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# ENERGY INTENSITY IN ROAD FREIGHT TRANSPORT OF HEAVY GOODS VEHICLES IN SPAIN

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## ABSTRACT

This paper examines the factors that have influenced the energy intensity of the Spanish road freight transport of heavy goods vehicles over the period 1996–2012. This article aims to contribute to a better understanding of the factors behind the energy intensity change of road freight and also to inform the design of measures to improve energy efficiency in road freight transport. The paper uses both annual single-period and chained multi-period multiplicative LMDI-II decomposition analysis. The results suggest that the decrease in the energy intensity of Spanish road freight in the period is explained by the change in the real energy intensity index (lower energy consumption per tonne-kilometre transported), which is partially offset by the behaviour of the structural index (greater share in freight transport of those commodities the transportation of which is more energy intensive). The change in energy intensity is analysed in more depth by quantifying the contribution of each commodity through the attribution of changes in Divisia indices.

**Keywords:** energy intensity, road freight transport, LMDI, Divisia index decomposition

## 1. INTRODUCTION

In recent decades there has been growing concern to achieve more efficient energy use (IEA, 1997). The interest in improving energy efficiency lies in the reduction of energy costs, as well as lower energy consumption and the reduction of greenhouse gas emissions resulting from fuel consumption. An in-depth analysis of the determinants of change in energy consumption is therefore important to facilitate the implementation of policies that promote savings and more efficient energy use.

Between 1996 and 2011, greenhouse gas emissions showed a different behaviour in Spain in relation to the European Union (EU). Spanish emissions increased by 14.9% over the period compared to a 14.0% reduction in the 28 EU member states (equivalent $CO_2$ emissions of the six gases covered by the Kyoto Protocol, European Commission, 2013). The transport sector has significantly contributed to this negative growth in emissions. The Spanish transport sector's emissions increased by 24.4% over the period, contributing to 24.9% of total emissions in 2011, of which 91.3% corresponds to road transport. The upward trend in emissions in the Spanish transport sector is explained by a 29.4% rise in energy consumption over the period, reaching 41.6% of total final energy consumption in 2011 (European Commission, 2013). These results show that between 1996 and 2011, the Spanish transport sector was unable to reverse the upward trend in terms of energy consumption observed since the 1970s (Stead, 2001), which explains the difficulty in reducing the related greenhouse gas emissions.

Numerous investigations have examined the role of the transport sector in final energy consumption and/or related emissions. Part of this literature employs IPAT descriptive models (the IPAT equation states that environmental impact (I) is the product of population (P), affluence (A), and technology (T)). Based on these models, the International Energy Agency has developed the ASIF equation (IEA, 1997) (described in the methodology section) to study the impact of any pollutant's emissions in the transport sector. Following this line, two distinct activities are distinguished: passengers and freight. It should be added that some investigations include parametric decomposition analyses, from traditional methods such as the Laspeyres index (Millard-Ball and Schipper, 2010) to more recent and improved methods, such as the log mean Divisia Index (LMDI) (Sorrell et al., 2009, 2012).

With regard to passenger transport, some specific contributions should be noted, such as those of Schipper (2011), who studies the behaviour patterns of car use and fuel consumption in industrialized countries between 1970 and 2010 and determines the factors that allow the reduction of related emissions, Millard-Ball and Schipper (2010), who evaluate the change in passenger transport energy consumption between 1973 and 2007 in eight industrialized countries, and Eorn and Schipper (2010), who investigate the passenger transport energy consumption trend in South Korea between 1986 and 2007.

Concerning road freight transport, among others, a number of works should be pointed out, namely: McKinnon and Piecyk (2009), who examine different sources and measurement methods of carbon dioxide emissions related to road freight transport of heavy goods vehicles in the United Kingdom; Kamakaté and Schipper (2009), who study the energy use of road freight transport in Australia, France, Japan, the United States and the United Kingdom between 1973 and 2005; Vanek and Campbell (1999), who explore energy consumption and energy intensity trends of road transport for 14 groups of commodity groups between 1985 and 1995 in the United Kingdom; Vanek and Morlok (2000), who investigate the change in energy consumption in freight transport in the United States disaggregated by commodities and transport modes; Sorrell et al. (2009, 2012), who analyse the factors leading to slower growth in the energy consumption of road freight transport in the United Kingdom between 1989 and 2004.

Energy consumption change and related emissions in the transport sector in Spain are investigated by Mendiluce and Schipper (2011), who analyse the energy consumption and emissions trends for the Spanish transport sector between 1990 and 2008, differentiating between passenger and freight transport modes; Pérez Martínez (2009) reviews certain indicators of efficiency and performance in Spanish road freight transport between 1997 and 2003; Pérez Martínez (2010) investigates the energy consumption of freight transport and related emissions for the period 1990–2008 and projections for 2025; finally, Pérez Martínez and Monzón de Cáceres (2008) compare the change in environmental indicators in the Spanish transport sector —energy consumption and carbon dioxide emissions— with EU countries for the period 1988–2006. These contributions have focused on the change in the energy consumption of the Spanish transport sector in the last few decades and on how this has contributed to changes in the related emissions.

In this paper, we focus on the study of the energy intensity of freight transport, its progression and its determinant factors. Moreover, the analysis is disaggregated by commodities. It complements previous studies on the energy consumption of freight transport. This investigation deepens understanding of one of the main components of energy consumption, energy intensity, a variable that has not previously been examined in detail for freight transport, but is a key component in achieving a more efficient use of energy in transport. The study relates to Spanish road freight transport of heavy goods vehicles over the period 1996–2012. It uses the ASIF methodology and is further enhanced by applying annual single-period and chained multi-period multiplicative LMDI-II decomposition analysis. To expand the results of the decomposition analysis, an extension is also applied: the attribution of changes in Divisia indices. This novel methodology allows the quantification of the contribution of each commodity group to the change in real energy intensity and structural indices. It identifies precisely the degree to which each commodity group has contributed to the change in energy intensity through the real energy intensity index (measured as energy consumption per tonne-kilometre transported) and through the structural index (the relative change in the composition of road freight transport). Thereby, this article aims to contribute to a better understanding of the determinant factors of the changes in the energy intensity of road freight transport. The results can inform the design of policies the purpose of which is to achieve more efficient energy use in freight transport.

The rest of the paper is organized as follows. Section 2 discusses the data and estimation methodology. Section 3 describes the results of energy intensity analysis (aggregated and by commodity). Section 4 presents the results of the decomposition analysis and its extension. Section 5 summarises and concludes the paper.

## 2. DATA AND METHODOLOGY

### 2.1. DATA

The database used is that of the Encuesta Permanente del Transporte de Mercancías por Carretera (EPTMC) for the years 1996–2012, a national survey of road freight carried out by the Ministerio de Fomento (2013). The main objective of this survey is to investigate the transport operations of heavy goods vehicles to measure the extent of the sector's activity in Spain. The survey is continuous and registers the movements of Spanish heavy goods vehicles with a gross weight in excess of 3.5 tonnes or maximum permissible laden weight above 6.0 tonnes. All operations performed by these vehicles are investigated both nationally and abroad. The survey collects information on origin, destination, distance of the operation and vehicle characteristics for different commodity groups, which follow the NST/R nomenclature (standard goods classification for transport statistics) disaggregated to two digits (see Appendix I).

Table 1 summarizes the technical characteristics of heavy goods vehicles which define different types of vehicles. Given the above, this investigation assigned to each type of vehicle an average fuel consumption per kilometre. The allocation of fuel consumption is made taking into account the following: i) the guidelines provided by the Instituto para la Diversificación y Ahorro de la Energía (IDAE, 2006), which contains the general reference standards of consumption of the different fleet vehicles; ii) the average fuel consumption per vehicle published by the Ministerio de Fomento (2010). Once the assignment was complete, the resulting annual average consumption was checked to ensure that it corresponds with that published by the IDAE (2010b), which collects the mean fuel consumption of the transport sector for different types of vehicles, including heavy goods vehicles.

**TABLE 1. HEAVY GOODS VEHICLE CATEGORIES**

| Vehicle type | Gross vehicle weight |
|---|---|
| Rigid vehicles | $\leq$ 7.5 tonnes<br>$>$7.5 tonnes $\leq$ 18 tonnes<br>$>$18 tonnes |

| | | |
|---|---|---|
| Articulated vehicles | ≤ 26 tonnes<br>>26 tonnes<br>>40 tonnes | ≤ 40 tonnes |

Source: Ministerio de Fomento (2013) and IDAE (2006).

It should be noted that until 2002 the EPTMC did not collect data on operations within the same municipality. For this reason and to obtain a homogeneous set of data, this analysis only includes operations between municipalities, which accounted for at least 97.1% of total road freight activity in the period considered (see Table 2).

**TABLE 2. PARTICIPATION OF INTERMUNICIPAL TRANSPORT OF HEAVY GOODS VEHICLES (2002–2012)**

| | Millions tonne kilometres | Intermunicipal |
|---|---|---|
| **2002** | 184,545 | 97.3% |
| **2003** | 192,587 | 97.1% |
| **2004** | 220,816 | 97.2% |
| **2005** | 233,219 | 97.5% |
| **2006** | 241,758 | 97.5% |
| **2007** | 258,870 | 98.0% |
| **2008** | 242,978 | 98.2% |
| **2009** | 211,891 | 98.5% |
| **2010** | 210,064 | 98.8% |
| **2011** | 206,840 | 98.9% |
| **2012** | 199,205 | 99.2% |

Source: EPTMC (Ministerio de Fomento, 2013).

To conduct the decomposition analysis of road freight energy intensity, we require annual data on energy consumption and activity disaggregated by commodity groups during the period 1996–2012. The EPTMC directly provides data on freight transport by commodity groups, whereas the data on the energy consumption of freight transport by commodity groups need to be estimated. The methodology used is presented in the following subsection.

## 2.2. METHODOGY

### 2.2.1. ASIF METHODOLOGY

The ASIF methodology, which was developed by the International Energy Agency (IEA, 1997), analyses the impact of emissions of any pollutant in the transport sector, such that:

$$G = \sum A\, S_i I_i \sum F_{i,j} \quad (1)$$

where $G$ is the emission of a particular pollutant, $A$ is total activity of the transport sector, $S_i$ represents the share of transport mode $i$ in total activity, $I_i$ is the energy intensity of mode $i$, and $F_{i,j}$ is the type of fuel $j$ used by transport mode $i$. It should be noted that this analysis only considers the direct consumption of final energy required for freight transport and does not take into account indirect energy consumption.[1]

Generally, studies that focus on energy consumption ($E$) and not on greenhouse gas emissions (e.g. Vaneck and Morlock, 2000; Millard-Ball and Schipper, 2010) analyse the first three components of the ASIF equation and ignore the consumption of different types of fuel. Thus, the ASIF equation changes to:

$$E = \sum A\, S_i I_i \quad (2)$$

In this research, the aim is to analyse the energy intensity of road freight and so transport mode is not the variable used to disaggregate the analysis. In this case, disaggregation is carried out by commodity group ($c$). Thus, the estimation, using our own terminology, is performed as follows:

$$E = \sum TKM\ S_c\, I_c \quad (3)$$

where $E$ is the energy consumption of road freight, $TKM$ is the activity of road freight measured in tonne-kilometre; $S_c$ represents the share of transport of commodity group $c$ in road freight activity, and $I_c$ is the energy intensity of transport of commodity group $c$.

The estimation of energy consumption of freight transport of commodity group $c$ in year $t$ ($E_{ct}$) is calculated as follows:

$$E_{ct} = \sum_k E_{ckt} = \sum_k VKM_{ckt}\ AF_{ckt}\ e \quad (4)$$

where $VKM_{ckt}$ is the annual distance travelled by vehicle type $k$ in year $t$ when transporting commodity group $c$, $AF_{ckt}$ is the average annual fuel consumption per kilometre of vehicle type $k$

[1] Therefore, it does not consider the energy consumption required in the manufacture of vehicles, infrastructure and its maintenance, decommissioning and recycling at the end of vehicles' useful life, or energy used in the production of fuel (extraction, refining and distribution).

in year $t$ when transporting commodity group $c$,[2] and $e$ is the conversion factor —fuel/energy— provided by IDAE (2010a).

Although the EPTMC directly provides $VKM_{ckt}$, a problem arises when the activity is disaggregated by commodity group: empty running is classified as another "commodity group". That is, there is no information concerning the correspondence between the loaded distance travelled for commodity groups and the amount of empty running. However, as loaded and empty running operations are recorded for each vehicle, the amount of empty running travelled by vehicle has been assigned proportionally to the loaded distance travelled by the vehicle in transporting each commodity group.

### 2.2.2. THE MULTIPLICATIVE LOG MEAN DIVISIA INDEX DECOMPOSITION

Index Decomposition Analysis (IDA) is a decomposition analysis technique that is widely used in energy studies. The object of IDA is to disaggregate the variable to be analysed into different explanatory factors. In the case of energy consumption, decomposition has three factors: scale, structure and intensity. To study the impact of structural change in the road freight transport sector in Spain, in this research we apply the decomposition method of the logarithmic mean Divisia index in its multiplicative form (M-LMDI-II) in relation to energy intensity rather than to energy consumption. Although the analysis of energy consumption is relevant, we focus the analysis on energy intensity and not on energy consumption to avoid the problem that appears when considering an extended period of analysis in which activity grows at a high rate: the scale factor estimated tends to be very significant and much higher than the other two factors (Ang, 1994). Thus, energy intensity is the most appropriate study variable in this case.

Energy intensity decomposition comprises two indices: i) a structural index ($SE$), which provides a measure of change in energy intensity due to the relative change in the share of the commodity groups that are more energy intensive in terms of transport; ii) a real energy intensity index ($EI$) as an indicator of energy intensity change due to the variation in the apparent energy efficiency of road freight transport —measured as energy consumption per tonne-kilometres—, the variation of which may be due to a change in fuel consumption per tonne-kilometre, traffic, and driving conditions or road conditions, among other factors.

In the IDA literature, aggregate energy intensity in year $t$ can be expressed as follows:

$$I_t = \sum_t S_{ct} I_{ct} \qquad (5)$$

[2] The allocation of fuel consumption per kilometre for vehicle type *k* in year *t* in the transport of commodity group *c* is described in section 2.1.

where

$S_{ct} = \frac{TKM_{ct}}{TKM_t}$ and $I_{ct} = \frac{E_{ct}}{TKM_{ct}}$

$IE_{ct}$ corresponds to energy consumption in road freight of commodity group $c$ in year $t$; $TKM_{ct}$ is an indicator of road freight activity and measures the total tonne-kilometre of commodity group $c$ in year $t$; $S_{ct}$ represents the relative share in road freight of commodity group $c$ in relation to total activity in year $t$; $I_{ct}$ defines energy intensity in road freight of commodity $c$ in year $t$ as energy consumption per tonne transported over a kilometre in year $t$.

The methodology used in this study corresponds to M-LMDI-II. The choice of this method is due to its theoretical foundation and its desirable properties (Ang, 2004). First, it is a perfect decomposition method; that is, residual terms do not appear in the results, so it overcomes the test of reversibility. Second, if data contain the value 0, it works properly when replaced by a very small value and thus the test shows robustness to the value 0. Third, it passes the test of reversibility in time, that is the results are identical if the decomposition is carried out forward or backward in time. Fourth, it overcomes the aggregation test, so it is consistent in aggregating the results of the decomposition by subgroup, regardless of how these subgroups are defined. Fifth, it is easily applied and its results are easily interpreted. Sixth, it is adaptable. Also, the absence of negative data in the database does not necessitate the use of alternative methods related to the Laspeyres index. Finally, it should be noted that the results obtained in the multiplicative version of this method are related to those obtained in the additive version through a simple formula. Thus, it is possible to derive the effect of the additive decomposition through the same effect estimated in the multiplicative decomposition and vice versa. For more detailed information on the properties of the various decomposition methods see, for example, Ang and Zhang (2000), Lenzen (2006) and Ang and Liu (2007).

Through the yearly single-period decomposition, the change in energy intensity (5) between two consecutive years can be defined as $\frac{I_t}{I_{t-1}}$ and can be decomposed into a real energy intensity index and a structural index as follows:

$$\frac{I_t}{I_{t-1}} = \frac{IE_t}{IE_{t-1}} \times \frac{SE_t}{SE_{t-1}} \tag{6}$$

In the M-LMDI-II, the formulae of the real energy intensity index and the structural index are respectively given by:

$$\frac{IE_t}{IE_{t-1}} \equiv exp\left( \sum_{c=1}^{n} w_c \, ln \frac{I_{c,t}}{I_{c,t-1}} \right) \tag{7}$$

$$\frac{SE_t}{SE_{t-1}} \equiv exp\left( \sum_{c=1}^{n} w_c \, ln \frac{S_{c,t}}{S_{c,t-1}} \right) \tag{8}$$

where

$$w_c = \frac{L\left(\frac{E_{c,t}}{E_t}, \frac{E_{c,t-1}}{E_{t-1}}\right)}{\sum_{c=1}^{n} L\left(\frac{E_{c,t}}{E_t}, \frac{E_{c,t-1}}{E_{t-1}}\right)} \qquad \text{and} \qquad L(a,b) = \begin{cases} \frac{(a-b)}{(ln\, a - ln\, b)}, & a \neq b \\ a, & a = b \end{cases}$$

where $L(a, b)$ is the logarithmic average of two positive numbers $a$ and $b$.

In chained multi-period decomposition, changes in Divisia energy intensity are described as:

$$\frac{\mathrm{I_T}}{\mathrm{I_0}} = \prod_{\mathrm{t}=1}^{\mathrm{T}} \frac{\mathrm{I_t}}{\mathrm{I_{t-1}}} = \prod_{\mathrm{t}=1}^{\mathrm{T}} \left( \frac{\mathrm{IE_t}}{\mathrm{IE_{t-1}}} \times \frac{\mathrm{SE_t}}{\mathrm{SE_{t-1}}} \right) = \prod_{\mathrm{t}=1}^{\mathrm{T}} \frac{\mathrm{IE_t}}{\mathrm{IE_{t-1}}} \times \prod_{\mathrm{t}=1}^{\mathrm{T}} \frac{\mathrm{SE_t}}{\mathrm{SE_{t-1}}} = \frac{\mathrm{IE_T}}{\mathrm{IE_0}} \times \frac{\mathrm{SE_T}}{\mathrm{SE_0}} \tag{9}$$

where the right-hand side of expression (9) is the cumulative product between $0$ and $T$ of the single-period real energy intensity index and the structural index, such that:

$$\frac{IE_T}{IE_0} = \prod_{t=1}^{T} \frac{IE_t}{IE_{t-1}} \tag{10}$$

$$\frac{SE_T}{SE_0} = \prod_{t=1}^{T} \frac{SE_t}{SE_{t-1}} \tag{11}$$

### 2.2.3. ATTRIBUTION OF CHANGES IN THE DIVISIA REAL ENERGY INTENSITY INDEX AND THE STRUCTURAL INDEX

The methodology described in Ang and Choi (2012) attributes the changes in the real energy intensity index measured by the Divisia index to different sources associated with such changes. In this case, we apply this methodology to the real energy intensity index and also to the structural index. This allows us to obtain a more detailed analysis of the contribution of each commodity group in the change in the two indices, taking into account that both determine the changes in energy intensity.

The methodology, both for the single-period attribution analysis and for the multi-period attribution analysis, is based on the transformation of a geometric mean index, as is the case of M-LMDI-II, into an arithmetic mean index. The procedure to be applied is presented below.

The formulae for the single-period attribution of the real energy intensity index and the structural index are given by:

$$\frac{IE_t}{IE_{t-1}} - 1 = \sum_{c=1}^{n} s_c^I \left(\frac{I_{c,t}}{I_{c,t-1}} - 1\right) \tag{12}$$

$$\frac{SE_t}{SE_{t-1}} - 1 = \sum_{c=1}^{n} s_c^S \left(\frac{S_{c,t}}{S_{c,t-1}} - 1\right) \tag{13}$$

where $s_c^I \left(\frac{I_{c,t}}{I_{c,t-1}} - 1\right)$ and $s_c^S \left(\frac{S_{c,t}}{S_{c,t-1}} - 1\right)$ correspond, respectively, to the contribution of road freight of commodity group c to the change in the real energy intensity index and to the change in the structural index between two consecutive years respectively and where $s_c$ is defined in each case such that:

$$s_c^I = \frac{\frac{w_c}{L\left(I_{c,t}, I_{c,t-1}\frac{IE_t}{IE_{t-1}}\right)} I_{c,t-1}}{\sum_{k=1}^{n} \frac{w_k}{L\left(I_{k,t}, I_{k,t-1}\frac{IE_t}{IE_{t-1}}\right)} I_{k,t-1}} \tag{14}$$

and

$$s_c^S = \frac{\frac{w_c}{L\left(S_{c,t}, S_{c,t-1}\frac{SE_t}{SE_{t-1}}\right)} S_{c,t-1}}{\sum_{k=1}^{n} \frac{w_k}{L\left(S_{k,t}, S_{k,t-1}\frac{SE_t}{SE_{t-1}}\right)} S_{k,t-1}} \tag{15}$$

For the multi-period attribution analysis, the formulae to disaggregate the real energy intensity index and structural index are as follows:

$$\frac{IE_T}{IE_0} - 1 = \sum_{c=1}^{n} \sum_{t=1}^{T} \frac{IE_{t-1}}{IE_0} s_{c,t-1,t}^I \left(\frac{I_{c,t}}{I_{c,t-1}} - 1\right) \tag{16}$$

$$\frac{SE_T}{SE_0} - 1 = \sum_{c=1}^{n} \sum_{t=1}^{T} \frac{SE_{t-1}}{SE_0} s_{c,t-1,t}^S \left(\frac{S_{c,t}}{S_{c,t-1}} - 1\right) \tag{17}$$

Equation (16) shows that the percentage change in the real energy intensity index between *0* and *T* is the cumulative sum of annual percentage changes evaluated at year *0* through $IE_{t-1}/IE_0$. $s_{c,t-1,t}^I$ is defined as follows:

$$\mathrm{s}_{\mathrm{c,t-1,t}}^{\mathrm{I}} = \frac{\frac{\mathrm{w}_{\mathrm{c,t-1,t}}}{\mathrm{L}\left(\mathrm{I}_{\mathrm{c,t}}, \mathrm{I}_{\mathrm{c,t-1}}\frac{\mathrm{IE}_{\mathrm{t}}}{\mathrm{IE}_{\mathrm{t-1}}}\right)} \mathrm{I}_{\mathrm{c,t-1}}}{\sum_{\mathrm{k=1}}^{\mathrm{n}} \frac{\mathrm{w}_{\mathrm{k,t-1,t}}}{\mathrm{L}\left(\mathrm{I}_{\mathrm{k,t}}, \mathrm{I}_{\mathrm{k,t-1}}\frac{\mathrm{IE}_{\mathrm{t}}}{\mathrm{IE}_{\mathrm{t-1}}}\right)} \mathrm{I}_{\mathrm{k,t-1}}} \tag{18}$$

In parallel, equation (17) expresses the percentage change in the structural index between *0* and *T*, such that $s_{c,t-1,t}^S$ is:

$$s^{S}_{c,t-1,t} = \frac{\frac{w_{c,t-1,t}}{L\left(s_{c,t}, s_{c,t-1}\frac{SE_t}{SE_{t-1}}\right)} s_{c,t-1}}{\sum_{k=1}^{n} \frac{w_{k,t-1,t}}{L\left(s_{k,t}, s_{k,t-1}\frac{SE_t}{SE_{t-1}}\right)} s_{k,t-1}} \qquad (19)$$

Therefore, the contribution of road freight transport in commodity group $c$ in the change of the real energy intensity index between $t\text{-}1$ and $t$ corresponds to the value $\frac{IE_{t-1}}{IE_0} s^{I}_{c,t-1,t}\left(\frac{I_{c,t}}{I_{c,t-1}} - 1\right)$ evaluated at year $0$, while $\frac{SE_{t-1}}{SE_0} s^{S}_{c,t-1,t}\left(\frac{S_{c,t}}{S_{c,t-1}} - 1\right)$ determines the contribution of road freight transport in commodity group $c$ in the change of the structural index between $t\text{-}1$ and $t$ and evaluated at year $0$.

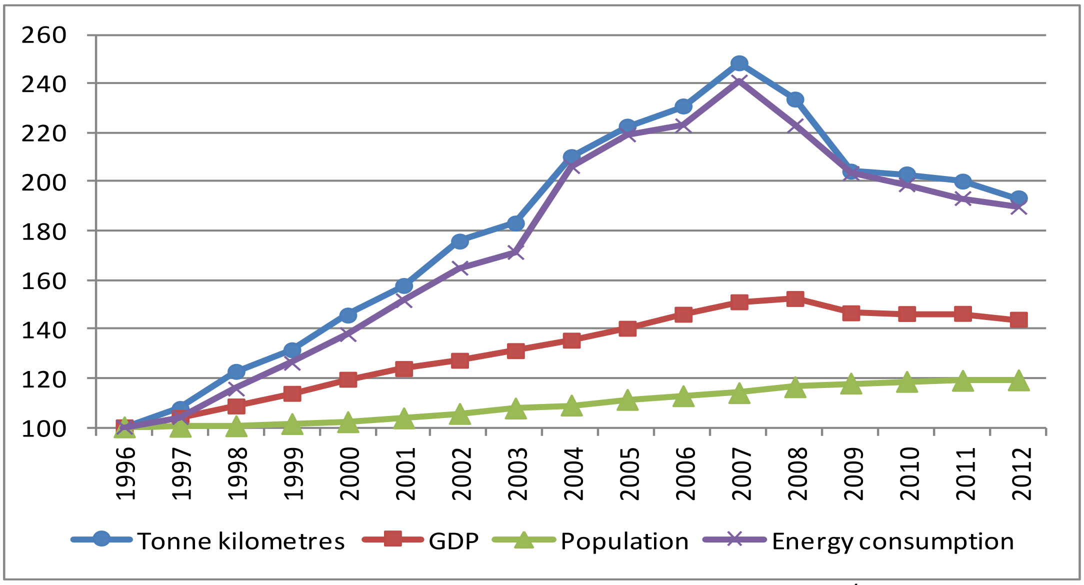
## 3. ENERGY INTENSITY EVOLUTION

During the period 1996–2012, the strong increase in Spanish road freight energy consumption is mainly explained by the activity's significant growth, which increased by 84.7% measured in millions of tonne-kilometre (TKM). The activity also grew faster than the whole economy as GDP increased by 43.9% over the period, which explains its greater share in final energy consumption and in related emissions in Spain.

Regarding modal shares in freight transport in Spain over the period 1996–2012, it should be noted that road freight grew by 95% (102,167 millions of TKM in 1996 compared to 199,205 millions of TKM in 2012), whereas the alternative, rail transport, fell by 10.3% (from 11,100 millions of TKM in 1996 to 9,957 millions of TKM in 2012). Thus, road freight accounted for 95.2% of total freight activity in Spain in 2012.[3]

**FIGURE 1. TRENDS IN GDP, POPULATION, ACTIVITY AND ENERGY CONSUMPTION IN ROAD FREIGHT (SPAIN 1996–2012)**

[3] In Spain, the total volume of road freight transport represented 84% of freight transport in 2007, railway transport 1% and maritime transport 15%, according to Eurostat (2013) data, taking into account that maritime transport covers both the activity of loading and unloading.




Source: the INE provides population (EPA) and GDP data (CNE)[4] and the EPTMC (Ministerio de Fomento, 2013) provides road freight activity data. In 1996, the population was 39,669 thousand people, tonne-kilometre transported amounted to 102,166 millions and GDP at constant prices of 2008 amounted to a total of 714,138 million euros.

Figure 1 shows a change in the trend of road freight as a result of the beginning of the economic crisis in Spain in 2008: activity grew by 153.4% from 1996 to 2007 and decreased by 23% from 2007 to 2012. Energy consumption for road freight was also affected by the economic crisis: over the period 1996 to 2012 it rose by 89.7% and at its peak in 2007, growth reached 140.7%.

**TABLE 3. CHANGES IN ACTIVITY, ENERGY CONSUMPTION AND ENERGY INTENSITY OF ROAD FREIGHT (SPAIN 1996–2012)**

| | Activity | Energy consumption | Energy intensity |
|---|---|---|---|
| **1997** | 7.5% | 4.0% | -3.3% |
| **1998** | 14.0% | 11.1% | -2.5% |
| **1999** | 7.2% | 9.1% | 1.8% |
| **2000** | 10.8% | 9.3% | -1.3% |
| **2001** | 8.3% | 10.0% | 1.6% |
| **2002** | 11.5% | 8.7% | -2.5% |

[4] If the GVA – agriculture, industry and construction – were taken as a reference, the difference in growth rates of road freight activity and the economy would be greater. For example, from 2000 to 2010, the growth rate of GVA at constant prices in the economy reached 23%, but excluding the service sector, the growth rate of GVA reached only 4%.

| | | | |
|---|---|---|---|
| **2003** | 4.2% | 3.9% | -0.3% |
| **2004** | 14.8% | 20.4% | 4.9% |
| **2005** | 5.9% | 6.3% | 0.3% |
| **2006** | 3.7% | 1.7% | -1.9% |
| **2007** | 7.6% | 8.0% | 0.3% |
| **2008** | -6.0% | -7.4% | -1.5% |
| **2009** | -12.6% | -8.7% | 4.4% |
| **2010** | -0.6% | -2.3% | -1.7% |
| **2011** | -1.4% | -2.8% | -1.4% |
| **2012** | -3.4% | -1.9% | 1.6% |

Source: EPTMC (Ministerio de Fomento, 2013),
and IDAE (2006, 2010a).

The energy intensity for road freight in Spain dropped by 1.9%, from 1.05 MJ/TKM in 1996 to 1.03 MJ/TKM in 2012. Table 3 shows this variable's behaviour over time. Its progression is erratic and it is not tied either to the activity of road freight or to energy consumption. Thus, during the years of economic crisis, the decrease in energy intensity was because energy consumption in road freight fell faster than road freight activity. During the period of economic expansion, energy intensity reduction was because road freight activity grew faster than energy consumption in road freight.

Table 4 summarizes the results of energy intensity, aggregated and by commodity group, and the share of commodity groups in road freight in Spain in the years 1996 and 2012.

**TABLE 4. ENERGY INTENSITY (MJ/TKM) AND SHARE (TKM) OF COMMODITY GROUPS IN ROAD FREIGHT (SPAIN 1996–2012)**

| | Energy intensity | | | Share | |
|---|---|---|---|---|---|
| | **1996** | **2012** | **Total change** | **1996** | **2012** |
| **1** | 0.74 | 0.72 | -2.0% | 3.2% | 2.4% |
| **2** | 0.86 | 0.88 | 2.0% | 10.0% | 12.3% |
| **3** | 1.64 | 1.47 | -10.4% | 1.3% | 0.9% |
| **4** | 0.87 | 0.99 | 13.8% | 2.8% | 1.3% |
| **5** | 1.09 | 1.31 | 20.1% | 0.7% | 0.8% |
| **6** | 1.11 | 1.00 | -9.8% | 17.0% | 22.0% |
| **7** | 0.78 | 0.74 | -4.7% | 1.1% | 1.5% |
| **8** | 0.78 | 0.74 | -4.9% | 1.1% | 0.6% |
| **9** | 0.40 | 10.62* | 2540.0% | 0.0% | 0.0% |
| **10** | 1.10 | 1.20 | 8.7% | 3.6% | 2.6% |
| **11** | 0.83 | 0.80 | -4.5% | 1.1% | 1.6% |
| **12** | 0.67 | 0.65 | -2.2% | 0.1% | 0.2% |
| **13** | 0.77 | 0.82 | 6.3% | 6.4% | 5.1% |

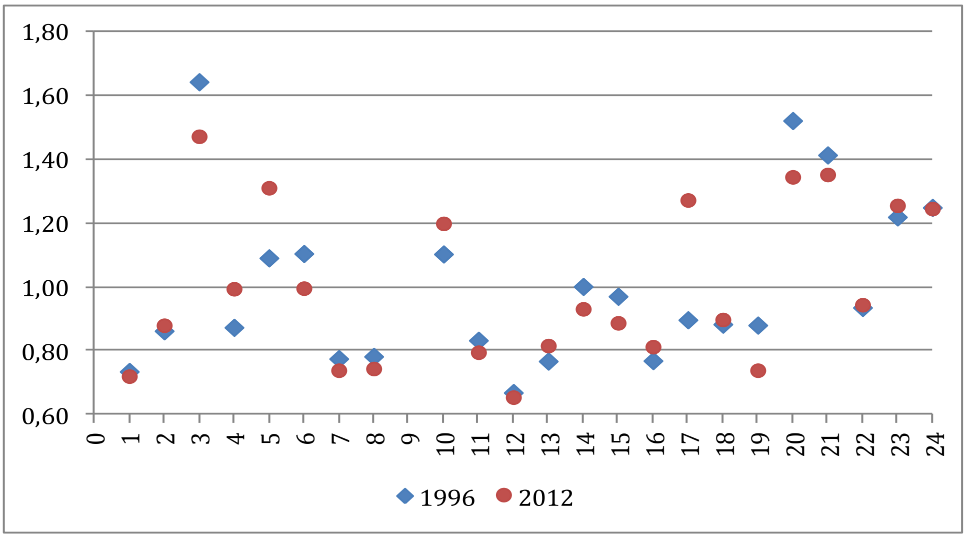
| | | | | | |
|---|---|---|---|---|---|
| **14** | 1.00 | 0.93 | -7.0% | 6.5% | 5.1% |
| **15** | 0.97 | 0.89 | -8.6% | 8.8% | 6.1% |
| **16** | 0.77 | 0.81 | 5.7% | 1.7% | 1.6% |
| **17** | 0.90 | 1.27 | 41.9% | 0.1% | 0.3% |
| **18** | 0.88 | 0.90 | 1.6% | 6.4% | 5.1% |
| **19** | 0.88 | 0.74 | -16.1% | 0.7% | 1.1% |
| **20** | 1.52 | 1.35 | -11.6% | 6.0% | 6.4% |
| **21** | 1.41 | 1.35 | -4.3% | 1.4% | 0.9% |
| **22** | 0.94 | 0.94 | 0.9% | 1.7% | 1.2% |
| **23** | 1.22 | 1.26 | 3.0% | 8.6% | 8.1% |
| **24** | 1.25 | 1.25 | -0.3% | 9.7% | 12.9% |
| **ACTIVITY** | 1.05 | 1.03 | -1.9% | 100.0% | 100.0% |

Source: EPTMC (Ministerio de Fomento, 2013) and IDAE (2006, 2010a).

*This result for *Crude petroleum* is unusual. Even though trucks travelled 617,666 kilometers to carry 9,733 tonnes of it, the analysis is not distorted because its share is not significant.

These first results point to a change in energy intensity as well as in structure for road freight activity over the period 1996–2012 in Spain. In particular, the energy intensity of different commodity groups reveals a distinct pattern. Energy intensity increased considerably in the case of the transport of Coal chemicals, tar (17), Textiles, textile articles and man-made fibres, other raw animal and vegetable materials (5) and Wood and cork (4). However, it decreased especially in the case of the transport of Paper pulp and waste paper (19), Transport equipment, machinery, apparatus and engines, whether or not assembled and parts thereof (20), and Live animals, and sugar beet (3). In 2012, the disparity in energy intensities, which ranged from 0.65 MJ/TKM for Non-ferrous ores and waste (12) to 1.47 MJ/TKM for Live animals and sugar beet (3), was lower than the disparity in 1996 as shown by Figure 2.

**FIGURE 2. DISPARITY IN ENERGY INTENSITY OF COMMODITY GROUPS IN ROAD FREIGHT (SPAIN – YEARS 1996 AND 2012 (MJ/TKM))**



Source: EPTMC (Ministerio de Fomento, 2013) and IDAE (2006, 2010a).

On the other hand, shifts in the share of commodity groups mark a significant structural change in transport activity. In fact, the importance of the transport of the commodities Foodstuff and animal fodder (6) and Potatoes, other fresh or frozen fruits and vegetables (2) increased notably, whereas the weight of Crude and manufactured minerals (15), Cement, lime and manufactured building materials (14), Metal products (13), and Chemicals other than coal chemicals and tar (18) was reduced in overall activity.

**TABLE 5. CHANGES IN ENERGY INTENSITY AND SHARE OF COMMODITY GROUPS IN ROAD FREIGHT**

| | | ENERGY INTENSITY | |
|---|---|---|---|
| | | Decrease | Increase |
| SHARE | Decrease | Cereals<br>Live animals, sugar beet<br>Solid mineral fuels<br>Cement, lime, manufactured building materials<br>Crude and manufactured minerals<br>Manufactures of metal | Wood and cork<br>Crude petroleum<br>Petroleum products<br>Metal products<br>Natural and chemical fertilizers<br>Chemicals other than coal chemicals and tar<br>Glass, glassware, ceramic products<br>Leather, textile, clothing, other manufactured articles |
| | Increase | Foodstuff and animal fodder<br>Oil seeds and oleaginous fruits and fats<br>Iron ore, iron and steel waste and blast furnace dust<br>Non-ferrous ores and waste<br>Paper pulp and waste paper<br>Transport equipment, machinery, apparatus, engines, whether or not assembled and parts thereof<br>Miscellaneous articles | Potatoes, other fresh or frozen fruits and vegetables<br>Textiles, textile articles and man-made fibres, other raw animal and vegetable materials<br>Coal chemicals, tar |

Source: Prepared by the authors with data from EPTMC (Ministerio de Fomento, 2013) and IDAE (2006, 2010a).

Taking into account the structural change, the data obtained from the EPTMC indicate that the amount of empty running with respect to total distance travelled decreased over the period considered, which represented a relative improvement in the logistics of the activity. Thus, 29.1% of the total distance travelled by heavy goods vehicles corresponded to empty running in 1996, whereas this was reduced to 22.9% in 2012. That is, whereas empty running increased by 53.9%, the loaded distance travelled increased by 99.0% over the period.

## 4. DECOMPOSITION ANALYSIS RESULTS

### 4.1. DESCOMPOSITION M-LMDI-II

The M-LMDI–II decomposition results are summarized in Table 6. Table 6A and Table 6B, respectively, show the results of the yearly single-period decomposition and the chained multi-period decomposition. Through the single-period decomposition, it can be seen that the progression of energy intensity of road freight activity was erratic over the period considered. In some years it increased, as illustrated by the negative contribution of the energy intensity index and structural index for the years 1999, 2001, 2005, 2007, 2009 and 2012; however, in other years (1997, 1998, 2006, 2008 and 2011), energy intensity decreased as both indices are shown to be positive .

However, through the multi-period decomposition analysis, it can be seen that the real energy intensity index contributed to energy intensity reduction by 3.0% over the period. In contrast, the structural index contributed to worsening energy intensity by 1.1% during the same period. The combination of these two effects led to a 1.9% decrease in energy intensity from 1996 to 2012.

**TABLE 6. M-LMDI-II DECOMPOSITION OF ROAD FREIGHT ENERGY INTENSITY**

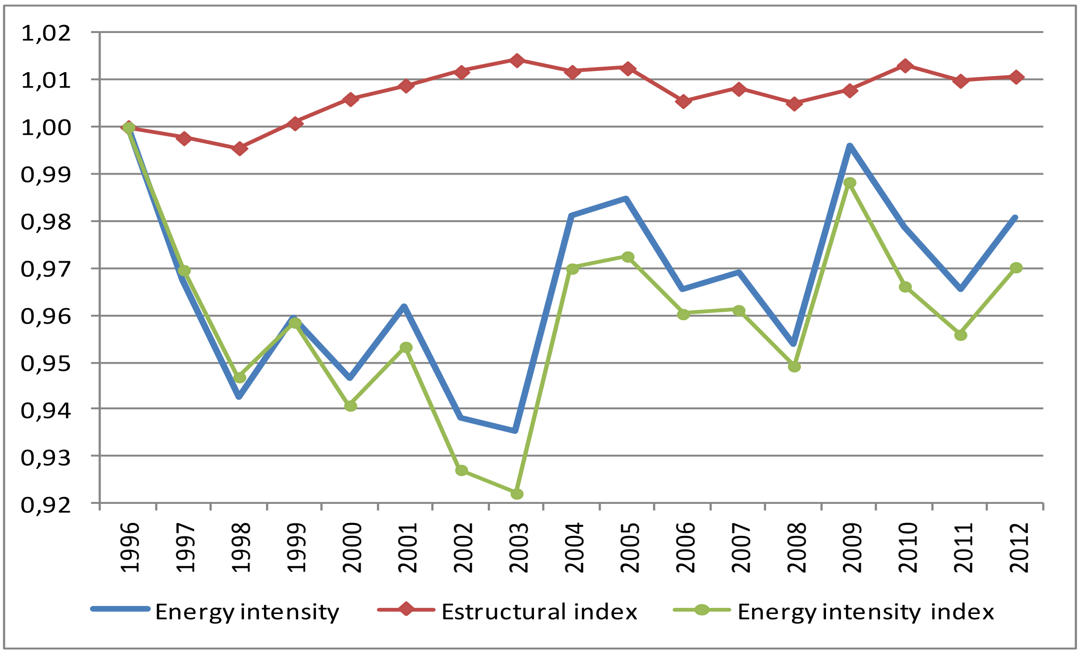
| | TABLE 6A. Single-period analysis (the base is the immediate preceding year) | | | | TABLE 6B. Multi-period analysis (1996 is the base) | | |
|---|---|---|---|---|---|---|---|
| | **Energy intensity** | **Real energy intensity index** | **Structural index** | | **Energy intensity** | **Real energy intensity index** | **Structural index** |
| **1997** | -3.3% | -3.0% | -0.2% | | -3.3% | -3.0% | -0.2% |
| **1998** | -2.6% | -2.3% | -0.2% | | -5.7% | -5.3% | -0.4% |
| **1999** | 1.8% | 1.2% | 0.5% | | -4.1% | -4.2% | 0.1% |
| **2000** | -1.3% | -1.8% | 0.5% | | -5.4% | -5.9% | 0.6% |
| **2001** | 1.6% | 1.3% | 0.3% | | -3.8% | -4.7% | 0.9% |
| **2002** | -2.5% | -2.7% | 0.3% | | -6.2% | -7.3% | 1.2% |
| **2003** | -0.3% | -0.5% | 0.3% | | -6.5% | -7.8% | 1.4% |
| **2004** | 4.9% | 5.2% | -0.2% | | -1.9% | -3.0% | 1.2% |
| **2005** | 0.3% | 0.3% | 0.1% | | -1.5% | -2.7% | 1.3% |
| **2006** | -1.9% | -1.3% | -0.7% | | -3.4% | -4.0% | 0.6% |
| **2007** | 0.3% | 0.1% | 0.3% | | -3.1% | -3.9% | 0.8% |
| **2008** | -1.5% | -1.2% | -0.3% | | -4.6% | -5.1% | 0.5% |
| **2009** | 4.4% | 4.1% | 0.3% | | -0.4% | -1.2% | 0.8% |
| **2010** | -1.7% | -2.2% | 0.5% | | -2.1% | -3.4% | 1.3% |
| **2011** | -1.4% | -1.1% | -0.3% | | -3.5% | -4.4% | 1.0% |
| **2012** | 1.6% | 1.5% | 0.1% | | -1.9% | -3.0% | 1.1% |

Source: Prepared by the authors with data from EPTMC (Ministerio de Fomento, 2013) and IDAE (2006, 2010a).

The implications of the results are immediate. The energy intensity reduction in road freight in Spain is the result of the positive contribution of the real energy intensity index —greater apparent energy efficiency in road freight (lower fuel consumption per tonne-kilometre)—, which was partially offset by the negative contribution of the structural index —the commodity groups which are more energy intensive increase their share in the activity. Thus, the multi-period decomposition analysis shows that the real energy intensity index has negative cumulative growth rates, which translate into an improvement in energy efficiency. Similarly, except for the years 1997 and 1998, the structural index has positive cumulative growth rates which contributed, in turn, to worsening energy efficiency. As the negative growth rates of the real energy intensity index were superior to the positive growth rates of the structural index, energy intensity decreased over the period.

It should also be noted that the erratic behaviour of energy intensity corresponds to the development shown by the real energy intensity index throughout the period, while the structural index shows less variability. In particular, the negative real energy intensity index for the years 2004 and 2009 changed the progression of energy intensity; detailed information is required to understand such behaviour (Figure 3). Again, the importance of the real energy intensity index is evident in determining energy intensity with respect to the structural index. To obtain more clues to the factors behind the contribution of both effects and to establish which policies could improve energy intensity for road freight in the future, we proceed to decompose these effects into the contribution to transport of each commodity group.

**FIGURE 3. TRENDS IN ENERGY INTENSITY: REAL ENERGY INTENSITY INDEX AND STRUCTURAL INDEX**



Source: Prepared by the authors with data from EPTMC (Ministerio de Fomento, 2013) and IDAE (2006, 2010a).

## 4.2. RESULTS OF ATTRIBUTION OF CHANGES IN DIVISIA TO THE REAL ENERGY INTENSITY INDEX AND THE STRUCTURAL INDEX

Table 7 summarizes the results of multi-period attribution analysis of energy intensity for the real energy intensity index and the structural index in the period 1996–2012. The last row of the table shows the contribution to the cumulative percentage change in energy intensity of the real energy intensity index and the structural index over the period. The method attributes this change quantitatively to the transportation of each of the 24 commodity groups. Regarding the real energy intensity index, it can be said that the commodity groups Foodstuff and animal fodder (6) and Transport equipment, machinery, apparatus and engines, whether or not assembled and parts thereof (20) determine almost entirely the positive development of the real energy intensity index between 1996 and 2012.

Regarding the structural index, it can be seen that the worsening in energy intensity derived from this index is due to the following commodity groups: Foodstuff and animal fodder (6) and Miscellaneous articles (24). This is despite the positive contribution of the commodity groups Crude and manufactured minerals (15) and Cement, lime and manufactured building materials (14).

**TABLE 7. ATTRIBUTION OF M-LMDI-II OF ENERGY INTENSITY TO REAL ENERGY INTENSITY AND STRUCTURAL INDEXES BY CHAIN METHOD (base = 1996)**

| | Energy intensity | Real energy intensity index | Structural index |
|---|---|---|---|
| 1 | -0.6 | 0.0 | -0.6 |
| 2 | 2.1 | 0.2 | 2.0 |
| 3 | -0.8 | -0.2 | -0.6 |
| 4 | -1.2 | 0.1 | -1.3 |
| 5 | 0.3 | 0.1 | 0.1 |
| 6 | 3.1 | -1.7 | 4.8 |
| 7 | 0.3 | 0.0 | 0.3 |
| 8 | -0.5 | 0.0 | -0.4 |
| 9 | 0.0 | 0.0 | 0.0 |
| 10 | -1.0 | 0.2 | -1.2 |
| 11 | 0.4 | 0.0 | 0.4 |
| 12 | 0.1 | 0.0 | 0.1 |
| 13 | -0.8 | 0.3 | -1.1 |
| 14 | -1.8 | -0.4 | -1.4 |

| | | | |
|---|---|---|---|
| **15** | -3.1 | -0.6 | -2.4 |
| **16** | 0.0 | 0.0 | 0.0 |
| **17** | 0.3 | 0.0 | 0.3 |
| **18** | -1.1 | 0.0 | -1.1 |
| **19** | 0.3 | -0.1 | 0.4 |
| **20** | -0.5 | -1.1 | 0.6 |
| **21** | -0.8 | -0.1 | -0.7 |
| **22** | -0.5 | 0.0 | -0.5 |
| **23** | -0.4 | 0.2 | -0.5 |
| **24** | 4.0 | 0.1 | 3.9 |
| **Activity** | **-1.9** | **-3.0** | **1.1** |

Source: Prepared by the authors with data from EPTMC (Ministerio de Fomento, 2013) and IDAE (2006, 2010a).

The combination of both indices provides the contribution of each commodity group to the progression of energy intensity in road freight in the period 1996–2012. Thus, the commodity groups Cement, lime and manufactured building materials (14) and Crude and manufactured minerals (15) contribute significantly to the reduction of energy intensity in road freight.

However, three commodity groups with a significant share in total activity, Foodstuff and animal fodder (6), Potatoes, fresh or frozen fruits and vegetables (2) and Miscellaneous articles (24), prevented further contraction in energy intensity over the period analysed. In the first case, Foodstuff and animal fodder (6), despite having reduced real energy intensity in the period considered (positive real energy intensity index), increased its relative weight in total activity (negative structural index) in such a way that the second index dominates the first. In the second two cases, Potatoes, fresh or frozen fruits and vegetables (2) and Miscellaneous articles (24), both increased in terms of real energy intensity and their relative weight in total activity.

Taking into account the above and in relation to the study of the erratic behaviour of energy intensity, the high variability of the real energy intensity index, as previously mentioned, may be explained by the commodity groups Foodstuff and animal fodder (6) and Miscellaneous articles (24). Specifically, both experienced a strong growth in the real energy intensity index in 2004 and 2009. Moreover, a more detailed analysis of the progression of the real energy intensity index in 2004 and 2009 reveals that the commodity groups Potatoes, fresh or frozen fruits and vegetables (2) and Leather, textiles, clothing and other manufactured articles (23) should also be considered. Similarly, the commodity group Transport equipment, machinery, apparatus and engines, whether or not assembled and parts thereof (20) should also be taken into account for 2009 (see Table A2 in the Appendix).

To examine what factors explain the results of the real energy intensity index for the commodity groups indicated in years 2004 and 2009, two key performance factors of the activity were analysed: transport content and transport efficiency. In 2004 and 2009, both key factors, transport content (distance travelled per tonne transported) and transport efficiency (tonnes carried per vehicle) worsened considerably.[5] In short, the negative development of the real energy intensity index in 2004 and 2009 is explained because in transporting these commodity groups, heavy goods vehicles carried fewer tonnes and travelled more kilometres per tonne transported.

**TABLE 8. PERFORMANCE OF KEY FACTORS IN ROAD FREIGHT ACTIVITY**

<table>
<tr><th colspan="2"></th><th>2003/2004</th><th>2008/2009</th></tr>
<tr><td rowspan="5">Transport content</td><td>2</td><td>11.0%</td><td>-5.6%</td></tr>
<tr><td>6</td><td>6.9%</td><td>8.0%</td></tr>
<tr><td>20</td><td>-</td><td>8.8%</td></tr>
<tr><td>23</td><td>18.5%</td><td>-0.8%</td></tr>
<tr><td>24</td><td>-3.0%</td><td>3.5%</td></tr>
<tr><td rowspan="5">Transport efficiency</td><td>2</td><td>-12.9%</td><td>-6.6%</td></tr>
<tr><td>6</td><td>-4.4%</td><td>-1.0%</td></tr>
<tr><td>20</td><td>-</td><td>-7.5%</td></tr>
<tr><td>23</td><td>-15.4%</td><td>-6.7%</td></tr>
<tr><td>24</td><td>-3.3%</td><td>-1.0%</td></tr>
</table>

Source: Prepared by the authors with data from EPTMC (Ministerio de Fomento, 2013) and IDAE (2006, 2010a).

## 5. CONCLUSION

The substantial increase in the energy consumption of freight transport in Spain during the period 1996–2012 is explained by the strong growth in activity. Road freight activity was clearly primarily responsible for this increase, accounting for between 90% and 95% of domestic freight transport over the period.

Investigating the energy intensity of transport, its progression and the factors that determine it, helps to understand the behaviour of one key component of energy consumption. This article aims to contribute to a better understanding of the factors behind the change in energy intensity in relation to road freight, which can inform the design of measures to achieve greater energy efficiency in the sector. The use of the M-LMDI-II decomposition analysis to examine energy intensity complements the research that to date has focused on the study of energy

[5] Regarding the transport content factor, the commodity group Miscellaneous articles (24) is an exception in 2004 and the commodity groups Potatoes, other fresh or frozen fruits and vegetables (2) and Leather, textiles, clothing and other manufactured articles (23) are the exceptions in 2009.

consumption in road freight. Similarly, expanding the study through considering the attribution of changes in the Divisia index probes the results in greater depth and shows how each commodity group has participated in changes in energy intensity. The energy intensity of road freight transport dropped by 1.9% in Spain over the period 1996–2012. The improvement in energy efficiency was very modest in relation to the 89.7% increase in the energy consumption of road freight transportation in the same period. The decomposition analysis of energy intensity shows that the positive result in energy intensity progression was due to the behaviour of the real energy intensity index —less energy consumption per tonne-kilometre— partially offset by the negative behaviour of the structural index —more energy intensive commodity groups increased their relative share in total activity.

Moreover, the results of the decomposition analysis show that the decrease in energy intensity over the period was not constant but erratic. This behaviour was due to the instability shown by the real energy intensity index, whereas the structural index presented little variability. In this sense, the attribution analysis of energy intensity shows that not all commodity groups participated positively in the reduction nor to the same degree over the period of time analysed. Thus, the commodity groups that contributed significantly to the reduction of energy intensity in road freight were Crude and manufactured minerals (15) and Cement, lime and manufactured building materials (14). An important remark is that these two commodity groups are directly related to construction. In contrast, Foodstuff and animal fodder (6), Potatoes, fresh or frozen fruits and vegetables (2)[6] and Miscellaneous articles (24) were the commodity groups that prevented greater contraction in energy intensity over the period. Furthermore, the trend in these three last commodity groups also helps to explain to a great extent the erratic movement of the real energy intensity index.

The level of importance of the real energy intensity index in explaining changes in energy intensity in relation to the structural index and the fact that the structural index depends on the specialization of the economy, reinforces the idea that the efforts of public authorities should aim to implement measures in the short and medium term leading to a further reduction in the real energy intensity index. These measures should not only consist of the gradual replacement of the fleet with more energy efficient vehicles, and/or the introduction of higher quality fuels, or more generally, of adequate infrastructure and efficient driving. The Spanish Government applied two plans according to these measures during the last decade: the Plan Estratégico para el Transporte de Mercancías por Carretera (PETRA) (Ministerio de Fomento, 2001) in the period 2001–2006 and the Plan Estratégico de Actuación para el Transporte de Mercancías por Carretera (PETRA II) (Ministerio de Fomento, 2010) in 2006–2011. The moderate decrease in

[6] The commodity groups Foodstuff and animal fodder (6) and Potatoes, fresh or frozen fruits and vegetables (2) are directly related to the food industry.

energy intensity over the period shows the limited success of these two plans. This is why other factors should also be considered to achieve greater energy efficiency.

This research has demonstrated that commodities are also important as each commodity group is involved to a different degree and with different sign in the reduction of energy intensity. In particular, two key performance indicators, transport content and transport efficiency, reveal the importance of logistics in achieving greater energy efficiency in road freight transport for each commodity group. Thus, for example, the negative behaviour of the real energy intensity index in 2004 and 2009 was predominantly due to two commodity groups, Foodstuff and animal fodder (6) and Miscellaneous articles (24). Heavy goods vehicles, when transporting these commodity groups, carried fewer tonnes and travelled more kilometres per tonne transported, i.e. the logistics did not work correctly.

The change in the structural index shows how the success of measures to achieve more efficient energy use in road freight transport depends on the extent to which the composition of commodity groups is properly taken into account. Thus, measures designed to achieve greater energy efficiency are even more necessary in a context in which the more energy intensive commodity groups increase their share in transport activity, as was the case in Spain over the period 1996–2012. Ultimately, the results of the attribution of the real energy intensity index and of the structural index by commodity group suggest the need to design measures that take into account the commodity group being transported.

Future research should focus on studying in greater detail different factors that may influence the progression of the real energy intensity index and thus find mechanisms that could lead to improvements. If an energy intensive commodity group such as Transport equipment, machinery, apparatus and engines, whether or not assembled and parts thereof (20) has managed to achieve greater energy efficiency in its transport, it is conceivable that this could also be achieved in the transport of other commodity groups. Thus, the study of the elasticity of demand for road freight transport by commodity group could be one factor to be considered. Similarly, the analysis should be extended by including another important mode of freight transport, namely rail. The analysis could then be carried out by disaggregating by commodity group and by mode of transport. Finally, this research can be expanded by focusing the study on the intensity of greenhouse gas emissions, both in terms of development and the implications, and on the identification of possible solutions.

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## APPENDIX

### TABLE A1. STANDARD GOODS CLASSIFICATION TRANSPORT STATISTICS. NST/R 24 GROUPS

| | **Commodity groups** |
|---|---|
| 01 | Cereals |
| 02 | Potatoes, other fresh or frozen fruits and vegetables |
| 03 | Live animals, sugar beet |
| 04 | Wood and cork |
| 05 | Textiles, textile articles and man-made fibres, other raw animal and vegetable materials |
| 06 | Foodstuff and animal fodder |
| 07 | Oil seeds and oleaginous fruits and fats |
| 08 | Solid mineral fuels |
| 09 | Crude petroleum |
| 10 | Petroleum products |
| 11 | Iron ore, iron and steel waste and blast furnace dust |
| 12 | Non-ferrous ores and waste |
| 13 | Metal products |
| 14 | Cement, lime, manufactured building materials |
| 15 | Crude and manufactured minerals |
| 16 | Natural and chemical fertilizers |
| 17 | Coal chemicals, tar |
| 18 | Chemicals other than coal chemicals and tar |
| 19 | Paper pulp and waste paper |
| 20 | Transport equipment, machinery, apparatus, engines, whether or not assembled and parts thereof |
| 21 | Manufactures of metal |
| 22 | Glass, glassware, ceramic products |
| 23 | Leather, textile, clothing, other manufactured articles |
| 24 | Miscellaneous articles |

Source: Eurostat (2013).

**TABLE A2. ATTRIBUTION OF M-LMDI-II REAL ENERGY INTENSITY INDEX. SINGLE-PERIOD ANALYSIS ($\text{base} = \text{previous year}$)**

| | Δ % IE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1997** | -3.04 | -0.05 | -0.20 | -0.17 | 0.06 | -0.11 | -0.89 | 0.04 | 0.00 | 0.00 | -0.06 | -0.06 | 0.00 | -0.19 | -0.36 | 0.02 | 0.00 | 0.00 | -0.04 | 0.00 | -0.52 | -0.09 | 0.11 | -0.27 | -0.26 |
| **1998** | -2.35 | 0.08 | -0.51 | -0.04 | -0.24 | 0.04 | -0.59 | -0.05 | -0.02 | 0.00 | -0.12 | 0.02 | 0.00 | -0.01 | -0.09 | -0.40 | -0.02 | 0.00 | -0.03 | -0.15 | -0.32 | -0.09 | -0.19 | 0.55 | -0.17 |
| **1999** | 1.23 | -0.08 | 0.20 | 0.13 | 0.13 | 0.03 | 0.18 | -0.02 | 0.03 | 0.00 | 0.14 | -0.03 | 0.00 | 0.00 | 0.05 | 0.21 | -0.06 | 0.00 | 0.03 | 0.03 | -0.05 | 0.19 | 0.10 | 0.08 | -0.06 |
| **2000** | -1.84 | 0.02 | -0.14 | -0.05 | 0.02 | 0.04 | -0.46 | 0.01 | -0.01 | 0.00 | -0.12 | -0.01 | 0.00 | 0.00 | 0.01 | 0.09 | -0.02 | -0.01 | -0.11 | -0.05 | 0.07 | -0.13 | -0.01 | -0.59 | -0.39 |
| **2001** | 1.33 | 0.02 | 0.03 | -0.03 | 0.00 | 0.02 | 0.08 | -0.02 | 0.01 | 0.00 | 0.12 | -0.01 | 0.00 | 0.12 | 0.02 | -0.06 | 0.01 | 0.01 | 0.16 | 0.07 | 0.13 | 0.11 | -0.01 | 0.75 | -0.19 |
| **2002** | -2.74 | -0.01 | -0.25 | -0.04 | 0.04 | 0.03 | -0.53 | 0.01 | 0.00 | 0.00 | -0.17 | 0.03 | 0.00 | -0.07 | 0.11 | 0.30 | 0.08 | 0.00 | -0.09 | -0.02 | -0.30 | -0.04 | -0.10 | -1.09 | -0.63 |
| **2003** | -0.54 | -0.01 | -0.03 | -0.01 | 0.04 | -0.05 | -0.04 | 0.01 | 0.00 | 0.00 | 0.00 | -0.02 | 0.00 | -0.09 | -0.12 | -0.30 | -0.05 | 0.00 | 0.09 | -0.02 | -0.28 | -0.14 | 0.07 | 0.11 | 0.29 |
| **2004** | 5.18 | 0.08 | 1.24 | 0.07 | -0.08 | 0.07 | 0.77 | 0.00 | -0.01 | 0.00 | 0.25 | 0.00 | 0.00 | 0.43 | 0.13 | 0.07 | 0.07 | 0.01 | -0.09 | 0.11 | -0.41 | 0.15 | 0.17 | 1.60 | 0.57 |
| **2005** | 0.27 | -0.03 | -0.48 | 0.11 | -0.02 | 0.12 | -0.51 | -0.02 | 0.01 | 0.00 | -0.02 | 0.04 | 0.00 | 0.09 | 0.03 | 0.03 | 0.00 | 0.01 | -0.09 | -0.03 | 0.13 | 0.01 | -0.07 | -0.01 | 0.96 |
| **2006** | -1.26 | 0.02 | -0.36 | -0.16 | 0.10 | -0.10 | 0.46 | -0.01 | -0.01 | 0.00 | 0.01 | -0.02 | 0.00 | -0.10 | 0.15 | -0.02 | 0.05 | 0.02 | 0.08 | 0.02 | -0.03 | -0.04 | -0.01 | -0.86 | -0.46 |
| **2007** | 0.09 | -0.05 | 0.29 | 0.02 | 0.02 | 0.06 | -0.40 | 0.01 | -0.03 | 0.00 | 0.09 | -0.05 | -0.01 | -0.02 | -0.07 | -0.23 | -0.04 | 0.00 | -0.06 | -0.03 | 0.10 | -0.03 | 0.05 | 0.11 | 0.35 |
| **2008** | -1.24 | 0.03 | -0.33 | -0.01 | -0.08 | 0.02 | 0.24 | -0.02 | 0.00 | 0.00 | -0.20 | -0.05 | 0.00 | -0.21 | -0.18 | 0.04 | 0.05 | 0.02 | -0.15 | -0.03 | -0.14 | -0.06 | -0.08 | -0.33 | 0.24 |
| **2009** | 4.12 | -0.01 | 0.60 | 0.04 | 0.08 | 0.09 | 0.27 | 0.07 | 0.04 | 0.00 | 0.16 | 0.09 | 0.00 | 0.30 | 0.13 | 0.03 | -0.02 | -0.01 | 0.20 | 0.04 | 0.67 | 0.25 | 0.04 | 0.78 | 0.30 |
| **2010** | -2.24 | 0.01 | 0.37 | 0.01 | 0.01 | -0.14 | -0.15 | -0.03 | -0.01 | 0.00 | -0.01 | -0.01 | -0.01 | 0.04 | -0.06 | -0.19 | -0.09 | -0.03 | 0.00 | -0.07 | -0.42 | -0.17 | -0.02 | -0.64 | -0.64 |
| **2011** | -1.06 | -0.06 | -0.50 | -0.01 | -0.03 | 0.02 | -0.58 | 0.00 | 0.01 | 0.00 | 0.05 | 0.00 | 0.01 | -0.13 | -0.01 | -0.10 | -0.02 | 0.00 | -0.02 | 0.06 | 0.12 | 0.09 | 0.02 | 0.19 | -0.17 |
| **2012** | 1.50 | 0.01 | 0.31 | -0.04 | 0.11 | 0.01 | 0.44 | -0.02 | -0.04 | 0.00 | 0.11 | 0.06 | 0.00 | 0.13 | -0.11 | -0.15 | 0.12 | 0.02 | 0.17 | 0.00 | 0.15 | -0.08 | -0.03 | -0.04 | 0.39 |
| **Mean** | -0.15 | 0.00 | 0.01 | -0.01 | 0.01 | 0.01 | -0.10 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.02 | -0.02 | -0.04 | 0.00 | 0.00 | 0.00 | -0.01 | -0.07 | 0.00 | 0.00 | 0.02 | 0.01 |

Source: Prepared by the authors with data from EPTMC survey (Ministerio de Fomento, 2013) and IDAE (2006, 2010a).

Note: The percentage change of energy intensity in year t over the preceding year derived from the real energy intensity index is presented in the first column of the table. The remaining columns show quantitatively the responsibility of each commodity group for that percentage change, so that their sum is equal to the first column. In the last row, the average annual percentage change of energy intensity due to the real energy intensity index shows the average annual percentage change for each commodity group between 1996 and 2012.

**TABLE A3. ATTRIBUTION OF M-LMDI-II STRUCTURAL INDEX. SINGLE PERIOD ANALYSIS (base = previous year)**

| | Δ % SE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1997** | -0.23 | -0.14 | 0.94 | 0.10 | 0.14 | 0.24 | 0.15 | 0.06 | -0.29 | 0.00 | 0.07 | 0.04 | -0.04 | 0.11 | -0.01 | -0.27 | -0.28 | -0.04 | -0.08 | 0.04 | -0.71 | -0.07 | 0.10 | -0.46 | 0.16 |
| **1998** | -0.21 | -0.12 | -0.47 | -0.37 | 0.28 | 0.07 | -0.88 | -0.04 | 0.02 | 0.00 | -0.19 | -0.01 | 0.00 | 0.36 | 0.45 | 0.14 | 0.12 | 0.03 | 0.41 | 0.01 | 1.04 | -0.20 | -0.12 | -2.15 | 1.41 |
| **1999** | 0.53 | 0.10 | -0.25 | -0.05 | -0.45 | -0.09 | -0.93 | -0.22 | 0.03 | 0.00 | -0.32 | 0.00 | -0.03 | 0.15 | 0.58 | 0.79 | 0.08 | 0.06 | -1.06 | -0.12 | 0.25 | -0.31 | 0.11 | 0.90 | 1.33 |
| **2000** | 0.51 | -0.15 | -0.26 | -0.11 | -0.01 | -0.12 | -0.64 | 0.05 | -0.08 | 0.00 | 0.24 | 0.09 | 0.02 | -0.10 | 0.30 | 0.04 | -0.16 | -0.02 | -0.09 | 0.03 | 0.62 | 0.14 | -0.17 | 0.56 | 0.32 |
| **2001** | 0.29 | -0.15 | 0.28 | 0.01 | -0.26 | 0.10 | -0.18 | -0.02 | -0.09 | 0.00 | -0.17 | -0.07 | -0.01 | -0.06 | -0.30 | 0.68 | -0.02 | 0.02 | -0.34 | 0.01 | 0.00 | 0.09 | 0.04 | 0.44 | 0.30 |
| **2002** | 0.28 | -0.05 | 0.23 | -0.30 | -0.46 | -0.12 | -1.15 | 0.00 | 0.12 | 0.00 | -0.19 | 0.06 | 0.01 | -0.14 | 0.10 | 0.19 | -0.21 | -0.03 | 0.05 | 0.02 | 0.06 | -0.09 | -0.03 | 0.92 | 1.30 |
| **2003** | 0.25 | 0.03 | -0.80 | 0.10 | -0.11 | -0.11 | -0.03 | -0.08 | -0.10 | 0.00 | -0.13 | -0.05 | -0.03 | 0.37 | 0.13 | 0.51 | 0.23 | 0.01 | -0.16 | 0.04 | 0.66 | 0.13 | -0.02 | -0.28 | -0.06 |
| **2004** | -0.25 | -0.46 | 0.43 | -0.11 | 0.47 | -0.02 | 0.62 | 0.39 | 0.12 | 0.01 | -0.32 | 0.10 | 0.11 | -0.70 | 0.61 | -0.57 | -0.03 | -0.01 | 0.63 | -0.10 | 1.06 | -0.39 | -0.48 | -1.21 | -0.38 |
| **2005** | 0.08 | 0.07 | -0.47 | -0.30 | -0.24 | -0.13 | 0.00 | -0.11 | 0.01 | -0.01 | -0.22 | -0.05 | 0.05 | -0.41 | 0.53 | 1.13 | -0.18 | 0.00 | 0.07 | 0.06 | -0.04 | 0.10 | 0.03 | 0.22 | -0.02 |
| **2006** | -0.69 | 0.01 | 0.83 | 0.10 | -0.43 | 0.13 | 1.94 | 0.06 | 0.07 | 0.00 | -0.06 | 0.00 | -0.07 | 0.62 | 0.36 | -0.29 | -0.15 | 0.08 | -0.39 | -0.15 | -0.81 | -0.02 | 0.06 | 0.85 | -3.42 |
| **2007** | 0.26 | 0.07 | -0.79 | 0.04 | -0.29 | -0.10 | 0.23 | -0.15 | -0.13 | 0.00 | -0.02 | 0.15 | 0.12 | 0.07 | 0.13 | 0.27 | 0.26 | 0.01 | -0.50 | 0.17 | 0.95 | -0.11 | -0.08 | -0.03 | -0.01 |
| **2008** | -0.31 | 0.11 | 0.31 | 0.13 | 0.02 | 0.08 | 1.27 | 0.25 | -0.09 | 0.00 | 0.36 | 0.23 | 0.05 | -0.29 | -1.10 | -1.38 | 0.13 | 0.04 | 0.24 | 0.18 | -2.46 | 0.21 | 0.03 | 0.76 | 0.60 |
| **2009** | 0.28 | 0.05 | 1.03 | -0.05 | -0.01 | 0.02 | 2.65 | 0.03 | -0.04 | 0.00 | 0.06 | -0.25 | -0.16 | -0.67 | -0.73 | -1.04 | -0.05 | 0.10 | -0.35 | -0.06 | -0.16 | 0.01 | 0.08 | -0.86 | 0.66 |
| **2010** | 0.53 | -0.10 | -1.19 | -0.12 | -0.07 | 0.02 | 0.02 | 0.06 | -0.12 | 0.00 | 0.08 | 0.21 | 0.05 | 0.50 | -1.08 | -0.94 | 0.01 | 0.13 | 0.47 | 0.11 | 0.55 | -0.01 | 0.02 | 0.63 | 1.29 |
| **2011** | -0.32 | 0.28 | 0.99 | 0.16 | 0.18 | 0.19 | 0.07 | 0.00 | 0.13 | 0.00 | -0.25 | -0.09 | 0.03 | -0.31 | -0.71 | -0.48 | 0.16 | -0.10 | 0.03 | 0.11 | -0.14 | -0.07 | -0.07 | -0.68 | 0.25 |
| **2012** | 0.09 | -0.14 | 1.16 | 0.19 | -0.09 | -0.02 | 1.63 | 0.01 | 0.01 | 0.00 | -0.10 | 0.05 | -0.02 | -0.54 | -0.61 | -1.16 | 0.06 | 0.06 | -0.06 | 0.01 | -0.25 | -0.09 | 0.01 | -0.16 | 0.14 |
| **Media** | 0.06 | -0.04 | 0.11 | -0.03 | -0.08 | 0.01 | 0.28 | 0.02 | -0.03 | 0.00 | -0.07 | 0.02 | 0.01 | -0.06 | -0.08 | -0.14 | 0.00 | 0.02 | -0.07 | 0.02 | 0.04 | -0.04 | -0.03 | -0.03 | 0.23 |

Source: Prepared by the authors with data from EPTMC survey (Ministerio de Fomento, 2013) and IDAE (2006, 2010a).

**TABLE A4. ATTRIBUTION OF M-LMDI-II REAL ENERGY INTENSITY INDEX. MULTI-PERIOD ANALYSIS (**base =1996**)**

| | Δ % IE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1997** | -3.04 | -0.05 | -0.20 | -0.17 | 0.06 | -0.11 | -0.89 | 0.04 | 0.00 | 0.00 | -0.06 | -0.06 | 0.00 | -0.19 | -0.36 | 0.02 | 0.00 | 0.00 | -0.04 | 0.00 | -0.52 | -0.09 | 0.11 | -0.27 | -0.26 |
| **1998** | -5.31 | 0.03 | -0.69 | -0.22 | -0.17 | -0.07 | -1.46 | -0.01 | -0.03 | 0.00 | -0.18 | -0.04 | 0.01 | -0.20 | -0.45 | -0.36 | -0.02 | 0.00 | -0.07 | -0.14 | -0.83 | -0.18 | -0.07 | 0.26 | -0.43 |
| **1999** | -4.15 | -0.05 | -0.50 | -0.09 | -0.05 | -0.04 | -1.29 | -0.03 | 0.01 | 0.00 | -0.04 | -0.06 | 0.01 | -0.20 | -0.40 | -0.17 | -0.08 | 0.00 | -0.04 | -0.12 | -0.88 | 0.00 | 0.02 | 0.33 | -0.48 |
| **2000** | -5.91 | -0.02 | -0.63 | -0.14 | -0.03 | 0.00 | -1.73 | -0.02 | -0.01 | 0.00 | -0.16 | -0.07 | 0.00 | -0.20 | -0.39 | -0.08 | -0.10 | -0.01 | -0.14 | -0.17 | -0.82 | -0.13 | 0.01 | -0.23 | -0.86 |
| **2001** | -4.67 | -0.01 | -0.60 | -0.16 | -0.03 | 0.02 | -1.66 | -0.04 | 0.00 | 0.00 | -0.04 | -0.08 | 0.01 | -0.08 | -0.37 | -0.14 | -0.09 | -0.01 | 0.01 | -0.10 | -0.69 | -0.02 | 0.00 | 0.47 | -1.03 |
| **2002** | -7.28 | -0.02 | -0.84 | -0.20 | 0.00 | 0.05 | -2.17 | -0.03 | 0.01 | 0.00 | -0.21 | -0.05 | 0.01 | -0.15 | -0.26 | 0.15 | -0.02 | -0.01 | -0.08 | -0.13 | -0.98 | -0.06 | -0.10 | -0.57 | -1.63 |
| **2003** | -7.78 | -0.03 | -0.87 | -0.20 | 0.04 | 0.01 | -2.20 | -0.01 | 0.01 | 0.00 | -0.21 | -0.07 | 0.01 | -0.23 | -0.38 | -0.13 | -0.06 | -0.01 | 0.01 | -0.15 | -1.24 | -0.19 | -0.04 | -0.47 | -1.37 |
| **2004** | -3.00 | 0.04 | 0.28 | -0.14 | -0.04 | 0.07 | -1.49 | -0.01 | -0.01 | 0.00 | 0.03 | -0.07 | 0.00 | 0.17 | -0.26 | -0.07 | 0.00 | 0.00 | -0.07 | -0.05 | -1.61 | -0.05 | 0.12 | 1.00 | -0.84 |
| **2005** | -2.75 | 0.02 | -0.19 | -0.04 | -0.06 | 0.19 | -1.98 | -0.03 | 0.01 | 0.01 | 0.01 | -0.04 | 0.00 | 0.25 | -0.23 | -0.04 | 0.01 | 0.01 | -0.16 | -0.08 | -1.49 | -0.04 | 0.06 | 0.99 | 0.09 |
| **2006** | -3.97 | 0.04 | -0.54 | -0.20 | 0.04 | 0.09 | -1.54 | -0.04 | 0.00 | 0.01 | 0.02 | -0.06 | 0.00 | 0.15 | -0.08 | -0.06 | 0.05 | 0.03 | -0.08 | -0.06 | -1.51 | -0.07 | 0.04 | 0.16 | -0.36 |
| **2007** | -3.89 | -0.02 | -0.25 | -0.18 | 0.06 | 0.15 | -1.92 | -0.03 | -0.03 | 0.01 | 0.11 | -0.11 | 0.00 | 0.14 | -0.16 | -0.29 | 0.01 | 0.04 | -0.14 | -0.09 | -1.41 | -0.11 | 0.09 | 0.26 | -0.02 |
| **2008** | -5.08 | 0.02 | -0.57 | -0.18 | -0.02 | 0.17 | -1.69 | -0.05 | -0.04 | 0.01 | -0.09 | -0.16 | -0.01 | -0.06 | -0.33 | -0.25 | 0.06 | 0.06 | -0.29 | -0.12 | -1.55 | -0.16 | 0.02 | -0.05 | 0.21 |
| **2009** | -1.17 | 0.01 | 0.00 | -0.15 | 0.06 | 0.25 | -1.43 | 0.01 | 0.00 | 0.01 | 0.07 | -0.07 | -0.01 | 0.22 | -0.20 | -0.22 | 0.04 | 0.04 | -0.10 | -0.08 | -0.92 | 0.08 | 0.06 | 0.68 | 0.49 |
| **2010** | -3.38 | 0.01 | 0.37 | -0.14 | 0.07 | 0.12 | -1.58 | -0.02 | -0.01 | 0.01 | 0.06 | -0.08 | -0.02 | 0.26 | -0.26 | -0.41 | -0.05 | 0.01 | -0.10 | -0.15 | -1.33 | -0.09 | 0.04 | 0.05 | -0.13 |
| **2011** | -4.41 | -0.05 | -0.12 | -0.15 | 0.04 | 0.14 | -2.14 | -0.02 | 0.01 | 0.01 | 0.11 | -0.08 | -0.01 | 0.14 | -0.28 | -0.51 | -0.07 | 0.01 | -0.12 | -0.10 | -1.22 | 0.00 | 0.06 | 0.23 | -0.29 |
| **2012** | -2.97 | -0.04 | 0.17 | -0.18 | 0.14 | 0.14 | -1.72 | -0.05 | -0.03 | 0.01 | 0.21 | -0.02 | -0.01 | 0.27 | -0.39 | -0.65 | 0.05 | 0.02 | 0.05 | -0.10 | -1.08 | -0.08 | 0.02 | 0.19 | 0.08 |

Source: Prepared by the authors with data from EPTMC survey (Ministerio de Fomento, 2013) and IDAE (2006, 2010a).

**TABLE A5. ATTRIBUTION OF M-LMDI-II STRUCTURAL INDEX. MULTI-PERIOD ANALYSIS (**base = 1996**)**

| | Δ % SE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1997** | -0.23 | -0.14 | 0.94 | 0.10 | 0.14 | 0.24 | 0.15 | 0.06 | -0.29 | 0.00 | 0.07 | 0.04 | -0.04 | 0.11 | -0.01 | -0.27 | -0.28 | -0.04 | -0.08 | 0.04 | -0.71 | -0.07 | 0.10 | -0.46 | 0.16 |
| **1998** | -0.45 | -0.26 | 0.47 | -0.27 | 0.42 | 0.30 | -0.73 | 0.01 | -0.27 | 0.00 | -0.12 | 0.03 | -0.04 | 0.47 | 0.44 | -0.13 | -0.16 | -0.02 | 0.34 | 0.05 | 0.33 | -0.28 | -0.02 | -2.61 | 1.57 |
| **1999** | 0.08 | -0.16 | 0.22 | -0.32 | -0.02 | 0.21 | -1.65 | -0.21 | -0.24 | 0.00 | -0.44 | 0.03 | -0.07 | 0.62 | 1.03 | 0.65 | -0.09 | 0.05 | -0.71 | -0.07 | 0.58 | -0.58 | 0.09 | -1.71 | 2.90 |
| **2000** | 0.60 | -0.32 | -0.04 | -0.43 | -0.03 | 0.09 | -2.30 | -0.15 | -0.32 | 0.00 | -0.20 | 0.12 | -0.05 | 0.52 | 1.33 | 0.69 | -0.25 | 0.02 | -0.81 | -0.04 | 1.20 | -0.45 | -0.08 | -1.15 | 3.22 |
| **2001** | 0.89 | -0.47 | 0.24 | -0.42 | -0.29 | 0.19 | -2.47 | -0.17 | -0.41 | 0.00 | -0.37 | 0.05 | -0.05 | 0.46 | 1.03 | 1.37 | -0.27 | 0.04 | -1.14 | -0.03 | 1.20 | -0.36 | -0.04 | -0.70 | 3.52 |
| **2002** | 1.17 | -0.52 | 0.47 | -0.72 | -0.76 | 0.07 | -3.64 | -0.17 | -0.29 | 0.00 | -0.56 | 0.11 | -0.05 | 0.32 | 1.12 | 1.56 | -0.49 | 0.01 | -1.10 | -0.01 | 1.26 | -0.45 | -0.07 | 0.23 | 4.83 |
| **2003** | 1.42 | -0.49 | -0.34 | -0.62 | -0.87 | -0.04 | -3.67 | -0.24 | -0.39 | 0.00 | -0.69 | 0.05 | -0.07 | 0.69 | 1.25 | 2.08 | -0.26 | 0.02 | -1.25 | 0.03 | 1.93 | -0.32 | -0.09 | -0.05 | 4.77 |
| **2004** | 1.17 | -0.96 | 0.10 | -0.73 | -0.40 | -0.06 | -3.04 | 0.15 | -0.27 | 0.01 | -1.02 | 0.15 | 0.04 | -0.03 | 1.87 | 1.50 | -0.28 | 0.01 | -0.62 | -0.08 | 3.00 | -0.72 | -0.58 | -1.28 | 4.39 |
| **2005** | 1.25 | -0.89 | -0.38 | -1.03 | -0.64 | -0.19 | -3.04 | 0.04 | -0.26 | 0.00 | -1.24 | 0.10 | 0.09 | -0.44 | 2.41 | 2.64 | -0.46 | 0.01 | -0.55 | -0.01 | 2.97 | -0.62 | -0.55 | -1.06 | 4.37 |
| **2006** | 0.56 | -0.88 | 0.46 | -0.93 | -1.07 | -0.06 | -1.08 | 0.09 | -0.19 | -0.01 | -1.30 | 0.10 | 0.02 | 0.19 | 2.77 | 2.35 | -0.62 | 0.09 | -0.95 | -0.17 | 2.14 | -0.64 | -0.49 | -0.20 | 0.91 |
| **2007** | 0.81 | -0.81 | -0.34 | -0.89 | -1.36 | -0.16 | -0.85 | -0.05 | -0.32 | -0.01 | -1.32 | 0.25 | 0.14 | 0.26 | 2.90 | 2.62 | -0.36 | 0.10 | -1.45 | 0.01 | 3.10 | -0.74 | -0.57 | -0.23 | 0.90 |
| **2008** | 0.50 | -0.70 | -0.03 | -0.76 | -1.34 | -0.08 | 0.43 | 0.20 | -0.41 | -0.01 | -0.96 | 0.48 | 0.19 | -0.03 | 1.79 | 1.23 | -0.22 | 0.14 | -1.20 | 0.19 | 0.62 | -0.53 | -0.54 | 0.54 | 1.50 |
| **2009** | 0.78 | -0.65 | 1.01 | -0.81 | -1.35 | -0.06 | 3.10 | 0.23 | -0.45 | -0.01 | -0.90 | 0.23 | 0.03 | -0.71 | 1.06 | 0.18 | -0.27 | 0.24 | -1.55 | 0.13 | 0.46 | -0.52 | -0.46 | -0.33 | 2.17 |
| **2010** | 1.32 | -0.74 | -0.19 | -0.92 | -1.41 | -0.03 | 3.12 | 0.29 | -0.57 | 0.00 | -0.82 | 0.45 | 0.08 | -0.21 | -0.03 | -0.76 | -0.26 | 0.37 | -1.08 | 0.23 | 1.01 | -0.53 | -0.44 | 0.30 | 3.47 |
| **2011** | 0.99 | -0.46 | 0.81 | -0.76 | -1.23 | 0.16 | 3.19 | 0.29 | -0.44 | -0.01 | -1.07 | 0.35 | 0.11 | -0.52 | -0.75 | -1.25 | -0.09 | 0.27 | -1.05 | 0.35 | 0.87 | -0.60 | -0.51 | -0.39 | 3.73 |
| **2012** | 1.07 | -0.60 | 1.97 | -0.57 | -1.33 | 0.14 | 4.84 | 0.30 | -0.43 | -0.01 | -1.17 | 0.40 | 0.10 | -1.06 | -1.37 | -2.42 | -0.03 | 0.32 | -1.11 | 0.36 | 0.62 | -0.70 | -0.50 | -0.55 | 3.87 |

Source: Prepared by the authors with data from EPTMC survey (Ministerio de Fomento, 2013) and IDAE (2006, 2010a).

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