16	0.05	0.04	-0.07	-0.02	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01	-0.36	0.10	0.07	-0.19	-0.11	0.01	0.01	-0.09	0.00	0.00	0.00	0.00
32	-0.09	-0.01	0.03	-0.07	-0.02	0.00	0.00	-0.02	-0.01	0.00	0.00	-0.01	-0.22	-0.02	0.05	-0.19	-0.05	0.00	0.00	-0.05	0.00	0.00	0.00	0.00
33	-0.06	0.01	0.34	0.29	-0.14	0.00	0.09	-0.05	0.19	0.00	0.05	0.24	-0.86	0.02	0.56	-0.28	-0.96	0.00	0.09	-0.87	0.02	0.00	0.01	0.03
34	-0.24	-0.07	0.10	-0.22	-0.07	-0.01	0.02	-0.06	-0.01	0.00	0.00	-0.01	-0.63	-0.09	0.13	-0.60	-0.07	-0.01	0.02	-0.07	0.01	0.00	0.00	0.01
35	0.00	-0.03	0.03	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.02	0.02	-0.04	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
36	-0.19	-0.02	0.07	-0.14	0.39	-0.05	0.21	0.55	-0.02	0.00	0.00	-0.02	-0.38	-0.02	0.07	-0.33	-0.05	0.00	0.01	-0.05	-0.01	0.00	0.00	-0.01
37	0.08	-0.01	0.08	0.15	0.09	-0.05	0.49	0.53	-0.24	-0.35	3.60	3.01	-0.04	-0.01	0.09	0.04	-0.03	0.00	0.01	-0.01	0.01	-0.02	0.18	0.18
38	-0.01	0.01	0.02	0.02	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.07	0.02	0.03	-0.02	-0.03	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
Tot	-9.87	2.25	11.23	3.61	-9.49	0.56	11.14	2.22	-8.25	1.69	11.27	4.71	-34.54	1.25	9.82	-23.47	-54.90	2.73	8.81	-43.36	-15.23	0.09	10.80	-4.34

Table C.2. Sector-based SDA, 2000-2005

	CO_2				N_2O				CH_4				NO_X				SO_X				NH_3			
	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0	F^{ef}/E_0	s^{ef}/E_0	v^{ef}/E_0	DE/E_0
1	0.03	-0.04	0.10	0.09	-4.68	-0.98	2.55	-3.12	-3.44	-0.55	1.42	-2.57	-2.07	-0.17	0.44	-1.80	-0.16	0.00	0.00	-0.16	-8.55	-1.46	3.79	-6.22
2	0.12	-0.08	0.01	0.05	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	-0.01	0.54	-0.34	0.05	0.25	-0.01	0.00	0.00	-0.02	-0.01	0.00	0.00	-0.02
3	0.97	-0.24	0.04	0.77	0.03	-0.01	0.00	0.03	4.09	-3.55	0.68	1.23	0.05	-0.02	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.07	-0.01	0.03	0.09	0.03	0.00	0.01	0.03	0.00	0.00	0.00	0.00	-0.05	-0.01	0.03	-0.03	-0.15	-0.01	0.02	-0.14	0.00	0.00	0.00	0.00
5	0.43	-0.07	0.11	0.48	-0.16	-0.03	0.05	-0.14	-0.06	-0.04	0.06	-0.04	0.06	-0.05	0.08	0.09	-0.40	-0.02	0.03	-0.39	-0.20	-0.03	0.05	-0.18
6	-0.25	-0.14	0.07	-0.32	-0.20	-0.02	0.01	-0.21	-0.03	-0.01	0.00	-0.03	0.04	-0.06	0.03	0.01	-0.52	-0.05	0.02	-0.54	-0.01	0.00	0.00	-0.01
7	-0.03	-0.01	0.01	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.07	-0.01	0.01	-0.07	-0.08	0.00	0.00	-0.08	-0.01	0.00	0.00	-0.01
8	-0.04	-0.01	0.01	-0.04	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01	-0.05	-0.01	0.01	-0.05	-0.07	0.00	0.00	-0.07	-0.01	0.00	0.00	-0.01
9	-0.04	-0.01	0.01	-0.03	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.09	-0.01	0.01	-0.08	-0.07	0.00	0.00	-0.07	-0.01	0.00	0.00	-0.01
10	-0.09	0.00	0.06	-0.03	-0.10	0.00	0.01	-0.09	-0.03	0.00	0.00	-0.03	-0.08	0.00	0.02	-0.06	-0.14	0.00	0.00	-0.14	0.00	0.00	0.00	0.00
11	-0.01	-0.01	0.02	-0.01	-0.03	0.00	0.00	-0.03	0.00	0.00	0.00	0.00	-0.03	-0.01	0.01	-0.02	-0.04	0.00	0.00	-0.04	-0.01	0.00	0.00	-0.01
12	1.39	-2.02	0.27	-0.36	0.11	-0.13	0.02	-0.01	-0.05	-0.12	0.02	-0.15	-0.21	-0.88	0.12	-0.97	-2.39	-4.48	0.62	-6.24	0.01	0.00	0.00	0.01
13	-0.38	0.13	0.21	-0.04	-0.15	0.54	0.86	1.25	0.00	0.03	0.05	0.08	0.42	0.05	0.08	0.55	-1.68	0.08	0.13	-1.46	-0.04	0.00	0.00	-0.04
14	-0.10	-0.01	0.03	-0.08	-0.02	0.00	0.01	-0.02	0.00	0.00	0.00	0.00	-0.08	-0.01	0.02	-0.07	-0.11	0.00	0.01	-0.11	-0.01	0.00	0.00	-0.01
15	0.81	-0.13	0.42	1.11	0.33	-0.02	0.07	0.38	0.01	0.00	0.00	0.01	-0.56	-0.10	0.34	-0.32	0.13	-0.07	0.22	0.29	0.00	0.00	0.00	0.00
16	-0.47	-0.56	0.27	-0.77	0.02	-0.03	0.01	0.01	0.14	-0.03	0.01	0.12	0.20	-0.19	0.09	0.10	0.13	-0.33	0.15	-0.04	-0.01	0.00	0.00	-0.01
17	-0.06	-0.01	0.03	-0.04	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.15	-0.01	0.03	-0.13	-0.03	0.00	0.01	-0.03	-0.02	0.00	0.00	-0.02
18	-0.12	-0.02	0.03	-0.10	-0.02	0.00	0.00	-0.01	-0.02	0.00	0.00	-0.02	-0.14	-0.02	0.03	-0.13	-0.19	0.00	0.01	-0.19	-0.02	0.00	0.00	-0.02
19	-0.02	-0.01	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.04	-0.02	0.01	-0.06	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
20	-0.18	-0.08	0.03	-0.23	-0.02	-0.01	0.00	-0.02	-0.06	-0.01	0.00	-0.06	-0.14	-0.06	0.02	-0.18	-0.39	-0.03	0.01	-0.41	-0.01	0.00	0.00	-0.02
21	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.00	0.00	-0.01	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
22	0.05	-0.10	0.04	-0.01	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.03	-0.04	0.02	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
23	-0.12	-0.02	0.01	-0.14	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	-0.16	-0.02	0.01	-0.18	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00
24	0.07	-0.01	0.01	0.07	0.06	0.00	0.00	0.06	0.37	-0.01	0.01	0.37	0.00	-0.01	0.02	0.00	-0.02	0.00	0.00	-0.02	0.02	0.00	0.00	0.02
25	0.80	1.42	1.50	3.72	0.14	0.03	0.04	0.21	-1.03	0.38	0.40	-0.24	-4.65	0.45	0.46	-3.74	-34.10	1.41	1.38	-31.31	0.01	0.00	0.00	0.01
26	-0.14	0.02	0.05	-0.07	0.02	0.00	0.01	0.03	-0.14	0.00	0.01	-0.13	-0.08	0.03	0.08	0.03	-0.86	0.01	0.03	-0.83	-0.01	0.00	0.00	-0.01
27	0.03	-0.08	0.20	0.16	-0.12	-0.02	0.05	-0.09	-0.30	-0.01	0.02	-0.29	-0.96	-0.14	0.38	-0.72	-0.65	-0.01	0.03	-0.63	-0.15	0.00	0.00	-0.14
28	0.04	-0.04	0.04	0.05	0.15	-0.02	0.03	0.16	0.07	-0.01	0.01	0.07	-0.51	-0.13	0.15	-0.49	-1.39	-0.09	0.11	-1.37	0.17	-0.03	0.04	0.18
29	1.25	0.12	0.22	1.59	0.17	0.01	0.02	0.20	-0.02	0.00	0.01	-0.01	0.62	0.30	0.52	1.45	-0.38	0.01	0.01	-0.36	-0.04	0.00	0.00	-0.04
30	-0.46	0.04	0.14	-0.28	-0.06	0.00	0.01	-0.04	0.00	0.00	0.00	0.00	-2.70	0.13	0.42	-2.16	-3.42	0.09	0.29	-3.04	-0.01	0.00	0.00	-0.01
31	-0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.21	0.05	0.03	-0.13	-0.03	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
32	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.05	0.00	0.02	-0.02	-0.02	0.00	0.00	-0.02	-0.01	0.00	0.00	-0.01
33	0.26	0.04	0.14	0.44	0.01	0.01	0.03	0.05	-0.36	0.00	0.02	-0.34	-0.39	0.08	0.27	-0.04	-0.34	0.01	0.02	-0.31	-0.10	0.00	0.00	-0.10
34	0.00	0.03	0.03	0.06	0.09	0.01	0.01	0.10	0.00	0.00	0.00	0.00	0.48	0.05	0.06	0.59	-0.05	0.01	0.01	-0.04	-0.03	0.00	0.00	-0.02
35	0.04	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.01	0.04	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
36	0.01	0.08	0.02	0.11	-0.87	0.25	0.08	-0.54	0.00	0.00	0.00	0.00	-0.03	0.08	0.03	0.08	-0.03	0.01	0.00	-0.01	-0.01	0.00	0.00	-0.01
37	0.45	0.00	0.04	0.49	-0.12	0.01	0.19	0.08	-6.16	0.08	1.25	-4.83	0.27	0.00	0.05	0.33	0.17	0.00	0.01	0.19	-0.28	0.00	0.07	-0.21
38	0.05	-0.01	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	-0.01	0.02	0.02	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
Tot	4.32	-1.81	4.26	6.76	-5.43	-0.44	4.08	-1.79	-7.05	-3.83	3.98	-6.90	-10.73	-1.13	3.96	-7.90	-47.33	-3.50	3.16	-47.67	-9.37	-1.52	3.97	-6.92

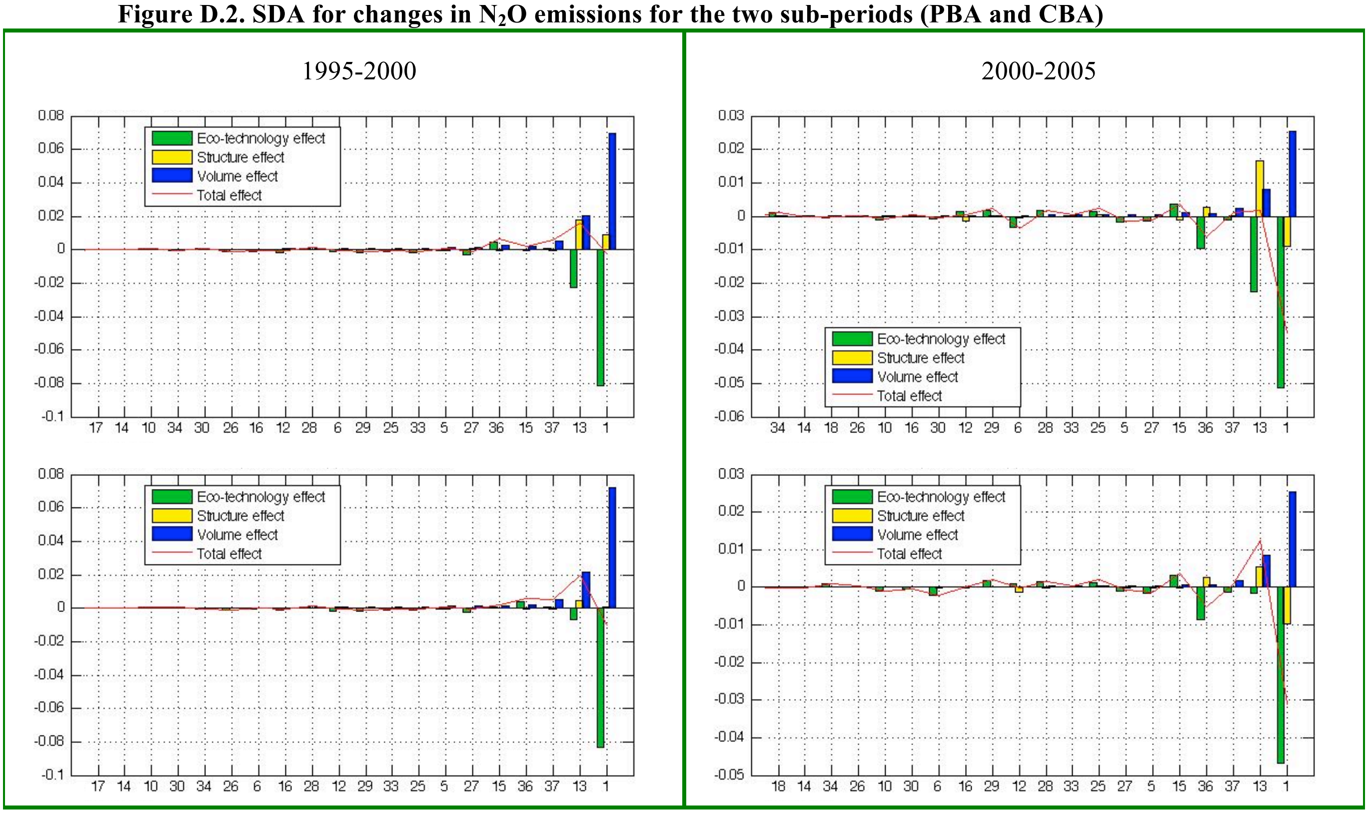
Appendix D. Graphic comparisons between PBA-SDA and CBA-SDA for the most relevant sectors

Figure D.1. SDA for changes in CO_2 emissions for the two sub-periods (PBA and CBA)



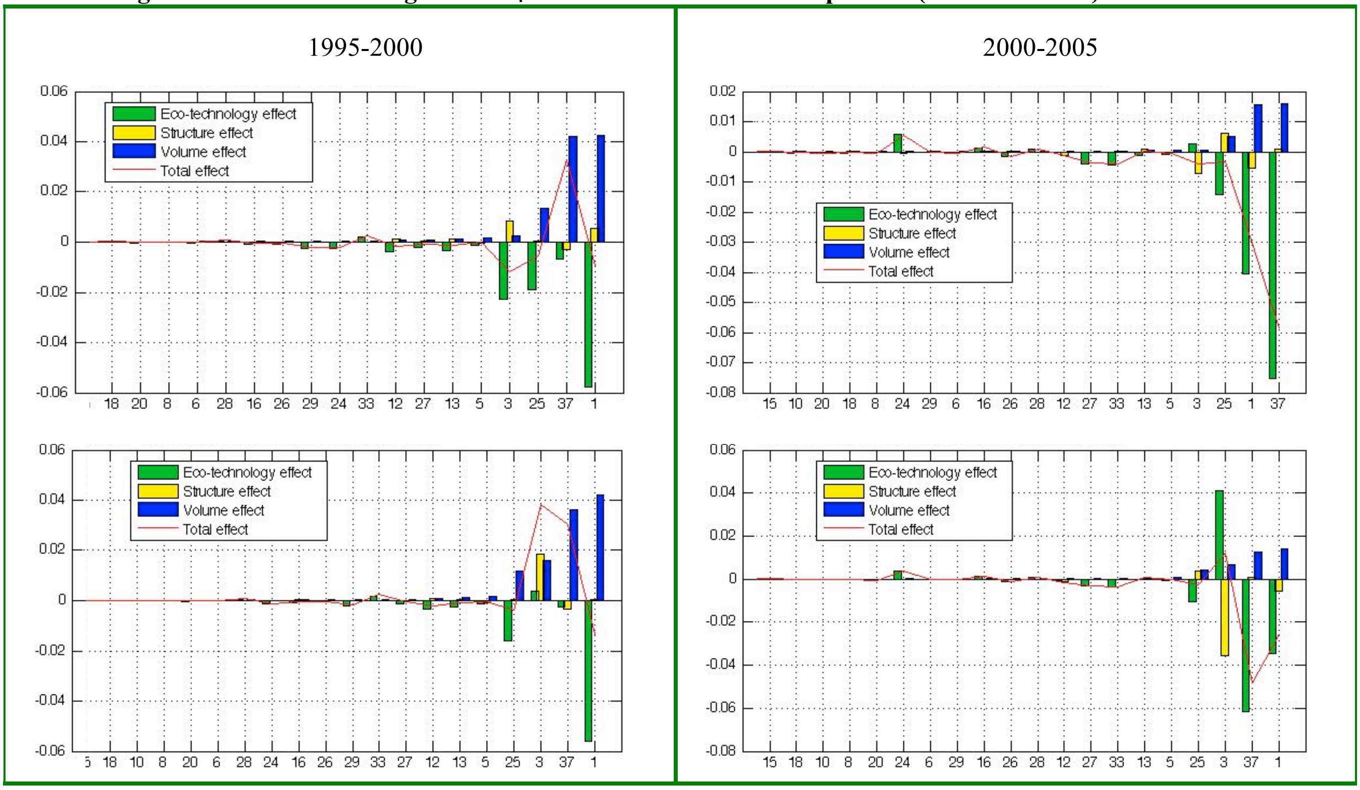
Source: own elaboration from 1995, 2000, 2005 Italian NAMEA and IO tables.

Figure D.2. SDA for changes in N_2O emissions for the two sub-periods (PBA and CBA)



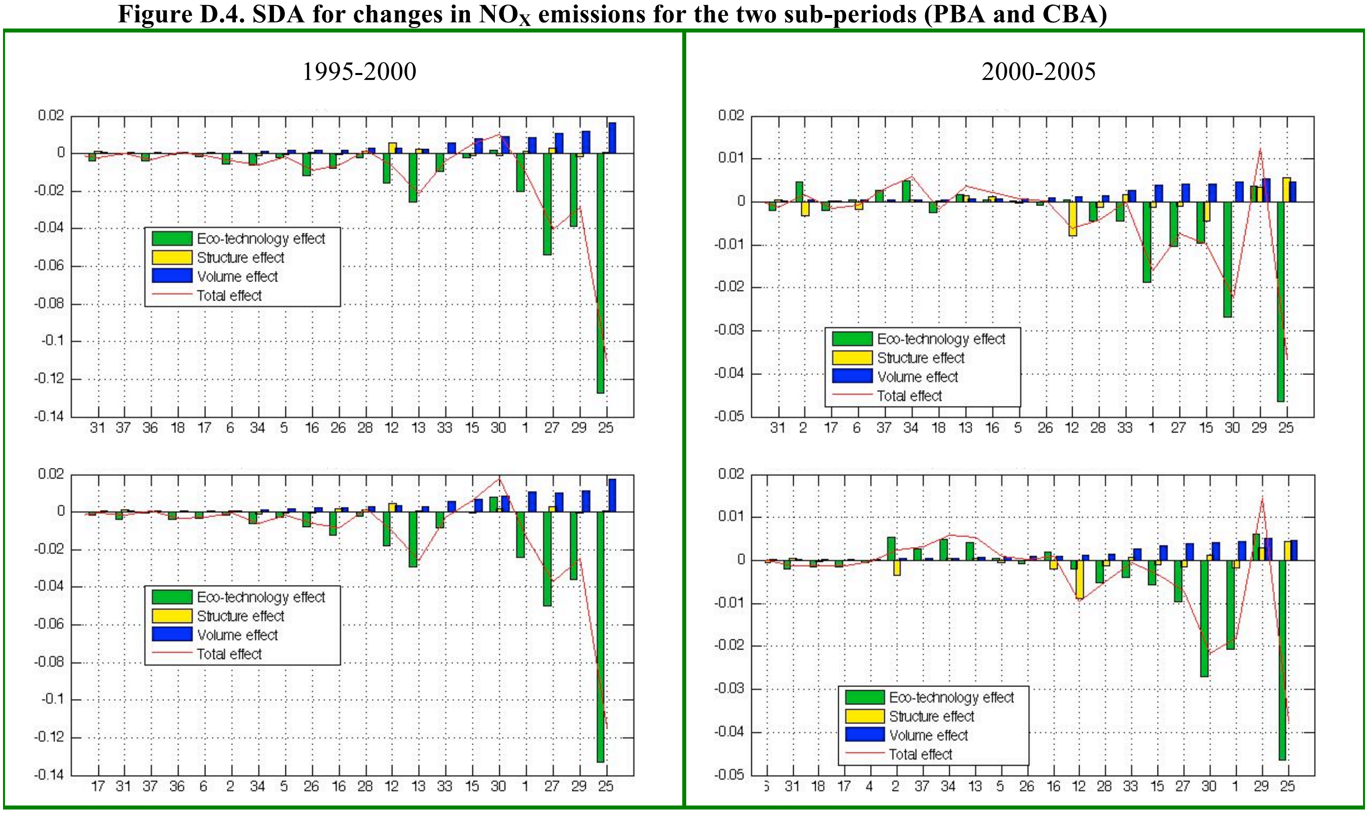
Source: own elaboration from 1995, 2000, 2005 Italian NAMEA and IO tables.

Figure D.3. SDA for changes in CH_4 emissions for the two sub-periods (PBA and CBA)



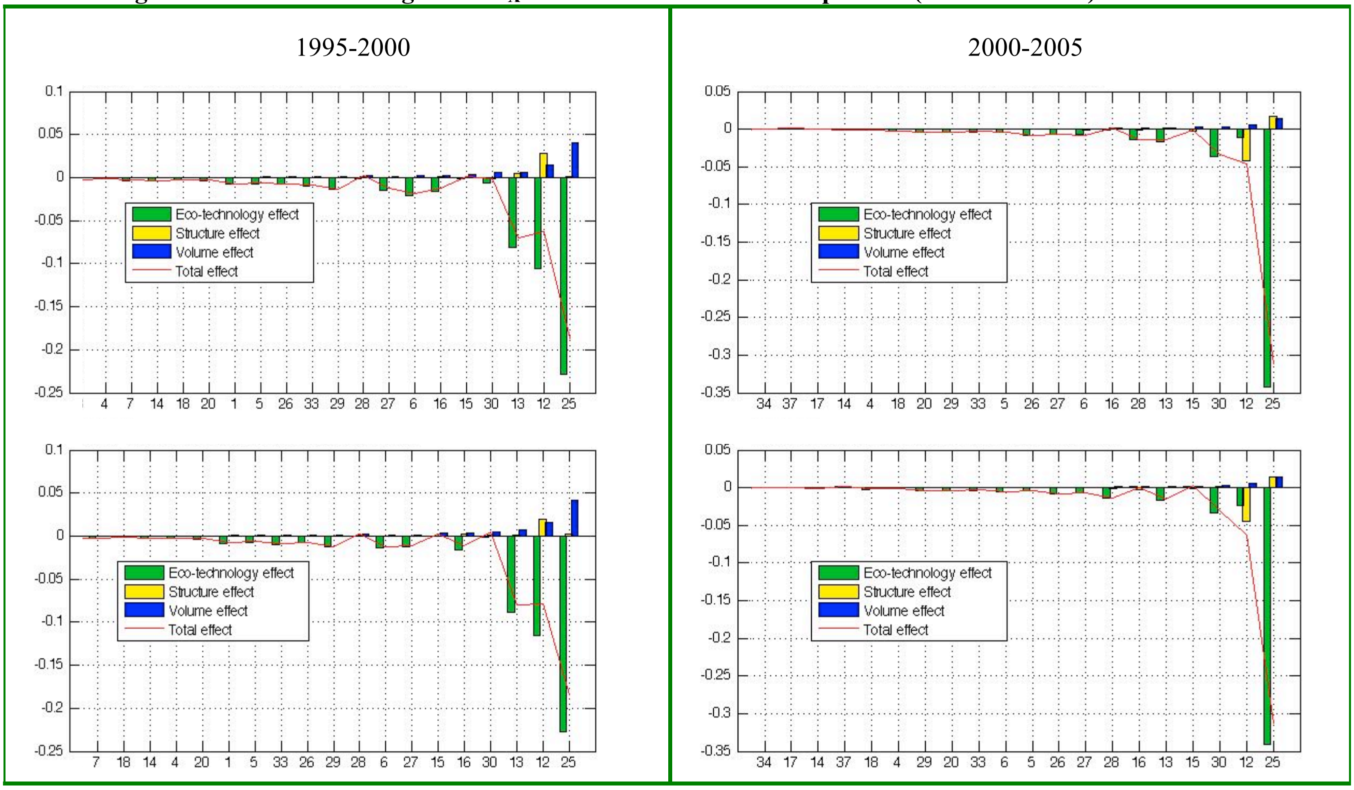
Source: own elaboration from 1995, 2000, 2005 Italian NAMEA and IO tables.

Figure D.4. SDA for changes in NO_X emissions for the two sub-periods (PBA and CBA)



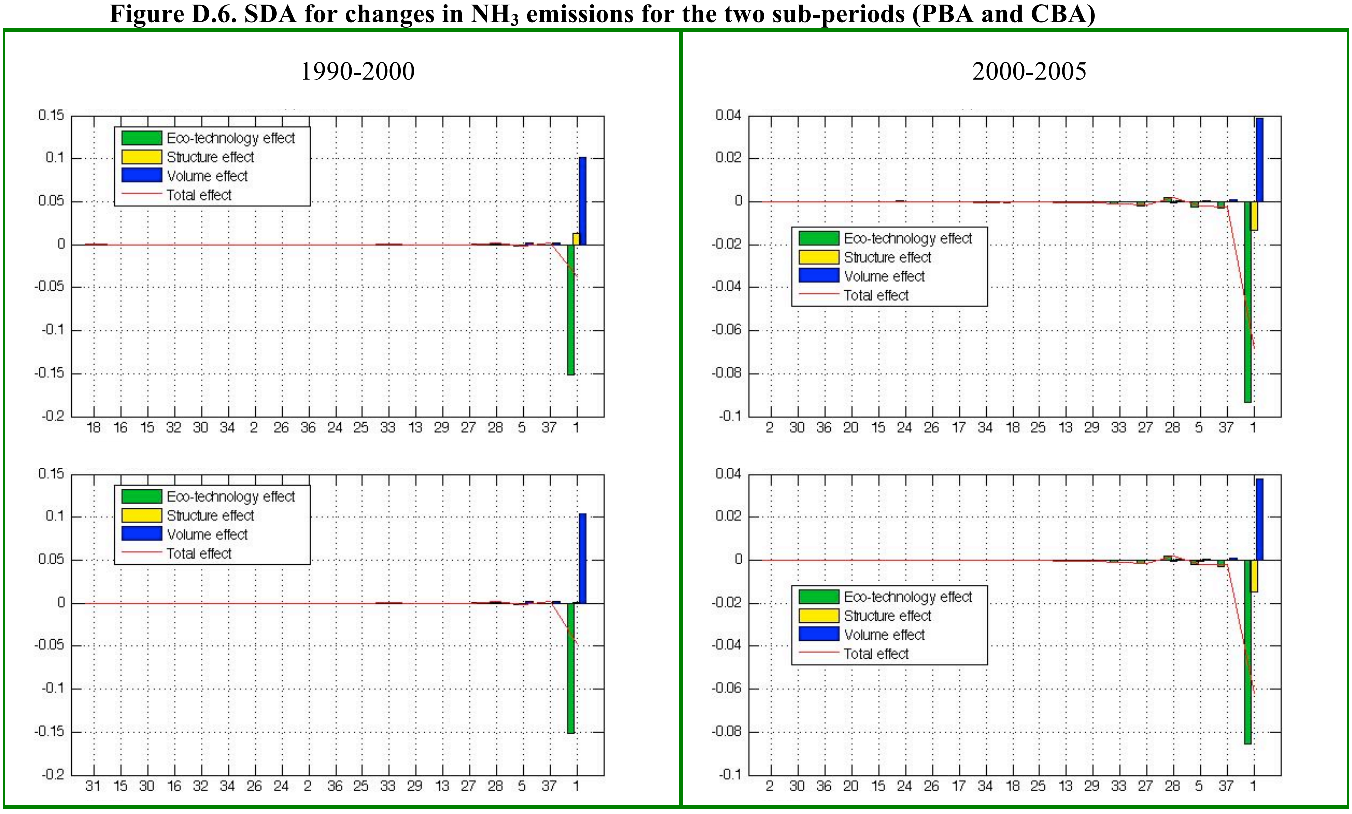
Source: own elaboration from 1995, 2000, 2005 Italian NAMEA and IO tables.

Figure D.5. SDA for changes in SO_X emissions for the two sub-periods (PBA and CBA)



Source: own elaboration from 1995, 2000, 2005 Italian NAMEA and IO tables.

Figure D.6. SDA for changes in NH_3 emissions for the two sub-periods (PBA and CBA)



Source: own elaboration from 1995, 2000, 2005 Italian NAMEA and IO tables.