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2 RESULTS OF AN INPUT-OUTPUT STRUCTURAL DECOMPOSITION ANALYSIS

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1 ABSTRACT

2 Decoupling road freight transport from economic growth has been acknowledged by the European Union
3 to be a key means to improving sustainability. It is therefore important to identify the drivers that explain
4 road freight transport demand in order to determine the most appropriate policy measures to reduce road
5 transport without curbing economic development. This research uses an Input–Output (IO) structural
6 decomposition analysis (SDA) to explain road freight transport in terms of a set of key variables that have
7 strongly influenced road freight demand in recent decades in European countries. This methodological
8 approach allows us to quantify the contribution of certain factors in each country —such as economic
9 growth, economic structure and the evolution of road freight transport intensity (including improvements
10 in both supply and transport systems) — to road freight transportation. The empirical basis for this
11 analysis is a dataset of nine European countries which have IO tables and road transport data available
12 from 2000 to 2007, comprising data on domestic production, imports and exports as well as tonne-kms
13 for 11 types of commodity classes. The results show that aggregate road transport demand has grown –
14 driven mainly by economic activity– but this growth has been strongly curbed in some countries by
15 changes in road freight transport intensity and moderately by the dematerialization of the economy. As a
16 result, different levels of decoupling can be seen across Europe.

17 **Keywords:** *Road freight transport, input-output, decoupling, Europe, structural decomposition analysis.*

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1 INTRODUCTION

2 Transport is essential for economic development, but it is also responsible for a wide variety of
3 externalities. Past trends indicate that for decades the European transport system has been moving away
4 from sustainability and causing environmental and social problems. Specifically, in the last decade
5 transport has accounted for around a third of all final energy consumption in European Union (EU)
6 countries, and more than a fifth of greenhouse gas emissions. Moreover, road transport, the most energy
7 and carbon intensive transportation mode, has become the dominant mode of transport within Europe,
8 recording the highest share of inland freight transport in 2007 with nearly 80% tonne-kms in EU-27.

9 In this scenario there is an urgent need for actions aimed at reaching transport sustainability
10 targets at both the national and European levels. The challenge, taken up by the EU, is to increase
11 transport efficiency through the full internalization of the negative side-effects of transport (1). The EU
12 has backed a number of policy measures to reduce road freight transport-related externalities (2), and one
13 of the key tools for accomplishing this goal is to promote the decoupling of road transport growth from
14 economic development (3).

15 Decoupling means to undo the traditional link between economic growth and road transport
16 activity. This concept has been widely discussed in policy reports. For instance, it was the focus of the
17 Standing Advisory Committee on Trunk Road Assessment (SACTRA) report in the United Kingdom in
18 1999, and has also been addressed in political documents such as the European White Paper entitled
19 “European Transport Policy for 2020: Time to Decide” (4).

20 There has traditionally been a historic correlation in most countries between gross domestic
21 product (GDP) and road transport demand. However this appears to have changed over the last few years
22 with the emergence of two trends that have been observed in a number of countries. In some (e.g. Spain,
23 Germany or Sweden), road freight transport has shown continued growth but at a lower rate than the
24 growth in GDP, in a process that can be defined as relative decoupling—that is, the link between
25 transport and the economy has been weakened. In others, like the UK, transport growth has been negative
26 while economic growth has been positive, which could be defined as absolute decoupling—the link has
27 been almost broken— (5). Numerous works have studied these trends in the evolution of road transport
28 demand (see e.g. REDEFINE project —(6)—, (7), (8), (9) and (10)). The approach—both when analysing
29 a single country and when comparing the behaviour of a group of countries— has been usually to break
30 down the road transport volume into explanatory factors. The results of these studies show that
31 divergences between growth in GDP and growth in freight transport in some countries—that is to say,
32 the decoupling level—are caused by differences in characteristics such as economic structure,
33 topography, geography, size, land uses, socio-economic factors and transport infrastructure.

34 Most industrialized countries, like the UK, have been making the transition during last decades to
35 more service-oriented economies, and thus their economic growth has become progressively detached
36 from road transport demand. Other sectors such as agriculture or mining demand more tonne-kms for
37 their production processes than service sectors. As services have expanded their share of total GDP, this
38 has led to higher economic growth than in the transport sector (11).

39 Transport demand derives from economic activity, and the restructuring of the economy may lead
40 to changes in the goods produced and moved, and in transport requirements. Specifically, freight activity
41 is driven by complex and interlinked production processes and trade relationships. Recent years have seen
42 increasing specialization, new production organization systems such as ‘just-in-time’ distribution, and an
43 ever greater concentration of manufacturing and storage (12). All these factors lead to changes in
44 transport patterns, as supply chain organization influences both transport distances and modal split (3).

45 Road transport volumes are influenced by a wide range of factors that cause different trends
46 across Europe. However, the importance of each one of these factors on the final demand in each country
47 is not yet clear. This knowledge is crucial to understanding the likelihood of decoupling in the EU and of
48 achieving sustainable development.

1 Explaining road freight transport volume through a sole indicator such as GDP may in some cases
2 provide erroneous results, as this variable does not take account of all the relevant factors mentioned
3 above. In contrast, by considering the productive structure from an Input-Output (IO) approach we can
4 see the structural relationships of production over time. This information, along with the evolution of road
5 transport intensity sorted by commodity—the volume of tonne-kms demanded by each economic sector
6 in its production processes, that is tonne-kms/output— allows us to connect economic indexes such as
7 production, economic structure, inter-sector dependences, imports and exports; and technological and
8 logistical factors such as modal split, supply chain structures and road networks. IO models are very
9 useful tools for analysing the relationships between sectors of the economy, the indirect impacts of
10 changes in household expenditure patterns, and the effects of economic restructuring on transport
11 demand.

12 Following this approach, the IO structural decomposition analysis (SDA) applied to road
13 transport demand serves to explain road freight changes over time by connecting the production
14 characteristics of a particular country with the efficiency of its road transport system. This analysis
15 enables us to conduct a cross-country comparison to identify the variables influencing European road
16 freight demand in the last few years, identify the countries that have achieved significant decoupling, and
17 determine which factors have played the greatest role in decreasing road transport volume in each one.

18 Although IO techniques have been used in the past to develop road transport models (see e.g.
19 (13)), neither this type of framework nor SDA analysis have ever been applied to explain and compare
20 transport trends. It is worth noting that the SDA technique has already been used in studies on energy
21 consumption (e.g. (14) and (15)) and atmospheric pollution trends (e.g. (16) and (17)), and may also be
22 useful in explaining road freight transport trends. This paper aims to contribute to the transportation
23 literature on this subject, and is structured as follows. In Section 2 we describe the methodology and
24 define the components explaining road transport demand. In Section 3 we apply this methodology to
25 some EU countries and discuss the main results. We also develop a cross-country comparison pointing
26 out the main similarities and divergences among them while confronting our findings with previous
27 research about this topic. Finally, in Section 4 we end with some conclusions and highlight the future
28 research needed in this area.

29

30 **METHODOLOGICAL FRAMEWORK**

31 The Input-Output (IO) table is based on national accounting. Its mathematical structure consists of
32 monetary transaction flows among the economic sectors of a country. In the basic IO model (18)
33 interactions between both productive and purchasing sectors representing industries are characterized as
34 an equilibrium between total supply and total demand, and can be expressed by the equilibrium equation
35 of Leontief model $x = (I - A)^{-1}f$, where x represents the production vector—that is, the total output
36 corresponding to all sectors of the economy—, f is the final demand vector and $(I - A)^{-1}$ is the Leontief
37 inverse matrix $[L]$ — which reflects the requirements of any industry supplied by sectors—.

38 Some of the most recent economic analyses based on an IO approach have added complementary
39 information to the basic IO model structure to overcome the limitations of the information provided by
40 the IO tables. Our methodological framework follows this approach in order to identify the key factors
41 explaining road freight transport demand in each of the countries analysed. We assume that transport
42 demand of a country depends on both production levels and productive structure, which is known through
43 IO data. To define completely road freight transport demand we need in addition information about the
44 volume of tonne-kms demanded by each economic sector in its production processes—that is the road
45 freight transport intensities (RFTI) measured in tonne-kms/output—.

46 Therefore, we add a vector to the conventional IO model containing road freight transport
47 intensity by sector—from sector 1 to sector n — in each term: $RFTI = [RFTI_1, RFTI_2, \dots, RFTI_n]$.

1 Road freight transport intensity (RFTI) may vary across sectors and countries due to differences
 2 in certain aspects such as supply chain organisation and the evolution of road share compared to other
 3 modes (9). RFTI can be expressed through several ratios. These ratios are: (a) the inverse of the average
 4 value density—that is the ratio of the average weight of goods to the monetary production value
 5 (tonne/\$), which is influenced by new product design techniques, manufacturing processes, and the
 6 current tendency to use lighter materials—; (b) handling factor—referring to the number of times a
 7 product is lifted between the origin and destination in the supply chain for each type of commodity—; (c)
 8 modal split—in this case we use the data for tonnes hauled by road—; and (d) average length of haul of
 9 the journeys carried out by the hauliers of a country—which depends on the location of industrial
 10 production and storage centres and on road networks configuration.

11 As equation (1) shows, by multiplying these values we can obtain the RFTI in a certain country
 12 for sector i , that is $RFTI_i$. These values may vary over time as a result of either structural or logistical
 13 changes, and thus for an accurate analysis of road transport trends, road freight transport intensity should
 14 be estimated annually for each economic sector and country.

$$\begin{aligned}
 RFTI_i &= \frac{\text{tonnes} - km_{road,i}}{\text{Output} (\$)} = \\
 &= \underbrace{\frac{\text{tonnes}_{produced,i}}{\text{Output}_i (\$)}}_{\text{inverse of value density}} \times \underbrace{\frac{\text{tonnes}_{lifted,i}}{\text{tonnes}_{produced,i}}}_{\text{handling factor}} \times \underbrace{\frac{\text{tonnes}_{lifted,road,i}}{\text{tonnes}_{lifted,i}}}_{\text{modal share}} \times \underbrace{\frac{\text{tonne} - kms_{road,i}}{\text{tonnes}_{lifted,road,i}}}_{\text{average lenght of haul}} \quad (1)
 \end{aligned}$$

15 According to previous definition, letting T be a vector ($n \times 1$) that contains the road transport
 16 demand by commodity class, we can define a vector whose elements express the sectorial RFTI value :

$$RFTI = T' \widehat{x}^{-1} \quad (2)$$

17 Thus, we can obtain the road transport volume in the form $T = \widehat{RFTI} x$, and therefore, by using
 18 the equilibrium equation of the Leontief model $x = (I - A)^{-1}f$ we define the aggregate road transport
 19 demand T according to the following equation (3):

$$T = \widehat{RFTI} (I - A)^{-1} f = \widehat{RFTI} L[\bar{s} \sum GDP + Imp] \quad (3)$$

20 By using an annual IO table, the final demand vector can be expressed from an expenditure
 21 approach by adding the sector GDP vector and the vector of import volumes (see (19)) We have used that
 22 mathematical relation to express equation (3) and also a vector $\bar{s} = (\bar{s}_1, \bar{s}_2, \dots, \bar{s}_n)$ that expresses the
 23 participation of the sector GDP in the aggregate national GDP (that is, sectorial shares of GDP of the n
 24 productive sectors), and thus we have included the global annual value of each country's GDP.

25 The matrix $[L]$ and the vectors used— t , \bar{s} and Imp — in this transport model must reflect an
 26 identical disaggregation in the n activity branches considered. In that way, we have connected the
 27 economic behaviour expressed by the IO model together with technological and logistic factors included
 28 in the definition of RFTI.

29 Thus by applying the SDA technique (see a detailed explanation of that method in 20), we are
 30 able to break down the aggregate changes in road freight transport demand in a particular economy into
 31 the contributions of five main factors, namely: (i) changes in RFTIs; (ii) variation in production linkages
 32 depending on the inter-sector relationships described by $[L]$; (iii) changes in GDP structure, that is to say,
 33 changes in \bar{s} ; (iv) global growth or decrease in GDP; and (v) changes in import volume. This analysis thus
 34 enables us to quantify the contributions of these five variables to the evolution of road freight transport
 35 volumes in a specific country from the base year—expressed by subscript 0—to each one of the
 36 following years in the study period—subscript 1. That is to say, we explain $\Delta T^{0-1} = T^1 - T^0$ —measured
 37 in tonne-kms—, through the following equation (4), resulted from applying the decomposition theory
 38 proposed by Dietzenbacher and Los (20) to (3).

$$\begin{aligned}
\Delta T^{0-1} &= \\
&= \underbrace{\left(\frac{1}{2}\right) (\Delta \hat{t})^{0-1} [L^0(\bar{s}^0 \Sigma GDP^0 + Imp^0) + L^1(\bar{s}^1 \Sigma GDP^1 + Imp^1)]}_{\text{Road freight transport intensity change effect (C}^1\text{)}} \\
&+ \underbrace{\left(\frac{1}{2}\right) [\hat{t}^0 (\Delta L)^{0-1} (\bar{s}^1 \Sigma GDP^1 + Imp^1) + \hat{t}^1 (\Delta L)^{0-1} (\bar{s}^0 \Sigma GDP^0 + Imp^0)]}_{\text{Production linkages effect (C}^2\text{)}} \\
&+ \underbrace{\left(\frac{1}{2}\right) [\hat{t}^0 L^0 (\Delta \bar{s})^{0-1} \Sigma GDP^1 + \hat{t}^1 L^1 (\Delta \bar{s})^{0-1} \Sigma GDP^0]}_{\text{GDP structure change effect (C}^3\text{)}} \\
&+ \underbrace{\left(\frac{1}{2}\right) [(\hat{t}^0 L^0 \bar{s}^0) + (\hat{t}^1 L^1 \bar{s}^1)] (\Delta \Sigma GDP)^{0-1}}_{\text{GDP growth/decrease effect (C}^4\text{)}} \\
&+ \underbrace{\left(\frac{1}{2}\right) [(\hat{t}^0 L^0) + (\hat{t}^1 L^1)] (\Delta Imp)^{0-1}}_{\text{Imports volume change effect (C}^5\text{)}}
\end{aligned} \tag{4}$$

1 Therefore the difference between the aggregate road freight transport demand in a country over
2 two years is explained by five factors — C^1 , C^2 , C^3 , C^4 and C^5 — which are each individually contained in
3 separated lines of equation (4).

4 The first term, C^1 , captures how much of the increase or decrease in tonne-kms can be attributed
5 to changes in RFTI values in the economic sectors. The second component, C^2 , is the “production
6 linkages effect”, and shows the effect on the aggregate road freight transport volume of the different use
7 of inputs in the production processes between the years 0 and 1. This effect is caused by technological
8 changes in the economy. C^3 reflects how changes in the GDP structure modify road freight transport
9 demand—the “GDP structure effect”; and finally C^4 and C^5 quantify the contributions of GDP growth and
10 the changes in import volumes to the increase/decrease in aggregate tonne-kms respectively in a country.

11 We should point out that our methodological approach can explain the evolution of road freight
12 transport demand derived from a country’s economic activity as measured by national IO tables. Our
13 model cannot explain far-reaching shifts in traffic in countries with substantial amounts of cross-country
14 traffic, only the proportion of national and international transport in these countries.

16 **EMPIRICAL APPLICATION. SDA OF FREIGHT TRANSPORT DEMAND OF** 17 **EUROPEAN UNION COUNTRIES**

18 The empirical application is carried out in nine countries in the European Union —Germany, Spain,
19 France, the United Kingdom (UK), Italy, Finland, Sweden, Portugal and Ireland— using data from 2000
20 to 2007. We considered these countries to be representative for several reasons: first, they are among the
21 largest in Europe; second, they show notable divergences in road transport trends; and third, some of them
22 have been the target-countries of previous decoupling studies, which allows us to compare and confront
23 our results. Other large European countries were not considered as there is no available data to conduct
24 the analysis described above in the study period.

25 The information on road freight transport demand —data series of tonne-kms sorted by
26 commodity group in each country— was obtained from Eurostat. Economic data were collected from the
27 Input-Output (IO) tables compiled by the World Input-Output Database (WIOD). This dataset provides
28 the IO tables at real prices in US\$ (updated to 2011) according to the national accounts.

29 The reason for using data until 2007 is twofold: first, the lack of complete information related to
30 sector transport demand by commodity after this year; and second, the intention to avoid the impact of the
31 economic downturn in Europe which might distort the final results.

To homogenize the economic and transport data in an identical disaggregate level, we aggregated the original IO tables into eleven groups representing the main areas of economic activity. This was done based on the commodity groups included in the transport dataset. The following eleven industries are considered: (1) Food, beverage and tobacco, (2) Mining, (3) Textile sector, (4) Wood industry, (5) Paper, printing and publishing, (6) Energy: fuel and power products; (7) Chemistry, (8) Machinery and transport equipment, (9) Manufacturing, (10) Construction, and (11) Services.

Table 1 shows the total percentage of increase/decrease of road transport demand in tonne-kms by commodity group, and the variation in aggregate road transport demand for each country throughout the study period. In this research we explain these changes through the effects described above. Different patterns can be identified at a glance. In most countries the aggregate road transport volume increased, albeit unevenly, with a very wide variability range across this group of countries. However, other countries such as Finland, Italy and the UK had lower road transport volumes in 2007 than in 2000, even with real GDP growing during this period—as we also see in the table—. The question that arises now is what factors really explain these differences and how we can characterise them.

TABLE 1. Variation in road freight transport demand—in % tonne-kms— by commodity group from 2000 to 2007

Countries Sectors	DE	ES	FI	FR	IE	IT	PT	SE	UK
Food, beverage & tobacco	+27	+73	-6	+6	+40	-10	+72	+17	-23
Mining	+8	+101	-4	+15	+102	-1	+47	+22	+5
Textile sector	+33	+81	-18	-17	+37	-6	+62	-8	-25
Wood industry	+25	-22	-24	-5	+57	-18	+50	+13	-27
Papers & Printing	+48	+90	-23	-15	+500	-3	+18	-3	+30
Energy goods	-7	+32	+24	+14	+22	+7	+58	-7	-34
Chemical products	+36	+50	-6	-19	+17	-10	+120	-14	-27
Machinery & Transports	+42	+107	+37	-17	+135	-22	+84	+4	-21
Manufacturing	+24	+25	+39	-8	-33	-26	+94	+46	-21
Construction products	-10	+116	+8	+28	+57	+12	+49	+12	-4
Service products	+44	+46	±0	+26	+49	+16	+167	+30	-12
Total	+24	+74	-7	+8	+54	-3	+73	+15	-17
Δ Real GDP	+74	+146	+102	+95	+163	+93	+103	+86	+92

Countries: (DE) Germany, (ES) Spain, (FI) Finland, (FR) France, (IE) Ireland, (IT) Italy, (PT) Portugal, (SE) Sweden, (UK) United Kingdom.

Key factors driving road freight transport trends in Europe

By applying the equation (4) we calculated the contribution of the evolution of road transport intensity, production structure, GDP structure, growth in GDP and import volumes on the annual aggregate road freight transport demand for each commodity class. The contributions are measured in % of tonne-kms that road transport volume would increase/decrease due to the isolated effect produced by

1 the change in each variable. By aggregating all sector contributions for all the five components we obtain
2 the total variation in total road freight transport explained by each effect, and finally by aggregating these
3 five contributions we obtain the total change in road freight transport between the base year 2000 and the
4 other years in the study period.

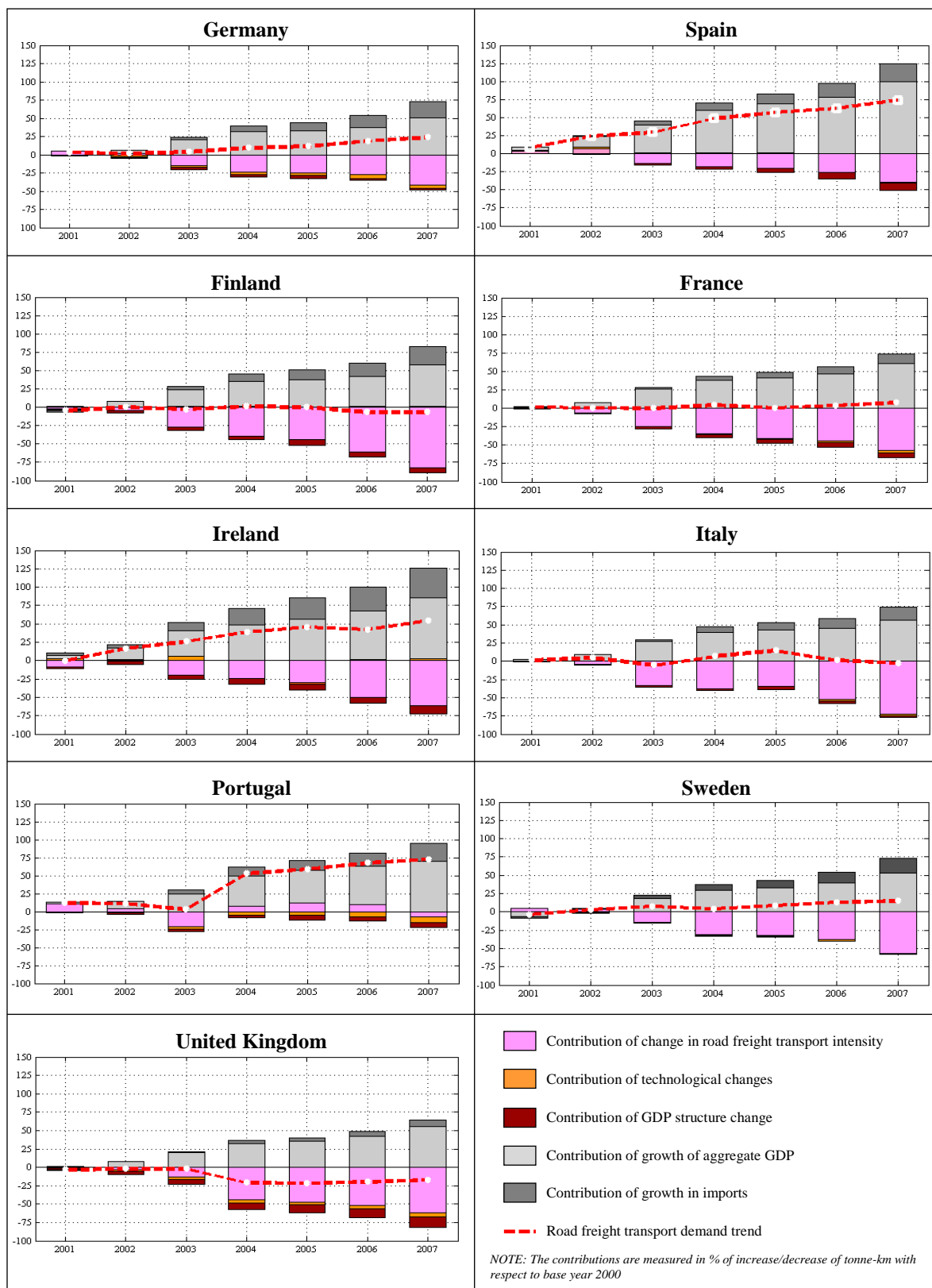
5 The sectorial results obtained by applying the decomposition expression reveal the most relevant
6 sectors fuelling road transport demand trends by adding or declining tonne-kms in each country. Overall
7 the food, beverage and tobacco sector emerges as being a key explanatory sector in road transport
8 volumes in Europe. It is the largest sector in terms of tonne-kilometres, largely due to the fact that it is
9 linked to long-distance transport, and thus has a higher road transport intensity than others. In most
10 countries the reduction of RFTI for the food, beverage and tobacco sector contributed substantially to the
11 decline in road freight transport demand. This sector has important linkages with other sectors; for
12 instance, it sells inputs to hotels and catering services.

13 Another sector worth highlighting for its positive contribution to freight transport demand in
14 some countries is the mining sector. This sector is partly driven by the construction industry, which from
15 2000 to 2007 –before the onset of the recession– grew significantly in countries such as Spain, Portugal
16 and Sweden.

17 However, despite these common patterns, the main conclusion to be drawn from the results is that
18 there are major asymmetries in the way industries contribute to increasing/decreasing road freight
19 transport volumes across the European countries in the study. This trend is largely dependent on each
20 sector's growth by country, the weight of each sector in the economy, the evolution of sector linkages,
21 and the performance of the supply chain.

22 As indicated above, the final contribution of each factor explaining road transport demand is
23 obtained as the sum of sector contributions. Figure 1 below shows the aggregate results per country
24 between 2000 and 2007. The graphs show that the growth in both GDP and imports contributed to
25 increasing tonne-kms in all countries. As a consequence of that trend, in Spain, Portugal and Ireland road
26 freight transport volume increased practically uninterruptedly at rates closely matching economic growth,
27 whereas in other countries such as Finland and Italy, road transport remained stable or even declined
28 under economic growth scenarios. This effect is mostly explained by changes in RFTIs, with moderate
29 contributions from sector production linkages and GDP structure effects. The results reveal that all these
30 countries evolved towards economies led largely by non-intensive transport sectors, and most (excluding
31 Portugal) incorporated structural, procedural and logistical changes into their supply chains that caused a
32 sustained decrease in global road freight transport intensity. All told, the most significant decoupling
33 effect took place in the UK, where road transport volume fell by 17% from 2000 to 2007 while its GDP
34 increased by 92% in the same period.

35



1
 2 **FIGURE 1. Contribution of all effects to changes in road freight transport from 2000 to**
 3 **2007**

4

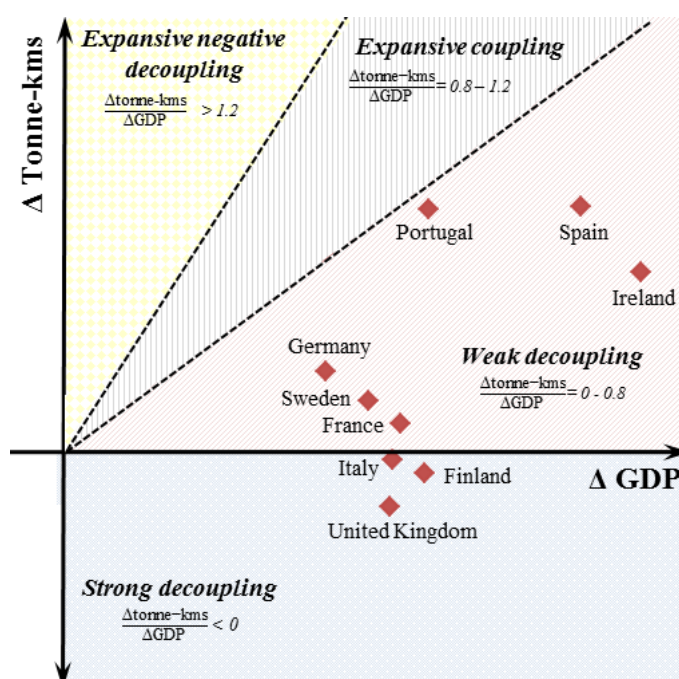
1 It is worth noting that data from Eurostat by commodity class in a country only include freight carried by
 2 domestic hauliers. Foreign-registered vehicle activity in a country—cabotage and international transport
 3 (both dispatch and receipt) carried by foreign-registered vehicles— is excluded from this type of data
 4 series.

5 However, according to Eurostat series we have verified that this activity can be considered almost
 6 negligible since it accounts for only about 1% or 2% of total tonnes lifted in all the case studies. So, this
 7 data limitation will barely distort our results.

8
 9 **Analysis of similarities and divergences through a cross-country comparison: :
 10 confrontation with previous researches**

11 In 2005, Tapio (21) cited a weak relative decoupling between freight traffic (and also for passengers) and
 12 GDP during the 1990s in five countries: Finland, Sweden, the UK, Ireland and Luxembourg. By contrast,
 13 in the Netherlands and Portugal, he identified an expansive negative decoupling while transport volumes
 14 grew at higher rates than GDP. In all the other countries of EU-15, GDP decreased during that decade
 15 while transport continued to grow. Tapio emphasized the exceptionally high elasticity values observed in
 16 Germany in that period. According to Leonardi, some drivers of that trend were the globalisation and the
 17 opening of Eastern European markets. This growth only was absorbed by the road mode due to the low
 18 competitiveness of German freight rail (22).

19 In view of our results, we can provide a classification of our sample of countries based on the degrees of
 20 coupling and decoupling of transport volume growth from economic growth given by Tapio in the above
 21 mentioned study.



22
 23 **FIGURE 1. Level of decoupling of freight transport volume from GDP in EU countries
 24 from 2000 to 2007**

25 We observe that most countries experienced a weak decoupling during last years. However, countries like
 26 the UK and Finland, where Tapio noted this situation of weak decoupling in the 90s, have already
 27 achieved a strong decoupling level. It is highlighted that other countries, like Portugal and Germany, have
 28 evolved from an expansive negative decoupling to a weak decoupling level. However, we observed that
 29 Portugal is still very near to the coupling region because its transport volume continues to grow closely to
 30 economic growth.

On the basis of the results obtained from the analysis of previous subsection, we can clearly identify groups of countries where some significant factors have strongly promoted decoupling. In order to synthesise all this information, we conduct a cross-country comparison focused on the three first aggregate contributions, which do not depend on national economic growth but on the evolution of structural and logistical features namely: road transport intensity evolution (C^1), production linkages effect (C^2) and GDP structure effect (C^3). These may be influenced in one way or another by structural and good supply' companies decisions and strategies, as well as by some policy measures. We use the value of the total contributions of these factors for each country (graphically represented in Figure 1). By contrasting them with the average value we can classify the countries (Table 2) in terms of their behaviour compared to the average contribution of each factor. In countries above the average, these factors contribute more to increasing road freight traffic and less to decoupling.

TABLE 2. Classification by countries on the basis of their contributions to decreasing road transport demand

$C^1 > C^1_{\text{mean}}$ (*)	$C^2 > C^2_{\text{mean}}$ (**)	$C^3 > C^3_{\text{mean}}$ (***)
Portugal, Spain, Germany	Ireland, Finland, Spain, Sweden, Italy	Sweden, Germany, Italy, Finland
$C^1 < C^1_{\text{mean}}$	$C^2 < C^2_{\text{mean}}$	$C^3 < C^3_{\text{mean}}$
Sweden, France, Ireland, United Kingdom, Italy, Finland	France, Germany, United Kingdom, Portugal	France, Portugal, Spain, Ireland, United Kingdom

(*) C^1 is the contribution of changes in road freight transport intensities

(**) C^2 is the contribution of restructuring in sector production linkages

(***) C^3 is the contribution of GDP structure changes

From this table, we can easily identify the countries that contribute either positively or negatively to decoupling. Finland, Italy and the UK are the countries in which the effect of RFTI evolution was most effective in reducing demand for road freight transport, and moreover these countries are the three ones that have achieved a strong decoupling (see Figure 2). These countries can be seen to have improved their logistical performance more than others during this period. In contrast, the RFTI evolution in Portugal had an almost negligible effect on reducing road freight transport demand. This last finding is also seen in Figure 1, which shows that this effect even led to an increase in road freight transport in many of the years in the study period compared to the base year 2000.

Table 3 shows the aggregate values of RFTI (total tonne-kms/total output) for each country in 2000 and 2007 together with the variation occurred in each one of them.

TABLE 3. Road freight transport intensity [tonne-kms/output] values and variation between 2000 and 2007 by country

Country \ Year	DE	ES	FI	FR	IE	IT	PT	SE	UK
2000	0,080	0,135	0,136	0,084	0,060	0,086	0,125	0,069	0,077
2007	0,054	0,091	0,061	0,046	0,034	0,043	0,107	0,042	0,033
Δ RFTI	-32%	-32%	-55%	-45%	-42%	-51%	-14%	-39%	-57%

1 Based on the conceptual framework develop by Mckinnon (9) that illustrates the way RFTI is
2 defined through the key ratios already mentioned in section 2—value density, handling factor, modal split
3 and length of haul— we can give some explanations of the different patterns followed by different
4 countries.

5 It is clear that after 2004 RFTI clearly contributed to reduce road transport in the UK (see Figure
6 1). In this country Lethonen identified in 2006 clear decoupling trends in the UK during 1990s and
7 provided a list of reasons of this situation by developing a decomposition analysis of road freight
8 transport into different factors (23). He found that after this year the shortening of the average length of
9 haul seemed to begin to influence decoupling. During previous decades, the increase of the average length
10 of haul was identified as the main factor contributing to increase road transport (6), partly due to the
11 concentration of the economic activity. However, the new trends pointed out by Lehtonen suggested that
12 such long-established concentration of production and inventory was beginning to weaken. It could be
13 also caused partly by the outsourcing of delivery processes to large companies managing warehouses in
14 many areas.

15 By contrast, in the case of Finland, (24) found that haulage lengths tended to increase in this
16 country so the growth of value density in all sectors appeared to be the main reason for the decreasing
17 road freight transport intensity between 1995 and 2010. This trend is similar to the one found in Swedem
18 between 1999 and 2008 (25). This explains our results regarding the negative contribution of RFTI to
19 Swedish road freight transport. In these cases, to foster decoupling value densities could have been
20 increased by processes such as the miniaturization of products, the increasing quality of goods or the
21 trend to use lighter materials.

22 As noted earlier, the contributions — C^2 and C^3 — of the other two factors did not have such
23 significant impacts as the evolution of RFTI on the reduction of tonne-kms. However, considerable road
24 freight transport decreases can be seen in cases such as the UK, Ireland and Spain, mainly due to the GDP
25 structure effect (see Figure 1).

26 In numerous developed countries there has been a movement towards service-oriented rather than
27 manufacture-oriented economies. Here we can highlight the UK, where the share of the service sector of
28 the economy began to rise in the mid 1990s, until reaching a peak of 70% in 2007. In this country,
29 Lethonen (23) had already found a declining share of GDP of manufacturing about 27% between 1989
30 and 2004 leading to less transport demand. In contrast, this trend was not noted in countries such as
31 Sweden and Germany, since transport intensive sectors such as mining and machinery rose rapidly over
32 this period together with service activities. As a result only minor road transport decreases were caused by
33 the restructuring of the GDP.

34 Finally, the effect of production linkages in Portugal, United Kingdom, Germany and France is
35 significant compared to the average. This signals that these countries changed their production processes,
36 either by implementing technological innovations or by substituting inter-sector relationships and these
37 changes reduced the dependence of their production on exchange of goods and therefore on road freight
38 transport. In contrast, Ireland and Finland are examples of the opposite trend as their production processes
39 required a growing amount of tonne-kms, as seen in Figure 1.

41 CONCLUSIONS

42 EU countries reveal different rates of decoupling. This issue that has received considerable attention in
43 the literature as it is viewed as an opportunity to promote sustainable development. In this paper we have
44 developed a new methodology to go as step further in understanding both the key factors driving road
45 freight transport trends in Europe at the macro level and the differences between countries. Thus, we have
46 connected all the influencing variables on road transport: economic indexes —production, economic
47 structure, intersectoral dependence, imports or exports — and technological and logistic factors. On the
48 basis of the implementation of the methodology to nine European countries, we can give several
49 conclusions. Firstly, we have identified the main coupling and decoupling factors in Europe during last

1 years. In this respect, we have found that the evolution of GDP and imports in Europe has contributed to
2 increasing road freight transport demand. This is only reasonable in view of the fact that the greater the
3 economic activity and trade, the higher the freight transport volumes. The positive decoupling trends
4 observed can be explained, as a whole, by (1) technological changes— that are prompting new sector
5 linkages in production processes that require less exchange of goods— (2) the transition to more service-
6 oriented economies has also led to a decline in road freight traffic; and (3) the pursuit of transport
7 efficiency —which has been measured through the road freight transport intensity (RFTI) ratio.

8 Particularly, we have noticed the effectiveness of RFTI evolution in decreasing final road freight transport
9 demand in most countries. This ratio includes different aspects such as the average distance of the trips —
10 based on the geographical location of production and consumption poles—, the structure of the supply
11 chain, the management of the transport system, and the evolution of the modal split. In this paper, we
12 have provided a first overview of the similarities and divergences of the contributions of global values of
13 RFTIs in road freight transport trends through a macro-analysis. Our results show that the evolution of the
14 factors explaining RFTIs in the EU countries is diverse and cause different impacts in countries' road
15 freight transport trends. Previous research works mentioned in this paper pointed out some similar
16 patterns like the negligible contribution of modal split on development of transport intensity, or the spatial
17 concentration of production and inventory in most developed countries.

18 However, despite the fact that we have highlighted some possible reasons such as the shortening of the
19 haulage distances in the UK or the increase in the value densities of Finnish goods, further analysis based
20 on a micro approach would be necessary in order to improve the understanding of the mechanisms
21 underlying RFTI trends in each country.

22 In the light of the cross-country comparison developed, we can confirm that Europe as a whole seems to
23 be on the path to decoupling without compromising economic growth. Six out of the nine countries
24 analysed —Sweden, France, Ireland, Portugal, Spain and Germany— experienced weak decoupling from
25 2000 to 2007. The UK, Ireland and Finland have even reached a strong decoupling level during this time.
26 Looking more in detail at the contribution of different decoupling factors, we notice that in just these
27 three countries RFTI has had the most notable effect in decreasing road freight transport demand. This
28 proves the relevance of such a variable in breaking the link between road transport and the economy.
29 RFTI performance has been almost negligible in Portugal and as a consequence of that, this is the country
30 nearest to a coupling situation.

31 Finally, our research has revealed that most countries have continued seeing greater decoupling levels
32 than found in previous research. This suggests that, if the current trends in the economy and in the
33 manufacturing and logistical industry continue, road transport is likely to keep on decoupling from GDP
34 at the EU-level, as already is happening in countries like the UK. However, Europe still has room for
35 improving other measures such as the shift of freight transport from road to alternative more
36 environmentally-friendly modes. Some decoupling policies aimed at promoting such changes would
37 further strengthen the sustainable mobility in the EU.

38 Actually, little research focused on to the effectiveness of “decoupling policies” has been undertaken.
39 Thus, going further into this issue could be essential to achieve the promotion of decoupling required in
40 the EU transport systems.

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