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Emisiones de NOx y estrucutra productiva en España: Una perspective insumo-producto

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Resumen

El presente documento analiza las emisiones de NOx de los diferentes sectores productivos en España. A partir del análisis insumo-producto, se estudia cada sector como un subistema de la economía y se clasifica respecto a sus emisiones totales (directas e indirectas). Este análisis es útil como guía respecto al tipo de políticas pertinentes en cada sector para mitigar las emisiones de NOx. Algunos sectores que no son considerados importantes respecto a sus emisiones directas, se vuelven muy relevantes cuando se consideran las emisiones totales. Esto indica que las políticas de demanda pueden ser efectivas en estos sectores, en particular en el sector de la Construcción, pero también en algunos sectores de servicios que no parecían relevantes por su contaminación directa. De este modo, se muestra en qué sectores las políticas de demanda pueden ser útiles como complemento a las mejoras tecnológicas y mejores prácticas que se apliquen en los sectores que contaminan directamente.

Palabras clave: análisis insumo-producto, emisiones de NOx, subsistemas.

Código JEL: C63, Q53

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NOx emissions and productive structure in Spain: an input–output perspective

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Abstract

We analyse the NOx gas emissions of different productive sectors in Spain. Using input–output analysis, we study all sectors as subsystems of the economy and classify them according to the explanatory factors of their total (direct and indirect) emissions. This classification provides guidance on the type of policies that should be developed in the different sectors with the aim of mitigating NOx emissions. Some sectors that seem less important when looking at their direct emissions turn out to be highly relevant in terms of their total emissions. The results indicate that demand policies can be effective in these sectors, especially in construction, but also in some service sectors that do not appear to be important polluters at first sight. These policies can complement technical improvements and best practice measures applied to directly polluting sectors.

Keywords: input–output analysis, NOx emissions, subsystems.

JEL Codes: C63, Q53

1. Introduction

Nitrogen oxides (NO_X) refer to the combination of nitric oxide (NO) and nitrogen dioxide (NO_2). NO_2 is the main component and has significant adverse effects on health and the environment. It is a by-product associated with combustion at high temperatures, mainly generated in the combustion processes of motor vehicles and power plants. These emissions are corrosive to the skin and the respiratory tract and prolonged exposure can affect the immune and respiratory systems. They react with moisture-forming nitric acid (HNO_3) and give rise to the phenomenon of acid rain, the precipitation of which causes major damage to forests and the acidification of surface waters. Furthermore, they react with volatile organic compounds (VOCs) forming ozone (O_3), which is a threat in terms of respiratory-related health problems. NO_X is therefore an acidifying and eutrophying pollutant and an ozone precursor.[1]

The directive on National Emission Ceilings for certain pollutants (NEC Directive, Directive 2001/81/EC) set limits for each EU country for emissions of the pollutants responsible for eutrophication, acidification and ground-level ozone pollution. The pollutants targeted were NO_X, non-methane volatile organic compounds (NMVOCs), sulphur dioxide (SO_2) and ammonia (NH_3). Each country determined its own specific measures to attain compliance. These targets had to be achieved by 2010. In 2012, the EEA highlighted the serious problem that NO_X pose for Europe (EEA, 2012). The later report of the European Environment Agency (EEA, 2013) showed that Spain was the only country that had met its target and that for only one pollutant (SO_2). According to the technical reports presented by member states, eleven countries exceeded their NO_X emission limits for 2010. In 2011, seven member states (Austria, Belgium, France, Germany, Ireland, Luxembourg and Spain) still exceeded their ceilings.

Table 1 shows the objectives and figures for 2011 in the different countries affected by the directive.

[TABLE 1]

Spain clearly failed to meet the objectives established in the directive. It thus seems especially relevant to research the role of different economic activities in the generation of NO_X emissions in Spain to contribute to the design of appropriate mitigation policies.

NO_X emissions in Spain decreased 23.1% between 1990 and 2011. The share of Spanish emissions in total EU-27 emissions in 2011 was 10.8%. Although Table 1 shows that emissions in 2011 were close to the target for 2010, there is little cause for celebration. In the crisis period, the downward trend of emissions seems to have been linked more to a decline in production than to possible structural changes motivated by economic and environmental policies aimed at reducing emissions. Indeed, there was even a small upturn in 2011. Figure 1 shows that in 2007 (the year chosen for our analysis) emissions were higher than in 1990 and very similar to those of 2006 (EEA, 2013).

[FIGURE 1]

[1] http://www.prtr-es.es/ (Spanish Register of Emissions and Pollutant Sources).

However, this does not mean that there have not been changes in the period. Table 2 shows some of the variations in the distribution of emissions by major groups of polluting processes in the SNAP classification of the CORINAIR inventory.

[TABLE 2]

The input–output analysis extended to environmental variables allows a better understanding of the relationship between economic structure and environmental degradation. To indicate which types of policy measures can be more effective in controlling emissions and in which sectors, this paper proceeds to analyse NO_X emissions in Spain using an input–output subsystems approach. Our specific methodology treats each branch as a subsystem and analyses its relationships with the rest of the economy. In this way, our technique allows us to investigate in detail the factors behind the total (direct and indirect) emissions of the different sectors and thus can be of help in orientating the appropriate mitigation policies to be applied to the relevant polluting sectors.

The paper continues as follows. Section 2 sets out the methodology. Section 3 describes the data employed. Section 4 presents the results of the application of the methodology to the analysis of NO_X emissions in Spain in 2007. Section 5 concludes.

2. Methodology

The subsystems notion was first posited by Sraffa (1960). If we consider a system of industries in which each industry produces a different commodity, as happens in an input–output table, "such a system can be subdivided into as many parts as there are commodities in its net product, in such a way that each part forms a smaller self-replacing system the net product of which consists of only one kind of commodity. These parts we shall call 'sub-systems'" (p. 89).

A subsystem allows us to examine the particular production structure of each sector of the economic system, considering its relationship with the rest of the economy. Its application is then of especial interest in understanding the factors behind the pollutant emissions caused by the demand of a specific sector. This section presents how the subsystems perspective can be applied to the study of NO_X emissions. Analogous to Sraffa's *commodity-by-commodity* concept, these subsystems can be interpreted as *pollution-by-pollution* generators.

The development of the subsystems approach, as it is understood in this paper, can be found in Harcourt and Massaro (1964) and Pasinetti (1973). From an environmental perspective, Alcántara (1995) develops a widely disaggregated analysis of pollution-generating subsystems. His analysis makes it possible to study the polluting interconnections that occur in a production system in order to obtain the final demand of each sector. This is complemented by the work Sánchez-Chóliz and Duarte (2003), who applied the former methodology to the study of water pollution according to economic activity in the Spanish region of Aragon. These authors obtain five measurement indices corresponding to each productive branch and each type of pollution. Other applications can be found in Alcántara and Padilla (2009) and Butnar and Llop (2011) for CO_2 emissions in the service sector in Spain, in Navarro and Alcántara (2010) for the methane emissions of the agroindustrial subsystem in the Spanish region of Catalonia and in Piaggio et al. (2015) for the CO_2 emissions of the service sectors in Uruguay. Llop and Tol (2012) approach the analysis of greenhouse gases in Ireland from the subsystems perspective, considering all productive branches as subsystems. A complementary application of subsystems analysis was implemented by Fritz et al. (1998) to analyse the pressure of non-polluting sectors on polluting sectors in the region of Chicago.

In this paper, we propose a decomposition of the explanatory factors of the emissions associated with economic activity developing the methodology initially proposed by Navarro and Alcántara (2010). This simple decomposition does not require discussion of the analysis of the different internal components of the subsystem, given that in this case each subsystem is a unique productive branch.

Let us consider the following matrix product, in which ^ expresses the diagonalisation of a vector[2]:

$$(\mathbf{I}-\mathbf{A})^{-1}\hat{\mathbf{y}} \tag{1}$$

This product determines $\mathbf{x}^{(j)}$, expressing the amount of output that all sectors have to produce to obtain the final demand of sector *j*, such that:

$$\sum_{\mathbf{i}} \mathbf{x}^{(j)} = \mathbf{x} \tag{2}$$

denotes the total output of the economy.

Therefore, the subsystem generating the final output of sector *j* is given by:

$$\mathbf{A}\mathbf{x}^{(j)} + \mathbf{y}^{(j)} = \mathbf{x}^{(j)} \tag{3}$$

where $\mathbf{y}^{(j)}$ is a vector in which all elements take the value zero, except the value corresponding to the final demand or net output of the productive branch *j*.

The system of equations in (3) is solved as:

$$\mathbf{A}(\mathbf{I}-\mathbf{A})^{-1}\mathbf{y}^{(j)} + \mathbf{y}^{(j)} = \mathbf{x}^{(j)} \tag{4}$$

Column *j* of the matrix product $\mathbf{A}(\mathbf{I}-\mathbf{A})^{-1}$ expresses the vertically integrated output that the whole system has to obtain per unit of net output of industry *j*.

The construction of a pollution-generating subsystem is immediate. A first step in subsystems methodology is the decomposition of the vector of the pollution directly and indirectly generated by a sector to obtain its final demand into two components: emissions generated to obtain productive inputs and emissions directly generated by the sector to obtain its final demand.

Let **c** be the vector of the NO_X emissions directly generated per unit of output of the different industries. Diagonalising this, we obtain:

$$\hat{\mathbf{c}}\mathbf{A}(\mathbf{I}-\mathbf{A})^{-1}\mathbf{y}^{(j)} + \hat{\mathbf{c}}\mathbf{y}^{(j)} = \hat{\mathbf{c}}\mathbf{x}^{(j)} \tag{5}$$

[2] In this work, vectors are defined as column vectors. Thus, the conversion of a vector into a row vector is expressed by indicating its transposition with the sign (/).

Column j of the matrix product $\hat{\mathbf{c}}\mathbf{A}(\mathbf{I}-\mathbf{A})^{-1}$ expresses the generation of vertically integrated pollution that the whole system has to generate per unit of net output of industry j.

To consider all industries as subsystems, we compute the following expression:

$$\hat{\mathbf{c}}\mathbf{A}(\mathbf{I}-\mathbf{A})^{-1}\mathbf{y}+\hat{\mathbf{c}}\mathbf{y}=\hat{\mathbf{c}}(\mathbf{I}-\mathbf{A})^{-1}\mathbf{y}=\hat{\mathbf{c}}\mathbf{x} \tag{6}$$

The elements of the main diagonal of the matrix product $\hat{\mathbf{c}}\mathbf{A}(\mathbf{I}-\mathbf{A})^{-1}$ express the pollution generated by an industry per each unit of net output obtained. The rest of elements in a given column, that is, excluding the elements corresponding to the main diagonal of the column, express the pollution generated by the rest of the industries per each unit of net output of this industry. According to our approach, total (direct and indirect) emissions generated by an industry have at least two components: the *internal component*, which is given by the magnitude of the corresponding element of the main diagonal, and the *spillover*, which is given by the rest of the elements of the corresponding column.

Although from the computation of expression (6) some indicators for the characterisation of subsystems could be obtained (Alcántara, 1995), given the aim of this paper, it seems more appropriate to approach the analysis from another perspective. We wish to analyse the factors behind the impact of each sector considering its relationship with the rest of the system to indicate in each case which are the most appropriate policies to mitigate emissions. With this aim, we consider again the elements of the main diagonal. We will show that these elements include two different components.

Taking into account that $\mathbf{A(I\text{-}A)^{-1}= (I\text{-}A)^{-1}\text{-}I}$, we can transform expression (6) into:

$$\hat{\mathbf{c}}\left[(\mathbf{I}-\mathbf{A})^{-1}-\mathbf{I}\right]\mathbf{y}+\hat{\mathbf{c}}\mathbf{y}=\hat{\mathbf{c}}\mathbf{x} \tag{7}$$

Let $B=(I-A)^{-1}$, with the aim of simplifying later expressions. Considering the inversion by parts of a square matrix, the elements of the main diagonal of the Leontief inverse are given by the following expression:

$$b_{jj}=\left[(1-a_{jj})^{-1}-1\right]+(1-a_{jj})^{-1}\sum_{i\neq j}a_{ji}\,b_{ij}+1 \tag{8}$$

The first term on the right-hand side shows the internal need of industry j for its own production to obtain its final demand. This can be denoted *own internal component*. The second term shows the output from industry j required for the production of inputs that it demands from other productive branches. It is own production induced through its requirement of inputs from other industries. It is thus a *feed-back component*.

Total (direct and indirect) emissions of sector j can be decomposed as:

$$\text{Total emission}=\underbrace{c_j\left[(1-a_{jj})^{-1}-1\right]y_j}_{\text{own internal component}}+\underbrace{c_j(1-a_{jj})^{-1}\textstyle\sum_{i\neq j}a_{ji}\,b_{ij}y_j}_{\text{feed-back}}+\underbrace{\textstyle\sum_{i\neq j}c_i\,b_{ij}y_j}_{\text{spillover}}+\underbrace{c_jy_j}_{\text{scale component}} \tag{9}$$

Emissions can then be decomposed into four components: own internal component, feed-back, spillover and the other part of the internal component that can be denoted the scale component.

3. Data

The data are taken from the World Input–Output Database (WIOD) (Timmer et al., 2012). WIOD provides input–output national matrices disaggregated into 35 sectors at basic prices (in current US$) for 27 countries of the European Union and another 13 relevant economies for the period 1995–2009. In addition, WIOD provides environmental accounts for greenhouse gases, air pollutants and materials use. The vectors of air pollution are built from the environmental accounts of EUROSTAT.

The analysis is applied to Spain for the year 2007. This year is chosen because it was the last year of economic stability prior to the beginning of the current economic crisis. In this way, we can analyse the Spanish economic structure avoiding the conjunctural effects of the decline in activity. Table 3 summarises the share of sectors in total output, value-added and direct emissions of NO_X. The main direct emitters are electricity, gas and water supply (17), agriculture, hunting, forestry and fishing (1), inland transport (23) and other non-metallic mineral (11) sectors, which amount to 66.8% of total emissions (26.1%, 16.3%, 14.9% and 9.5% respectively). The share of these sectors in total output and value-added of the economy does not exceed 3% in any case.

It is also relevant to highlight the role of the construction (18) sector. Even though its share of direct emissions is lower than that of the aforementioned sectors (5.7%), it represents 15.9% of total output and 11.9% of total value-added. Taking into account these data, it would seem that in comparison to the other sectors, the construction sector has a relatively low environmental impact per unit of output.

[TABLE 3]

4. Results

Table 4 presents the results of the decomposition of sectoral emissions into the different components defined in the methodology section. While half of total emissions are produced (directly or indirectly) by the different sectors to satisfy their final demand (scale, internal and feedback components), the other half is a consequence of the pollution generated in the production of inputs required from other sectors (spillover component). Moreover, emissions are less concentrated in a small group of sectors.

The four main direct polluters—electricity, gas and water supply (17), agriculture, hunting, forestry and fishing (1), inland transport (23) and other non-metallic mineral (11) sectors—have a share of 66.8% of direct emissions, but only 22.78% of total (direct and indirect) emissions. The emissions of these sectors are mainly explained by the scale component, while the internal component is also significant for sector 17.

On the other hand, the construction (18) sector is the major polluter when total emissions are considered, amounting to 16% of total emissions. Of these emissions, 70% are a consequence of the indirect pollution induced in the rest of the economy by its demand for inputs. While the sector has an impact well below the average per unit of final demand with regard to its direct emissions, its impact in total emissions is above average. This, jointly with its disproportionally large share compared to the European context (Bielsa and Duarte, 2011), make the sector the most polluting industry. Others that are also important due to the spillover component are food, beverages and tobacco (3) and hotels and restaurants (22), which together represent 13.7% of total emissions for the economy.

[TABLE 4]

The importance of these sectors as a consequence of their indirect emissions opens up a range of options for developing mitigation measures through demand policies. These measures could complement technical improvements and the implementation of best practice in the sectors that pollute through their own production processes. Figures 2 and 3 show the relationship between the components associated with own emissions and the component related to the emissions that are required from the rest of the economy (both weighted by their final demand). This allows us to identify in which sectors demand policies (such as certification processes, improving the information given to the consumer on product labels, specific taxes or input substitution programmes) will be more effective. Besides the three aforementioned sectors, transport equipment (15), other community, social and personal services (34), public administration (31), real estate activities (29), health and social work (33) and renting of machinery and equipment (30) can be highlighted. In particular, some of these are service activities, the role of which could wrongly be considered irrelevant if only indirect emissions were evaluated.

[FIGURE 2]

[FIGURE 3]

5. Conclusions

In spite of the impact of the economic crisis, Spain still did not meet its European commitments on the mitigation of NO_X emissions in 2011. To guide mitigation policy, this research has applied the input–output subsystems methodology to analyse the relationship between the Spanish productive structure and NO_X emissions for the year 2007, the last year before the economic crisis. We have analysed each industry as a subsystem, thus taking into account its relationship with the rest of the system. In this way, we have been able to determine the factors behind emissions and hence the type of policies that best fit in each case.

The results show the importance of some sectors that do not seem significant when looking only at their direct emissions. In short, when looking at total emissions, a sector that stands above the rest is the construction sector. This sector becomes the most important in terms of total emissions mainly due to the indirect pollution that it induces in the sectors that provide the inputs required to satisfy its final demand. Other sectors that stand out for the pollution they induce in the rest are foods, beverages and tobacco, hotels and restaurants and various service sectors. A relevant result of this research is the importance of various sectors associated with service provision. The role of these sectors in NO_X emissions may wrongly be seen as unimportant if one only looks at their direct emissions. Our analysis has allowed us to indicate the possible effectiveness in these sectors of various demand policies aimed at complementing technological and supply policies in those sectors with greater significance in terms of their direct emissions.

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Table 1: NO_X emission data and emission ceilings for 2010 and 2011

Member State	NO_X final emission data 2010 (Gg)	NO_X provisional emission data 2011 (Gg)	NO_X ceilings
Austria	147.5	144.2	103
Belgium	220.7	210.1	176
Bulgaria	116.9	115.8	247
Cyprus	18.0	20.8	23
Czech Republic	239.1	225.3	286
Denmark	133.5	125.5	127
Estonia	36.7	35.6	60
Finland	166.2	155.4	170
France	1,075.3	1,005.0	810
Germany	1,331.9	1,292.9	1,051
Greece	318.8	295.5	344
Hungary	162.5	129.2	198
Ireland	75.4	67.6	65
Italy	963.6	936.6	990
Latvia	34.3	32.0	61
Lithuania	54.8	50.5	110
Luxembourg	17.9	18.0	11
Malta	8.1	7.9	8
Netherlands	274.1	259.4	260
Poland	863.4	850.7	879
Portugal	185.6	175.8	250
Romania	217.9	221.4	437
Slovakia	88.6	85.0	130
Slovenia	44.7	44.4	45
Spain	901.1	934.1	847
Sweden	153.4	145.5	148
United Kingdom	1,106.6	1,033.1	1,167

Source: EEA (2013).

Table 2: Distribution of NO_X emission in 2000 and 2011

		2000		2011	
	SNAP groups	**t**	**%**	**t**	**%**
1	**Combustion in energy production and transformation**	341,319.8	24.1	218,774.7	20.6
2	**Small combustion (Non-industrial combustion plants)**	44,881.6	3.2	48,499.4	4.6
3	**Combustion in industry**	192,219.9	13.6	169,885.4	16.0
4	**Production processes without combustion**	10,448.7	0.7	8,993.5	0.8
7	**Road transport**	533,559.6	37.7	337,140.9	31.8
8	**Other transport and mobile machinery**	214,375.1	15.1	212,370.1	20.0
9	**Waste treatment and disposal**	4,941.0	0.3	4,436.4	0.4
10	**Agriculture**	26,415.5	1.9	20,928.0	2.0
11	**Nature**	47,236.9	3.3	39,077.4	3.7
	TOTAL SECTORS	1,415,398	100	1,060,105	100

Source: MAGRAMA (2013), CORINAIR inventory.

Table 3: Output, value-added, and direct emissions of NO_X. Spain 2007

		Output		Value Added		NO_X	
	Sector	**US$:**	**%**	**US$:**	**%**	**Tons.**	**%**
1	**Agriculture, Hunting, Forestry and Fishing**	65,043.9	2.3%	37,279.0	2.9%	196,205.7	16.3%
2	**Mining and Quarrying**	9,175.5	0.3%	3,559.2	0.3%	7,543.1	0.6%
3	**Food, Beverages and Tobacco**	128,145.9	4.5%	26,708.3	2.1%	22,911.7	1.9%
4	**Textiles and Textile Products**	22,658.5	0.8%	6,701.7	0.5%	8,285.7	0.7%
5	**Leather, Leather and Footwear**	7,474.7	0.3%	1,985.9	0.2%	998.5	0.1%
6	**Wood and Products of Wood and Cork**	15,486.6	0.5%	4,433.6	0.3%	4,799.5	0.4%
7	**Pulp, Paper, Paper , Printing and Publishing**	47,053.4	1.7%	17,049.0	1.3%	14,921.7	1.2%
8	**Coke, Refined Petroleum and Nuclear Fuel**	47,171.2	1.7%	3,455.0	0.3%	45,445.5	3.8%
9	**Chemicals and Chemical Products**	65,116.6	2.3%	18,052.2	1.4%	21,870.9	1.8%
10	**Rubber and Plastics**	27,514.2	1.0%	7,826.9	0.6%	2,302.3	0.2%
11	**Other Non-Metallic Mineral**	52,455.9	1.8%	15,903.3	1.2%	114,627.9	9.5%
12	**Basic Metals and Fabricated Metal**	120,843.8	4.3%	34,762.7	2.7%	32,446.2	2.7%
13	**Machinery, Nec**	41,675.5	1.5%	14,269.6	1.1%	2,365.4	0.2%
14	**Electrical and Optical Equipment**	47,084.9	1.7%	12,052.2	0.9%	882.6	0.1%
15	**Transport Equipment**	104,715.8	3.7%	20,959.1	1.6%	5,651.3	0.5%
16	**Manufacturing, Nec; Recycling**	33,342.9	1.2%	9,485.2	0.7%	2,734.0	0.2%
17	**Electricity, Gas and Water Supply**	78,711.9	2.8%	27,118.1	2.1%	313,031.3	26.1%
18	**Construction**	443,732.3	15.6%	153,550.8	11.9%	69,042.7	5.7%
19	**Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel**	52,054.3	1.8%	21,822.5	1.7%	8,207.9	0.7%
20	**Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles**	98,269.0	3.5%	53,797.6	4.2%	25,778.7	2.1%
21	**Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods**	96,592.8	3.4%	60,659.7	4.7%	5,746.3	0.5%
22	**Hotels and Restaurants**	160,363.6	5.6%	93,361.2	7.2%	2,777.2	0.2%
23	**Inland Transport**	70,532.8	2.5%	30,593.7	2.4%	178,839.5	14.9%
24	**Water Transport**	4,388.3	0.2%	1,600.7	0.1%	65,040.8	5.4%
25	**Air Transport**	14,565.7	0.5%	4,628.2	0.4%	27,296.8	2.3%
26	**Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies**	62,782.6	2.2%	22,514.6	1.7%	8,424.2	0.7%
27	**Post and Telecommunications**	59,487.9	2.1%	28,494.1	2.2%	2,056.0	0.2%
28	**Financial Intermediation**	107,410.2	3.8%	68,583.9	5.3%	399.9	0.0%
29	**Real Estate Activities**	160,303.3	5.6%	118,489.3	9.2%	71.5	0.0%
30	**Renting of M&Eq and Other Business Activities**	190,196.6	6.7%	104,983.0	8.1%	240.9	0.0%
31	**Public Admin and Defence; Compulsory Social Security**	114,523.1	4.0%	78,348.7	6.1%	579.0	0.0%
32	**Education**	70,989.2	2.5%	61,212.0	4.7%	38.4	0.0%
33	**Health and Social Work**	113,537.7	4.0%	72,754.4	5.6%	5,835.4	0.5%
34	**Other Community, Social and Personal Services**	105,546.3	3.7%	57,885.8	4.5%	3,742.2	0.3%
Total		2,838,946.8	100%	1,294,881.3	100%	1,201,140.7	100%

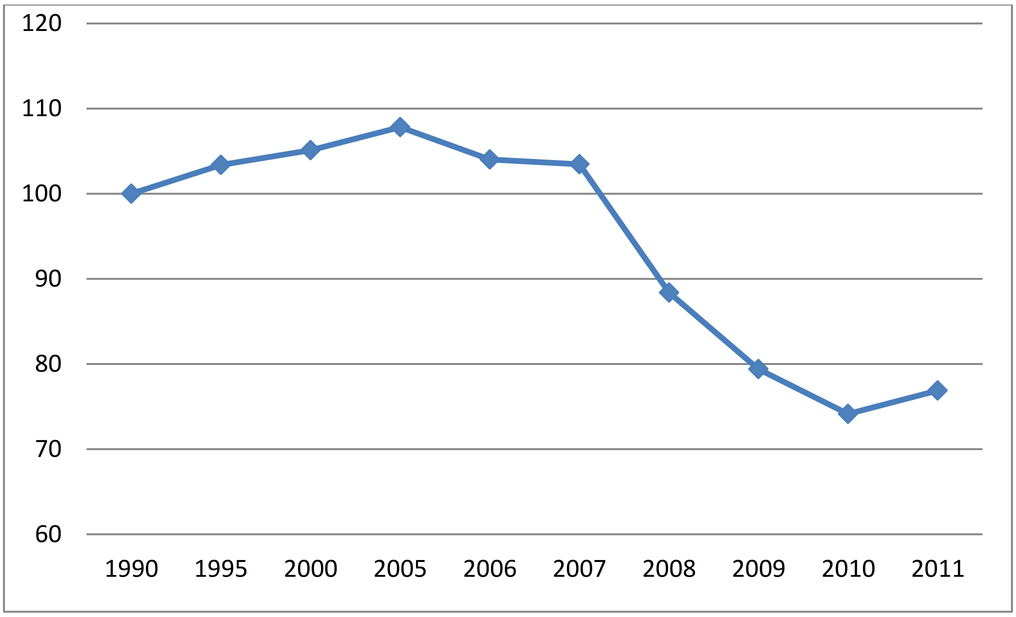
Source: Prepared by the authors with data from WIOD (2012).

Table 4: Decomposition of NO_X emissions in Spain, 2007

	Sector	Scale		Internal own		Feedback		Spillover		Total	
		Tons.	%	Tons.	%	Tons.	%	Tons.	%	Tons.	%
1	Agriculture, Hunting, Forestry and Fishing	99,815.66	85.3%	4164.9	3.6%	2414.13	2.1%	10674.99	9.1%	117069.7	9.7%
2	Mining and Quarrying	1,417.48	51.3%	12.2	0.4%	4.18	0.2%	1327.92	48.1%	2761.8	0.2%
3	Food, Beverages and Tobacco	13,693.11	13.0%	2465.3	2.3%	385.69	0.4%	88802.49	84.3%	105346.6	8.8%
4	Textiles and Textile Products	5,636.45	38.8%	836.6	5.8%	5.45	0.0%	8035.29	55.4%	14513.8	1.2%
5	Leather, Leather and Footwear	897.50	20.2%	75.9	1.7%	0.06	0.0%	3465.55	78.1%	4439.0	0.4%
6	Wood and Products of Wood and Cork	931.98	28.0%	277.8	8.4%	2.04	0.1%	2112.23	63.5%	3324.1	0.3%
7	Pulp, Paper, Paper , Printing and Publishing	5,524.06	33.7%	808.6	4.9%	48.26	0.3%	10002.36	61.1%	16383.3	1.4%
8	Coke, Refined Petroleum and Nuclear Fuel	27,734.03	83.7%	2314.2	7.0%	45.63	0.1%	3021.66	9.1%	33115.5	2.8%
9	Chemicals and Chemical Products	15,726.88	36.8%	1269.0	3.0%	54.54	0.1%	25699.38	60.1%	42749.8	3.6%
10	Rubber and Plastics	845.47	12.1%	115.9	1.7%	2.79	0.0%	6051.84	86.3%	7016.0	0.6%
11	Other Non-Metallic Mineral	21,812.97	67.5%	2542.9	7.9%	125.82	0.4%	7820.38	24.2%	32302.1	2.7%
12	Basic Metals and Fabricated Metal	9,951.32	33.1%	2473.1	8.2%	326.92	1.1%	17291.49	57.6%	30042.8	2.5%
13	Machinery, Nec	1,359.64	11.8%	74.4	0.6%	9.28	0.1%	10061.77	87.5%	11505.1	1.0%
14	Electrical and Optical Equipment	539.46	4.5%	55.7	0.5%	1.44	0.0%	11470.99	95.1%	12067.6	1.0%
15	Transport Equipment	4,447.82	12.8%	655.4	1.9%	16.66	0.0%	29570.45	85.2%	34690.3	2.9%
16	Manufacturing, Nec; Recycling	1,257.20	14.4%	39.0	0.4%	25.49	0.3%	7434.04	84.9%	8755.8	0.7%
17	Electricity, Gas and Water Supply	75,545.71	76.4%	19994.8	20.2%	799.45	0.8%	2528.32	2.6%	98868.3	8.2%
18	Construction	40,221.66	20.9%	18960.5	9.9%	590.37	0.3%	132347.47	68.9%	192120.0	16.0%
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	4,371.06	32.9%	111.8	0.8%	25.65	0.2%	8780.31	66.1%	13288.8	1.1%
20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	11,370.22	33.4%	330.0	1.0%	90.46	0.3%	22226.26	65.3%	34016.9	2.8%
21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	2,790.63	13.6%	12.7	0.1%	16.23	0.1%	17666.25	86.2%	20485.8	1.7%
22	Hotels and Restaurants	2,578.34	4.4%	2.4	0.0%	5.46	0.0%	56280.98	95.6%	58867.2	4.9%
23	Inland Transport	64,739.94	85.5%	1202.7	1.6%	2544.49	3.4%	7198.18	9.5%	75685.3	6.3%
24	Water Transport	44,616.97	96.3%	17.9	0.0%	73.80	0.2%	1608.66	3.5%	46317.3	3.9%
25	Air Transport	22,292.45	82.7%	417.0	1.5%	53.03	0.2%	4191.48	15.6%	26954.0	2.2%
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	2,740.72	12.5%	536.9	2.5%	131.56	0.6%	18448.33	84.4%	21857.5	1.8%
27	Post and Telecommunications	800.93	9.0%	116.8	1.3%	7.45	0.1%	8017.84	89.7%	8943.0	0.7%
28	Financial Intermediation	179.02	3.3%	35.3	0.7%	1.03	0.0%	5182.94	96.0%	5398.3	0.4%
29	Real Estate Activities	50.60	0.3%	0.3	0.0%	0.31	0.0%	14737.58	99.7%	14788.8	1.2%
30	Renting of M&Eq and Other Business Activities	96.42	0.5%	9.2	0.1%	2.29	0.0%	18096.80	99.4%	18204.7	1.5%
31	Public Admin and Defence; Compulsory Social Security	534.71	1.7%	1.8	0.0%	0.86	0.0%	30530.77	98.3%	31068.2	2.6%
32	Education	36.35	0.4%	0.1	0.0%	0.01	0.0%	8819.89	99.6%	8856.3	0.7%
33	Health and Social Work	5,293.51	21.1%	290.4	1.2%	4.13	0.0%	19505.95	77.7%	25094.0	2.1%
34	Other Community, Social and Personal Services	2,618.59	10.8%	358.8	1.5%	15.38	0.1%	21250.11	87.7%	24242.9	2.0%
Total		492,468.84	41.0%	60,580.60	5.0%	7,830.33	0.7%	640,260.96	53.3%	1,201,140.7	100%

Source: Prepared by the authors with data from WIOD (2012).

Figure 1. NOx emissions in Spain 1990–2011 (Index 1990 = 100)



Source: EEA (2013).

Figure 2: Multipliers of own (scale + internal + feedback) and spillover components weighted by final demand (emissions per unit of final demand)

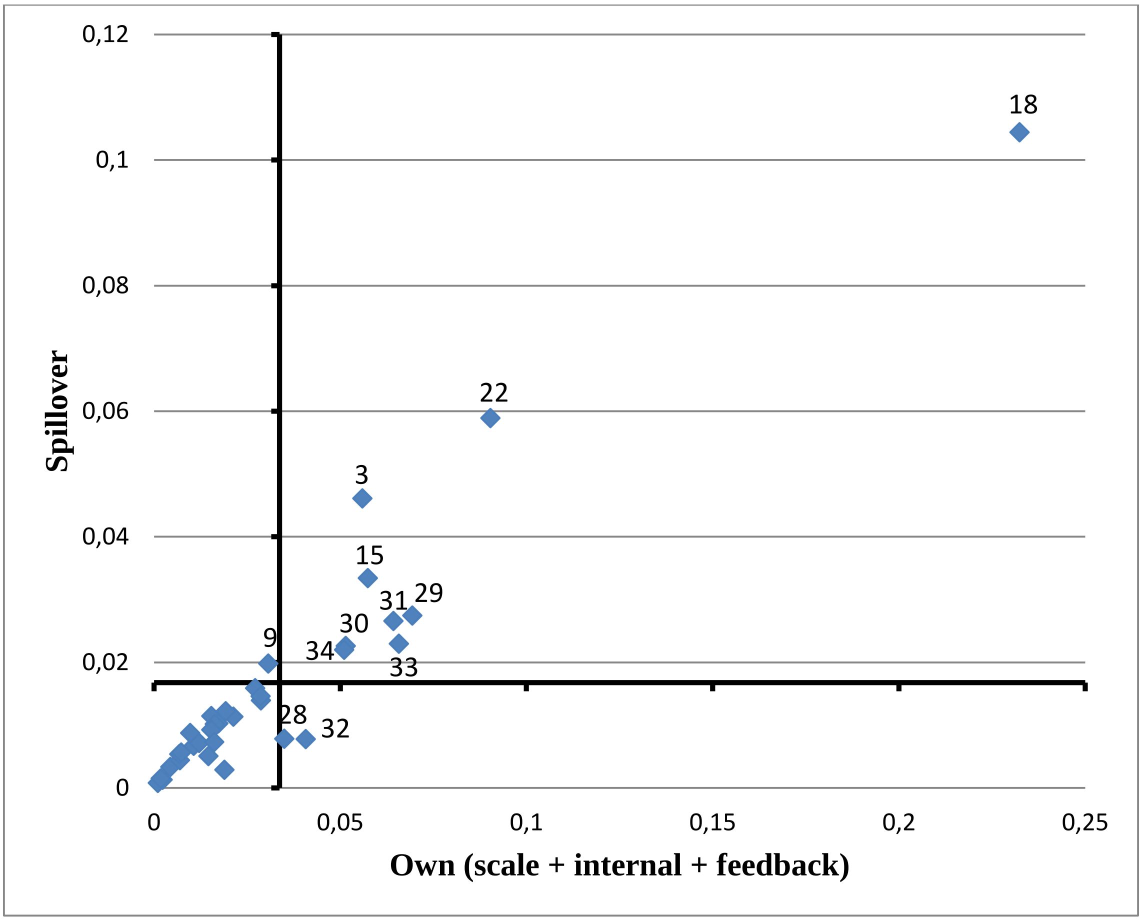
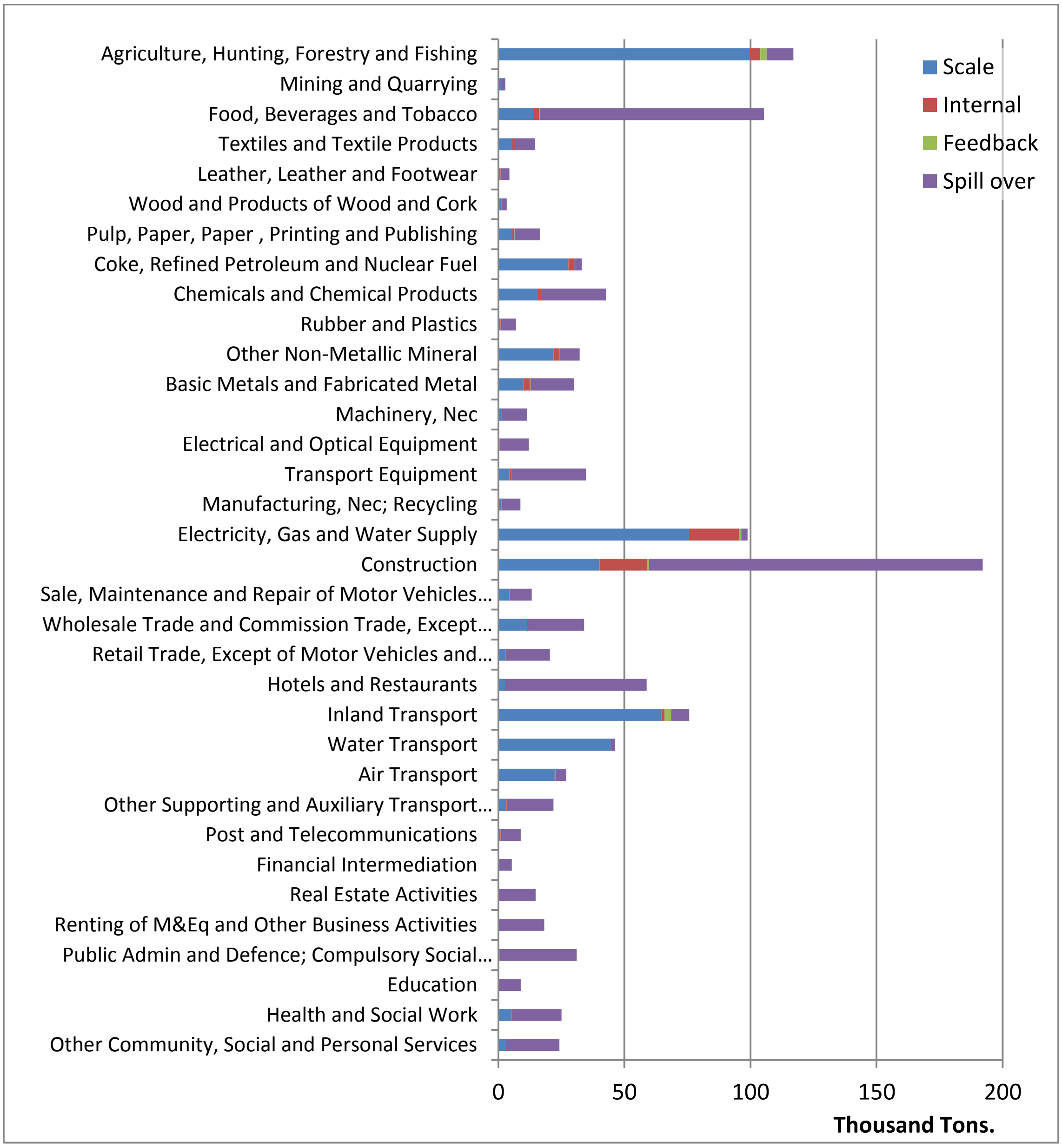


Figure 3: Multipliers of the scale, internal, feedback and spillover components weighted by final demand (emissions per unit of final demand)



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