The dynamics of the Food & Drink industry and their environmental and social implications in selected European countries

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Abstract

Industry has been going through a period of changes worldwide, in response to global challenges in all three dimensions of sustainable development; the economic, the social and the environmental one. The Food & Drink (F&D) sectors are traditional manufacturing branches that are often considered to have more difficulties in coping with the requirements of sustainability in a highly competitive globalised market. However, in the EU, F&D remains at the top of all manufacturing sectors, while at the same time significantly reducing its total CO_2 emissions and maintaining an almost stable employment level. The scope of this paper is to implement a decomposition analysis in the EU's F&D industry, in order to identify the driving forces behind these changes. Decomposition analysis is widely recognised as a powerful tool for detecting the driving factors behind changes in various aggregate indicators over time. Moreover, it aims to identify if and how the economic crisis has affected the impact of each separate driving factor. The decomposition method used in this study relies on the Log Mean Divisia Index I and the developed models comprise some common or closely related drivers, in order to offer useful insights into relevant complementary and/or antithetical effects on the examined sustainability indicators.

The obtained results indicate that although the developments in the F&D sector seem to have a more or less stable evolution, the economic crisis has significantly influenced the relative contribution of the determinant factors. Specifically, in times of economic prosperity it was mainly the resource (energy or labour) intensity and the consumption intensity effects that overbalanced the augmenting effect of growth. During the recent economic crisis, the technological improvements of the previous period continued and helped the sector enhance its competitive advantages at the global market and significantly increase its exports. Thus, it is shown that tradition and technological progress through innovations are not controversial and that their combination in the case of the F&D sector has been quite successful.

1 Introduction

In a global and increasingly competitive context, European economies have realized that it is urgent to effectively overcome the major challenges the new century faces. In particular, these are the climate change and the growing unemployment, which threatens social cohesion and human welfare.

During the last decades changes in energy and/or carbon intensity and in carbon emissions over time have been studied extensively. Decomposition analysis has been one of the most widespread tools used for shedding light on the factors explaining changes in CO_2 emissions at the economy or sectoral level. Compared to other methodologies, such as econometric methods, which reduce the attribute space of a large number of variables to a smaller one for indicating the most influential factors, decomposition analysis has the great advantage to quantify the positive or negative contribution of each explanatory factor. There are two broad categories of decomposition analysis, namely the Index Decomposition Analysis (IDA) and the Structural Decomposition Analysis (SDA). The former relies on the use of statistical data and is the most commonly used method for energy and emissions analyses. The principal advantages of IDA methods are their flexibility and the data availability, which facilitate time-series analysis and cross-country comparisons. Alternatively, the SDA employs Input-Output tables allowing a refined decomposition analysis of intersectoral links. A comparison of the two categories can be found in Hoekstra and Van der Bergh (2003) and in Su and Ang (2012).

The industrial sector, being one of the major contributors to total CO_2 emissions has been a privileged application field for decomposition analysis. Some examples amongst relevant studies which used an IDA method are Akbostanci et al. (2011), Hammond and Norman (2012), and Ouyang and Lin (2015), who decomposed CO_2 emissions of industrial sectors in Turkey, the UK and China, respectively. Furthermore, Diakoulaki and Mandaraka (2007) decomposed, by means of an IDA method, the industrial CO_2 emissions of 14 EU countries and assessed the real efforts undertaken in each country in order to proceed to a fair comparative evaluation. Regarding the use of SDA, we mention the work of Chang et al. (2008) who implemented a SDA approach for Taiwan's industry by examining nine driving factors in three distinct time periods. Other publications focused on specific industrial sectors, especially the most energy- and carbon-intensive ones, such as the cement industry (Branger and Quirion, 2015; Lin and Zhang, 2016), the iron and steel industry (Sheinbaum et al., 2010; Hasanbeigi et al., 2014), and the chemical industry (Lin and Long, 2016).

As the food industry has a medium to low energy and carbon intensity, there are only a few publications dealing with the decomposition of energy and/or CO_2 emissions. In fact, Lin and Lei (2015) decomposed through an IDA method energy consumption and CO_2 emissions in China's food industry and concluded that the activity and the energy intensity effects were the main factors driving respectively up and down CO_2 emissions, carbon intensity and energy structure present a volatile but not significant effect, while the industry scale contributed mostly to the increase in emissions level. In a more detailed analysis, Lin and Xie (2016) applied a SDA to decompose CO_2 emissions from China's food industry into four main factors: total output, emission factor, energy intensity and energy mix. Furthermore, the output effect was split into four sub-effects accounting for intermediate and final demand, imports and exports, with the two last sub-effects found to have played a minor role compared to the two first ones.

However, there is an obvious need to get a deeper understanding of the factors behind the evolution of the food sector and of associated sustainability indicators because of its leading role in total manufacturing and its significant economic, environmental and social implications. The scope of this paper is to implement a decomposition analysis in the EU Food & Drink (F&D) industry, which represents the biggest manufacturing sector in the EU, in terms of turnover, value added and employment [FoodDrinkEurope, 2014). In a global comparison, the EU F&D industry ranked first in terms of turnover in 2012, ahead of China and the USA (FoodDrinkEurope, 2016). This outstanding performance is certainly due to the long tradition of EU countries on food manufacturing and also to the continuous efforts of the industry to effectively meet the increasing global competition through intensive innovation (Olper et al., 2014). These industries have for long been characterized as non-research-intensive, considered to offer little to enhance the prospects for future growth. Therefore, they have received little policy attention or support (Bender, 2006). On the other hand, although the food sector was considered to be a low-tech sector with a poor innovation potential, it is increasingly recognised that EU companies have succeeded in standing out from their global competitors due to their capacity to introduce incremental, rather than radical innovations and to fulfil consumers' expectations for safe, healthy and high quality products (Menrad, 2004; Minarelli et al., 2015). Still, in recent years, the sector presents a decrease in its relative competitiveness compared to other world producers, mostly as a result of a slower growth in labour productivity and value added (EC, 2016).

The analysis is not limited to the decomposition of CO_2 emissions, but it is also applied in the employment in the manufacturing sector. In this way, it is aimed to investigate any conflicts or synergies associated with critical economic, technological or social factors and to determine the effect of these factors on carbon emissions and employment. It should be noted that decomposition analysis has not been widely used for analysing social and economic issues. A recent study, which applied a stochastic frontier model to evaluate the resource and environmental efficiency problem of European countries, suggested the decomposition analysis as a useful approach to reveal which factor (labour, capital or energy) is behind the performance of each country in terms of eco-efficiency (Robaina-Alves et al., 2015). Studies which used the structural decomposition analysis focused mostly on decomposing labour productivity (Tang and Wang, 2004; Yang and Lahr, 2010). Thus, the main objective set in our study is to proceed to a parallel investigation of the factors explaining the evolution of CO_2 emissions and employment, two indicators which reflect the overall sustainability challenge, together with economic growth.

In a previous study, Kopidou et al. (2015) decomposed the CO_2 emissions and the employment of the entire manufacturing sector into the effects of production-based factors, such as the economic output, the industry structure, the resources intensity and the energy mix. In this paper, it was aimed to develop a decomposition model encompassing all common critical factors denoting the changes brought about in modern production systems, in a globalised and highly competitive market and in consumers' behaviour.

The novelty of this study is the introduction of three additional driving factors in the decomposition model. These are: a) the share of domestic value added in total output, b) the international trade in the form of a production to consumption ratio, and c) the consumption intensity of the products of the examined sector. Besides, the analysis is performed only for one manufacturing sector.

The decomposition models developed for CO_2 emissions and employment are implemented in the food, beverages and tobacco manufacturing sector of 13 EU countries for the period 2000-2013, divided in two sub-periods, 2000-2007 and 2007-2013, in order to assess the impact of the economic crisis[1]. It should be noted that the Food, Beverages and Tobacco sectors are handled as one unified manufacturing sector due to the format of the available statistical data. Nevertheless, it should be noted that the F&D industry is the dominating branch influencing the developments and the performances of the whole sector. In fact, the tobacco industry represents only 1% of total employment and around 4% of the total turnover (Nomisma, 2012).

The following section gives information and data about the Food and Drink sector in the European Union focusing on its innovative performance. The next section presents the driving factors under consideration and the respective decomposition models used to identify their contribution to changes in CO_2 emissions and employment levels. The subsequent section presents the decomposition results and discusses the similarities and differences between the two indicators as well as between the examined countries. Conclusions are drawn in the final section.

2 Innovation in the Food and Drink Sector in Europe

The F&D industry is a steadily growing manufacturing sector with important contribution to the European economy. According to the latest available data, the F&D sector is a major contributor to Europe's economy, ahead of other manufacturing sectors, being a stable, resilient and robust branch. In 2015, the volume of food and drink production was the highest since 2008 while it generated a

[1] Using the year 2007 as a threshold for defining the "pre crisis" period is based on key events and impacts on European economies referring to the crisis such as the collapse of Lehman brothers in September 2008, the banking system bailouts in a number of euro area countries since early 2009 and the subsequent slowdown of real economic activity which for a number of European countries resulted in a deep and prolonged recession.

turnover of €1,089 billion (2014) and a value added of €212 billion (2013). Over the past decade, the growth of value added in the food and drink industry has been higher than the overall manufacturing growth. It is a significant – and a relatively stable - employer in the EU with over 4.25 million people, while it is the biggest employer in manufacturing in more than half of the EU Member States. The average number of persons employed by a food and drink company is 16, 2 more than the average manufacturing company. It is a highly diversified sector with many companies of different sizes (FoodDrinkEurope, 2014; 2016).

In terms of innovation, the F&D sector is indeed a relatively traditional sector which exploits advanced technologies to develop processes and products. This is the result of a highly competitive and challenging global market environment characterized by increasing globalization, intensive liberalization, and the entry of new players (Kastelli et al., 2016). Although in the F&D industry R&D and innovation levels are low according to most official national statistics, the technological change in other sectors can affect the whole food industry value chain from raw materials to final consumers ('from farm to fork'), and present opportunities based on technological advancements in fields such as ICTs, biotechnologies, and health-care (European Commission, 2009). Moreover, according to the OECD technology classification, the F&D sector is considered as a low-tech sector. Indeed, the mainstream view is that such traditional industries are not sufficiently innovative, and thus, cannot be considered as drivers of growth and competitiveness. This view is rooted mainly in the linear approach to innovation, according to which R&D intensity is the main driver of innovation. While high tech industries have enjoyed preferential policy treatment so far, low-tech sectors have been systematically neglected (Hirsch-Kreinsen, 2008; Potters, 2009; Bender, 2006; Robertson and Jacobson, 2011).

Another important issue is that at least in the case of the European F&D industry, small and medium sized enterprises (SMEs) account for half of the industry turnover and 63.3% of F&D employment (FoodDrinkEurope, 2016). Small firms have limited resources and opportunities for R&D and are less able to cope with the risks inherent in R&D investment. So the vast majority of firms operating in this sector face the usual resource constraints which do not allow for extensive R&D spending. Nevertheless, since 2005 R&D expenditure in the F&D sector has increased with a slightly higher rate compared to the whole industry (European Commission, 2016), while according to the Investment Scoreboard (IRI, 2014) the sector's R&D intensity is medium to low ranging between 1% and 2%. Moreover, the R&D in this industry has a specific character. Many F&D products endure over long periods, and new products are mainly extensions of older ones, resulting in incremental change based on activities that often are reported as operating costs rather than investment. Nevertheless, this sector regularly develops products incorporating not only marginal but also some more radical innovation such as functional foods which represents a fusion between the food industry and biotechnology. In fact, despite the medium to low level of R&D, the F&D sector absorbs technological developments and innovations developed in other industries. The combination of these technologies and activities expands the sectoral knowledge base with positive effects on competitiveness (Kastelli and Caloghirou, 2014). This has been proven empirically by numerous cases where technological developments in the F&D industry have been grounded on new emerging research fields such as biosensor technology in the area of food safety, advances in materials science and nanotechnology in the food processing area, packaging, quality control, and functional foods, ICTs for improving cropping system assessments, new technology systems in food processing, etc.

This gradual but steady enhancement of the sector's competitiveness resulted in a continuous increase of its trade surplus. Although imports of food and drink products from emerging countries increased clearly over the last six years, the EU exports grew faster so that the EU appears to be a net exporter and is ranked first in global exports (European Commission, 2016).

In any case, the F&D industry is a very active and dynamic sector of the European economy. Its patterns of growth, the ways it takes advantage of the technological advances in other fields to incorporate change, while at the same time meeting environmental challenges (reducing its total CO_2 emissions) without losses in employment is an interesting topic to examine. The next section tries to open this black box of growth and provide empirical evidence for policy consideration.

3 Methodological approach

Among the available IDA methods, the Log Mean Divisia Index I (LMDI I) method was chosen. The LMDI method was first introduced by Ang and Liu (2001) and is the most commonly used IDA method in a wide application field. The method facilitates the presentation of results in the familiar and easily comprehensible percentage form. Besides its easy formulation, other advantages of LMDI I can be found in Ang (2004; 2005).

The models developed for the decomposition of CO_2 emissions and employment include basically common or closely related determinant factors. These are the following:

Economic growth (G): the factor refers to the Gross Domestic Product (GDP) of a country (G) which is the leading cause of increases in emissions and employment. It is clear that the industrial growth is an overarching goal for all countries and that the challenge for policy makers is to combine growth with fewer emissions and more jobs.

Consumption intensity (m): the factor is defined as the ratio of domestic final consumption of the sector's products (D) to total GDP (G) and its change with time reveals changes in consumers' behaviour.

Self-sufficiency of domestic production (x): the factor is defined as the ratio of domestic production (P) to domestic final consumption (D) and indicates the relative growth and the direction of trade flows of the sector's products.

Value Added (v): the factor is defined as the share of value added (V) in total output (P) and is a proxy of the degree of integration in the production process.

Resources intensity (e and l): the factor refers to energy intensity in the emissions model and to labour intensity in the employment model, namely to the ratio of the respective resource (E or L) to value added (V). It reflects the efficiency of the production process in the use of resources and its decrease denotes technological and/or organisational improvements.

In addition to the above five factors, the emission model includes the following factors:

Energy mix (s_j): the factor is defined as the ratio of the consumption of fuel j (Ej) to the total energy consumption (E) in the food sector. Thus, changes in the energy mix induce changes in total CO_2 emissions.

Utility mix (f_j): the factor refers to the carbon emissions (Cj) emitted from burning an energy unit of fuel j (Ej). The emission factors of all fuel categories are considered to remain constant over the examined period except for electricity, which is produced in utilities by a yearly changing fuel mix. Thus, the factor is defined as the sum of the shares of different energy forms used in power stations, each one multiplied by its CO_2 emission factor.

Based on the above determinant factors the decomposition models used for analysing CO_2 emissions (C) and employment (L) in the food sector are presented in equations (1) and (2), respectively:

$$C = G \cdot m \cdot x \cdot v \cdot e \cdot \sum s_j \cdot f_j = G \cdot \frac{D}{G} \cdot \frac{P}{D} \cdot \frac{V}{P} \cdot \frac{E}{V} \cdot \frac{E_j}{E} \cdot \frac{C_j}{E_j} \quad (1)$$

$$L = G \cdot m \cdot x \cdot v \cdot l = G \cdot \frac{D}{G} \cdot \frac{P}{D} \cdot \frac{V}{P} \cdot \frac{L}{V} \quad (2)$$

The change in CO_2 emissions from the base year *0* to year *t* is decomposed into these seven driving factors and is expressed as shown in Eq. (3). The seven factors are the growth effect (ΔG), the consumption intensity effect (Δm), the trade effect (Δx), the value added effect (Δv), the energy intensity effect (Δe), the energy mix effect (Δs) and the electricity mix effect (Δf).

$$\Delta C_{0-t} = C_t - C_0 = \Delta G_{0-t} + \Delta \mathrm{m}_{0-t} + \Delta \mathrm{x}_{0-t} + \Delta v_{0-t} + \Delta e_{0-t} + \Delta s_{0-t} + \Delta f_{0-t} \quad (3)$$

Similarly, the change in the employed persons from the base year *0* to year *t* is decomposed into five factors, according to Eq.4. These are the growth effect (ΔG), the consumption intensity effect (Δm), the trade effect (Δx) and the value added effect (Δv), which are the same as in the environmental decomposition model described above, whereas the energy intensity effect has been replaced by the labour intensity effect (Δl).

$$\Delta L_{0-t} = \Delta G_{0-t} + \Delta m_{0-t} + \Delta x_{0-t} + \Delta v_{0-t} + \Delta \mathrm{l}_{0\text{-t}} \quad (4)$$

It should be noted that the rationale behind the decomposition model is to identify the effect of each single factor under the *ceteris paribus hypothesis*, e.g. if all other factors remain constant at the level of the base year 0. Each of the effects included in Eq. (3) and (4) is calculated using a technique similar to the one used by Ang (2005). We exemplify for the growth effect ($\Delta G_{0\text{-t}}$) in Eq. (5). The effect for the rest of the factors is calculated in a similar way.

$$\Delta G = \left(\left(C^t - C^0\right) / \left(\ln C^t - \ln C^0\right)\right) \cdot \ln\left(G^t / G^0\right) \quad (5)$$

4 Results

The developed decomposition models have been implemented in the food, beverages and tobacco manufacturing sector (TBC sector) of 13 EU countries, for which complete time series datasets are available for the period 2000-2013. The sample of countries is representative of the whole EU, including Southern European countries (Portugal, Spain, Italy and Greece), Central and Western European countries (France, Belgium, the Netherlands, Germany and Austria), a Scandinavian country (Finland), and Eastern European countries (Slovenia, Slovakia and Estonia). Besides the geographical coverage, these countries contain a wide range of economic, structural, technological, and behavioural features that contribute to the environmental and social performance of an industrial sector. The economic data are collected from the World Input-Output Database (Timmer et al., 2015), which offers the advantage of determining sectoral interrelations in both domestic production and imports and also, the exports from each industrial sector. All the economic data are given in current prices US $ and they are converted into constant prices 2010 EUR. Finally, data for energy consumption and employment are collected from the Eurostat database.

The analysis is performed for two time periods, 2000-2007 and 2007-2013. In this way, the analysis illustrates any differences due to the consequences of the recent economic crisis.

4.1 The period 2000-2007

Fig. 1 shows the percentage change in Value Added (ΔG), CO_2 emissions (ΔC) and employment (ΔL) for the first period, 2000-2007. It can be seen that the sector continues growing in half of the countries, especially in the Southern EU countries (except Italy), in the East Europe countries (except Slovenia), in Austria and in Belgium. In the remaining countries the Value Added presents a rather small decline. However, in most countries a decoupling between growth and emissions and employment is clearly discernible, since the two examined indicators are decreasing or increase by a slower rate than the value added. The only exception is the increased CO_2 emissions in Belgium and Germany.

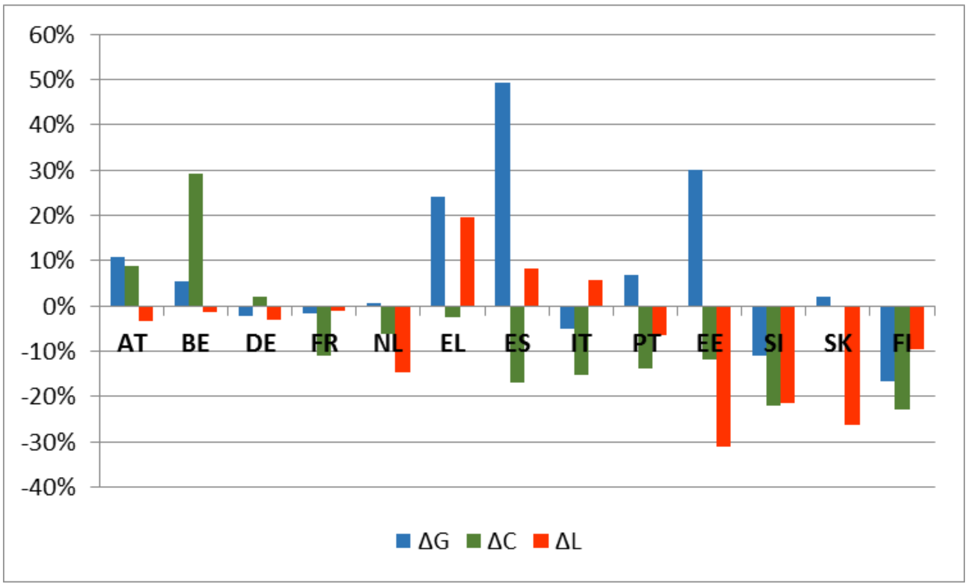

Figure 1. Change of Value Added, CO_2 emissions and employment in the F&D sector, period 2000-2007 (%)

The decomposition results in Fig. 2 and Fig. 3 reveal the factors contributing to the reported changes in CO_2 emissions and employment in 2000-2007. The driving factors that appear to have played a key role in shaping the emissions of the food industry are three. These are the economic growth of each country (ΔCgdp), the consumption intensity of the sector (ΔCcns) and the energy intensity of the sector (ΔCint). The same factors, but labour-intensive factor (ΔLl) in this case, played a key role in the evolution of the employment in the sector.

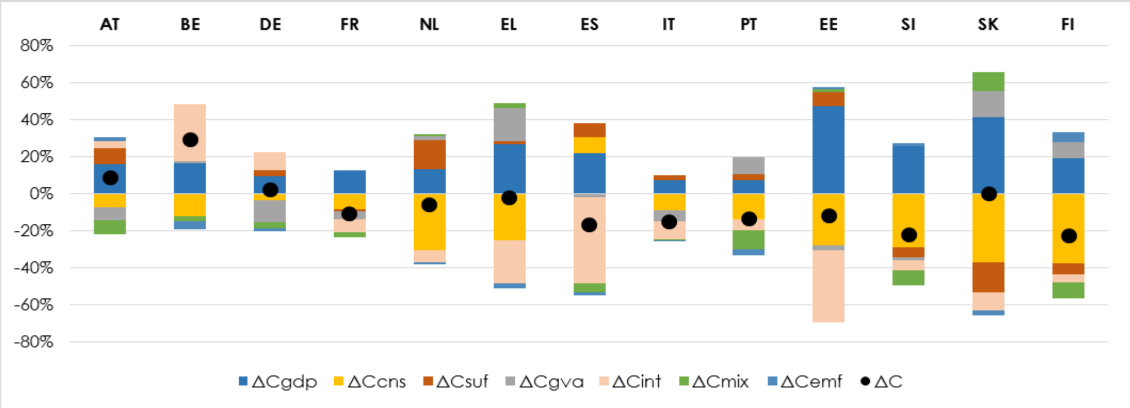

Figure 2. Decomposition of CO_2 emissions change of the F&D sector for the period 2000-2007 (%)

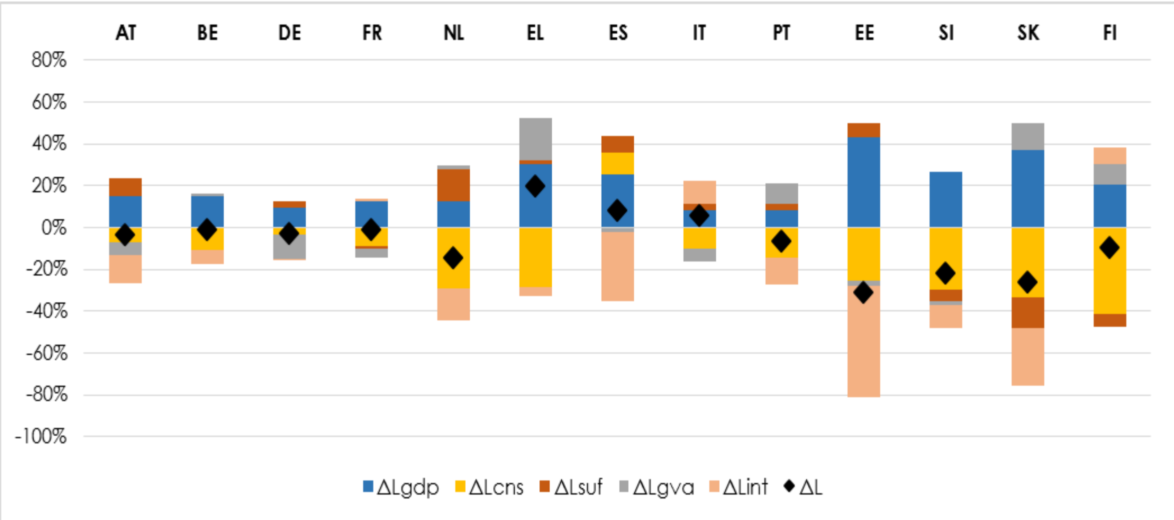

Figure 3. Decomposition of employment of the F&D sector for the period 2000-2007 (%)

The first period 2000-2007 was marked by a rapid growth of GDP in all examined countries. Obviously, the economic growth factor (ΔCgdp, ΔLgdp) had an increasing impact both on CO_2 emissions and on employment in all the examined countries, since an increase in the national income tends to boost consumption and production and the associated emissions and employment at higher levels.

However, it can be seen that, in reality, the consumption intensity has declined significantly, meaning that the consumption level did not follow the rate of GDP growth. This drop may indicate a shift towards a more rational consumer behaviour but is also the result of the low income elasticity of food products in high income countries. Thus, the consumption intensity effect (ΔCcns and ΔLcns) had also a significant contribution to the reduction of the two indicators, with the only exception of the increasing effect in Spain.

The factor of self-sufficiency did not affect to a large extent either the level of CO_2 emissions (ΔCsuf) or employment (ΔLsuf) in most European countries. Despite the fact that during this period the imports and exports of the products of the F&D sector increased in all countries, the relative self-sufficiency of each country, i.e. the ratio of production to consumption, did not change significantly, resulting to a marginal contribution to the change is both indicators. Nevertheless, the effect was positive in most countries (except SK, SI, and FI) meaning that during this period all other countries have increased the competitiveness of F&D products in the global market and achieved higher exports (or lower imports) that contributed to the rise in emissions and employment levels.

The value added effect on CO_2 emissions (ΔCgva) and employment (ΔLgva) is also relatively limited, but of a great interest. There are two groups in which the countries can be separated according to the value added effect.

- In countries, such as Slovakia, Finland, Portugal and Greece, where this effect contributed to the increase in CO_2 emissions and employment, the ratio of domestic value added to output in the F&D sector also increased. These countries maintained stable or reduced the intermediate consumption of the sector's products and increased the value added, resulting in higher CO_2 emissions and employment. This suggests a strengthening of the domestic value chain and a shift towards consumption of domestic intermediate products (raw materials or semi-finished products).
- On the contrary, in countries, such as Austria, France, Italy and Germany, where the effect of value added contributed to the decrease in CO_2 emissions and employment, the ratio of domestic value added to output in the F&D sector decreased from 2000 to 2007. This indicates that imports of raw materials and/or semi-finished products, which incorporate carbon dioxide emissions and labour cost, but are not credited to the country of production of final products, had increased.

The resource intensity effect is proven to be –in addition to the consumption intensity effect- the second most important contributor to the reduction of both CO_2 emissions (ΔCint) and employment (ΔLint). The decreasing intensities denote the respective increase in resources productivity and indicate technological and/or organisational improvements that led to higher efficiency in the production process. It is worth noticing that the energy intensity effect has a positive contribution only in three countries (AT, BE and DE), all three with a strong and highly efficient F&D sector whose energy intensities despite their recent increase remain much lower compared to those of other less technologically advanced countries. The same inverse effect is reported also in the case of labour intensity in IT and FI. However, it should be noted that structural changes within the sector may affect the overall sector's intensities, since individual sub-sectors (e.g. bakery, dairy or meat products) are characterised by a wide spectrum of resource productivity due to differences in the firm size and in the production process.,

The energy mix effect, ΔCmix, and the emission factor effect, ΔCemf, are very limited in all countries. Their contribution to total emissions change is mostly negative which reveals a switch to cleaner energy resources (in particular the rate of liquid fuels consumption was reduced in favour of the natural gas and renewables) and a cleaner electricity mix.

4.2 The period 2007-2013

The second period is marked by the economic crisis which started in 2008 and was still ongoing in many EU countries up to 2013. Fig. 4 shows that the value added of the F&D sector dropped by 10% to 20% in most countries, with the only exception of EE, where a significant increase was recorded. In Portugal (PT) and Greece (EL) as well as in Austria (AT), Germany (DE) and France (FR) it remained almost stable, slightly positive or slightly negative, respectively. It can also be seen that CO_2 emissions continue falling with even higher rates compared to the previous period, while the decrease in employment is smaller and only in SI, SK and PT exceeds 10% for the whole period.

Figure 4. Change of Value Added, CO_2 emissions and employment in the F&D sector, period 2007-2013 (%)

Looking at the factors that have contributed to the above described falling trends, we find out that in many countries the examined factors have an inverse effect, indicating different responses of the F&D sector to the crisis. As shown in Fig. 5 and Fig. 6, the economic growth factor (ΔCgdp and ΔLgdp) had in all countries a rather negligible effect which is mostly negative, although in central western EU countries appears as slightly positive. Only in Greece the F&D sector was affected to a much greater extent by this factor due to the country's steep decline in GDP (ΔCgdp = -28%, ΔLgdp = -29%).

On the contrary, despite the economic crisis, the consumption intensity factor (ΔCcns and ΔLcns) contributed to the increase of the two indicators in seven out of the thirteen European countries, indicating that the decline in GDP in most countries did not affect to the same extent the final consumption of F&D products. The reason behind this change should be again attributed to the low income elasticity of the final products of the F&D sector which are basic consumer goods. A particular case is the Netherlands where a notable increase of the sector's consumption intensity has been recorded, leading to a respective increase in emissions and employment.

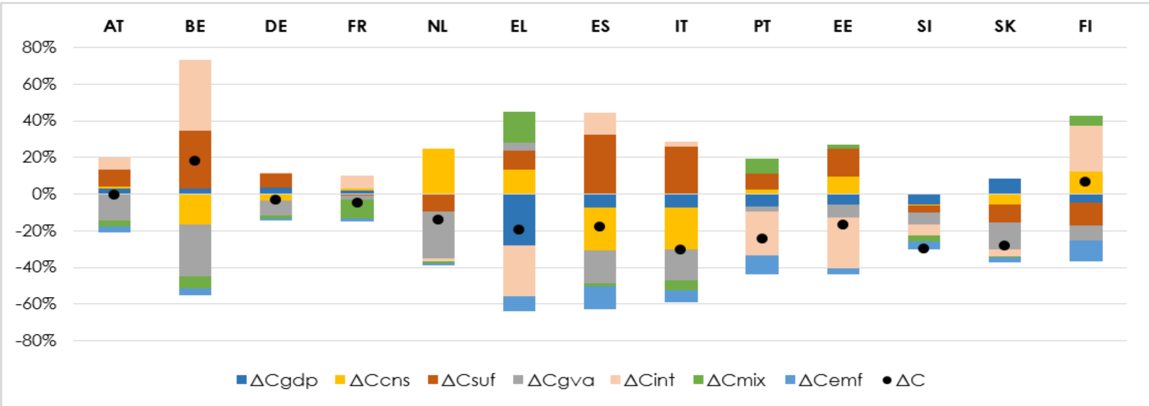

Figure 5. Decomposition of CO_2 emissions change of the F&D sector for the period 2007-2013 (%)

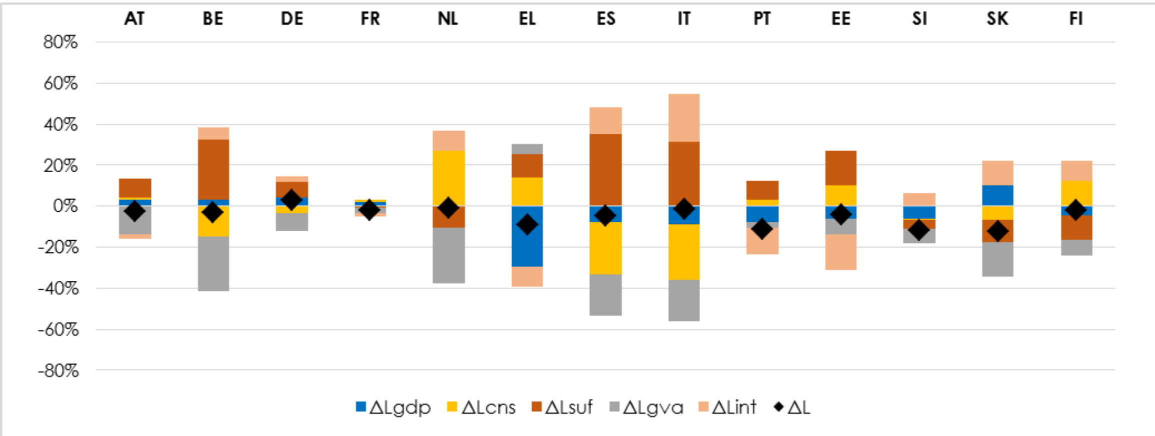

Figure 6. Decomposition of employment change of the F&D sector for the period 2007-2013 (%)

The contribution of the self-sufficiency factor (ΔCsuf and ΔLsuf) retained the sign of the previous period, with only four countries (SK, SI, FI and FR) presenting a negative contribution as a result of their dependence on imports of F&D products. For the rest of the countries the positive effect becomes much larger, indicating that these countries have increased their trade surplus, either because of the enhanced competitiveness of the domestically produced F&D products or because the crisis and the drop in the domestic consumption has boosted the extraversion of local companies. This response is more pronounced in Spain, Italy and Belgium presenting the highest positive effect among all countries and in the same time, a largely negative effect of the consumption intensity.

The value added factor (ΔCgva, ΔLgva) was the main driving factor contributing to the decrease in CO_2 emissions and employment in all countries, with the only exception of Greece. Overall, it appears that despite the increased trade surplus of the F&D products, imports of intermediate inputs, notably raw materials and/or semi-finished products have increased and thus, resulted in the reduction of domestic emissions and the loss of jobs.

Contrary to the results of the previous period, the energy intensity effect (ΔCint) does not appear as the decisive factor for the reduction of CO_2 emissions in the F&D sector, with the only exception of Greece, Portugal and Estonia. In all other countries energy intensity has a rather limited and mostly positive effect, especially in central western EU countries and in Finland. These countries are characterised by high technological and energy efficiency so that the space for further improvements was limited and not sufficiently cost-effective, especially in a period of economic recession. Similarly, the labour intensity factor (ΔLint) appears to have been more strongly affected by the economic crisis. Particularly, the labour intensity improved only in five of the examined European countries (Greece, Estonia, Austria, France and Portugal) contributing to decreased employment levels.

The energy mix factor (ΔCmix) continued to show a limited but mostly negative contribution to emissions reduction. It is noted that in some countries its contribution was more pronounced in this period, such as in Greece. Finally, the CO_2 emission factor effect (ΔCemf) was stronger than the first period and with a negative effect in all countries. This is due to the fact that over these years the EU countries have stepped up their efforts to achieve the Kyoto targets and have been actively introducing RES in the power generation sector.

5 Conclusions

The F&D sector is a strong traditional sector of the economy that tries to face the big challenges of the new century, namely the growing global competition, along with the abatement of climate change and of the increasing unemployment rates. The EU F&D sector has achieved these challenges to a great extent. During the last years, the F&D industry has remained at the top of all manufacturing sectors, has reduced its total CO_2 emissions by around 20% as well as has maintained an almost stable level of employment.

In this paper, an index decomposition analysis is used for detecting the factors which contribute these more or less favourable changes. Specifically, the developed decomposition models for both emissions and employment comprise five common (or closely related) determinant factors. In addition, the emissions model includes two more factors referring to the energy mix used in the production process and in electricity generation, which affect directly and indirectly the emissions from the F&D sector. Moreover, it was aimed to identify whether and how the economic crisis has affected the contribution of each factor as well as the two examined indicators.

In fact, in the two time periods examined, 2000-2007 and 2007-2013, the evolution of CO_2 emissions and employment do not follow an identical pattern. Actually, in times of economic prosperity, emissions dropped in most of the examined EU countries by 10%-20%, whereas employment levels showed similar but smaller percentage reductions. On the other side, in times of economic recession, the decrease in CO_2 emissions followed higher rates, while changes in employment took place only in the least developed EU countries and reduction percentages hardly exceeded a 10%. The factors that have influenced these changes differ also considerably in the two time periods. In the first period, it was mainly the resource (energy or labour) intensity and the consumption intensity effect that overbalanced the augmenting effect of growth. During the economic crisis, the technological improvements of the previous period continued and helped the sector enhance its competitive advantages at the global market and significantly increase its exports. Thus, the economic crisis has actually been translated into an opportunity for the firms of the F&D sector.

These results are very interesting at an industrial policy level. Despite a declining share of manufacturing employment and value added, manufacturing will continue to matter for European economies, but primarily for its innovation capacity. The character of manufacturing production in Europe is changing and will tend to involve more intellectual assets and high value added activities, such as R&D, design, aftersales services, supply chain management and logistics. The emphasis on high value added activities translates into a growing servitisation of manufacturing and the greater importance of innovative capacity (Veugelers, 2013).

Obviously, the obtained results give a rough indication of the major driving factors that have influenced the developments in the F&D sector during this challenging period and in the context of a highly competitive global market. Therefore, they should be scrutinised at a firm level through field research in order to identify and better understand the firms' innovative responses and the specific actions undertaken. Overall, it can be argued that tradition and innovation are not two controversial terms and that their combination in the case of the F&D sector has been quite successful.

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