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by

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Abstract

This paper assesses the efficiency in resource allocation across firms within industries in Spain since early 90's until 2013. A static and a dynamic decomposition of total factor productivity are performed in order to study the degree of misallocation in each manufacturing sector and its evolution over time. We find that within industries allocative efficiency increased moderately and productivity grew slightly (almost stagnated) from 1992 to 2007. The great crisis was characterized by a sharp drop in productivity and a general rise in within industry misallocation of resources (but it seems that only capital misallocation worsened, while employment misallocation diminished). From 2011 to 2013, productivity and allocative efficiency started to recover, but the productivity levels previous to the crisis were still not achieved at the end of the period.

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1 Introduction

The aim of this paper is to assess the evolution of misallocation of production factors across firms within industries in Spain for the period 1992-2013. Allocative efficiency can be defined as the degree of ability to allocate or reallocate resources (capital or labor) towards the most productive firms. Misallocation arises when production factors are assigned to firms with low level of productivity.

Spain, among other Southern-Europe countries, has been characterized by low productivity levels during the economic boom of 2000's, and also during the crisis that started in 2008. This work intends to provide better knowledge about the evolution of productivity in Spain since 1992, considering the different stages that the Spanish economy went through since early 90's.

Productivity (or productivity growth) can be disaggregated in order to disentangle the contribution of different elements to the evolution of aggregate productivity in each industry. Two methods are going to be followed: the static decomposition method of Olley and Pakes (1996) (which divides productivity into the mean of firms' productivity and the covariance between productivity and market shares), and the dynamic decomposition proposed by Diewert and Fox (2010), which allows to explain aggregate productivity growth in each industry, disaggregating growth into the contribution of each firm's productivity change (within-firm component), changes in market shares (between-firm component), the contribution to aggregate productivity of entrant firms and that provoked by the exit of existing ones (business churn). The analysis of the contribution of the three last components (composition changes) can provide evidence of misallocation.

Hence, we will study the changes in productivity in manufacturing industries over time and the contribution to aggregate productivity of each of the components considered in the two decomposition methods previously named. By doing so, it will be found the degree of efficiency in the allocation of production factors at every phase of the economic cycle, and if misallocation has increased or decreased as a consequence of the economic crisis.

The main contribution of this work will be the analysis of misallocation of Spanish firms with both a static and a dynamic decomposition of productivity (the Diewert and Fox, 2010, method, as far as I know, has still not been applied to Spain). The dataset contains panel data from *Encuesta sobre Estrategias Empresariales* (ESEE), never used before to study allocative efficiency in Spain. Moreover, in order to assess misallocation, any productivity decomposition method covering the crisis and post-crisis periods has still not been applied for Spanish firms. Therefore, this piece of research intends to fill this gap in the literature, which will allow to explore the degree of allocative efficiency from the nineties to the crisis and recovery periods with a different methodology and dataset.

We conclude that the within industries misallocation evolution is common to the two productivity decomposition methods we have conducted. In general, productivity and allocative efficiency of resources kept stagnated or slightly increasing during the 90's until the starting of the crisis of 2008. During the recession years (2008-2010), these magnitudes evolved negatively, misallocation of labor and capital took place, but it seems that the trend changes in the 2011-2013 period (there is some recovery in terms of total factor productivity and allocative efficiency). The dynamic decomposition points that the change in market shares of firms within industries is the component with the largest contribution to productivity growth. Moreover, there is some evidence indicating that allocative efficiency of employment evolved negatively along the whole period analyzed, but misallocation of labor diminished with the crisis, while capital allocation worsened in this period.

This paper is organized as follows: Section 2 contains a brief survey of previous literature related to allocative efficiency and productivity decompositions, as well as the methodology used to perform the two productivity decomposition methods applied in Section 4. Section 3 describes the data, the methods of calculation of total factor productivity that have been conducted and the main descriptives of data. Section 4 presents the results in terms of allocative efficiency from the productivity decomposition methods. The conclusions of the research are discussed in Section 5.

2 Previous literature and methodology

The measurement of misallocation has become a research field of interest for economists. There are several studies in which different methods to measure the efficiency of resource allocation are applied. In this section some of the most important papers related to this topic are summarized, and also the methodology of the productivity decomposition methods applied in Section 4 is explained.

Olley and Pakes (1996) provide a static decomposition method of the aggregate productivity level in each period, which is applied to the Telecommunications Equipment Industry from 1974 to 1987. This method measures the gains or losses in aggregate productivity relative to a situation where market shares are distributed randomly across firms within industries: the weighted average of productivity is decomposed into the unweighted mean of the firm productivity distribution, and the covariance between productivity and market shares. If the covariance term is positive, resources are allocated efficiently, while if negative, it indicates the misallocation of production factors. Olley and Pakes decomposition does not allow to disentangle the contribution of business churn (entry and exit) to aggregate productivity.

$$TFP_t = \frac{1}{N_t}\sum_i TFP_{it} + \sum_i (s_{it} - \overline{s}_t)(TFP_{it} - \overline{TFP}_t) \tag{1}$$

where TFP_t is aggregate total factor productivity at time t, N_t is the number of firms at time t, TFP_{it} is firm-level productivity, s_{it} is the market share of firm i, a bar above a variable indicates the unweighted industry average of the firm-level measure.

These authors find a rise in productivity growth of the Telecommunication Equipment Industry after the deregulation of the sector. The productivity improvement is due to the reallocation of capital towards more productive firms, even though plants' rates of productivity growth do not increase.

Hsieh and Klenow (2009) try to find the impact of resource misallocation on aggregate productivity. They build a model of monopolistic competition with heterogeneous firms that differ in their efficiency levels and in the distortions that affect them. These authors conclude that if revenue productivity differs across firms, there must be some kind of distortion that provokes wedges between marginal products of capital and labor between firms within industries, which will reduce aggregate TFP. Their model is applied to China, India and the U.S. (benchmark) and by comparing the efficient output with the actual level, they assess the size of misallocation and the potential gains from allocating resources more efficiently (TFP gains would be of 30-50% in China and 40-60% in India).

Dias et al. (2014) extend the model of Hsieh and Klenow with a production function that contains intermediate inputs, so the difference between Hsieh and Klenow (2009) and Dias et al. (2014) is that the former use a value added production function and the latter a revenue production function. By applying the model to the Portuguese economy, they find a negative evolution of within industry allocative efficiency from 1996 to 2011 and potential gains from reallocation of resources at the industry and aggregate economy levels (misallocation would have reduced 1.3% the annual GDP growth).

Melitz and Polanec (2015) propose an extension of the static method of Olley and Pakes, including the contributions of firm entry and exit, providing a dynamic decomposition. Productivity change is decomposed into the following components: productivity distribution shifts among continuing firms (within effect), market share reallocations among continuing firms (between effect), entry and exit.

Garcia-Santana et al. (2015) analyze allocative efficiency of Spanish firms from 1995 to 2007 with data that are obtained mainly from the *Central de Balances Integrada* provided by Banco de España. They perform Hsieh and Klenow (2009) and Olley and Pakes (1996) methods. Both measures indicate the deterioration of allocative efficiency in every sector when comparing the period 2001-2007 with the previous one, 1995-2000, mainly due to across-firms (within-industries) misallocation of resources. The period of these authors' analysis does not cover the great crisis, so they cannot analyze its possible effects on misallocation, issue that the present work will examine.

Gopinath et al. (2015) also implement the methodology of Hsieh and Klenow (2009) for Spanish and other Southern Europe manufacturing firms. They use a dataset from ORBIS-AMADEUS that covers manufacturing firms in Spain and Italy (1999-2012), Portugal (2006-2012), Germany (2006-2012), France (2000-2012) and Norway (2004-2012). They find low rates of TFP growth in South Europe since 1999. TFP declines with respect to the efficient level between 1999 and 2012. They prove that the dispersion of the marginal product of capital increases and the efficiency of resource allocation worsens across manufacturing firms in Spain, Italy and Portugal. They construct a model of heterogeneous firms in which misallocation of capital is due to financial frictions, investment adjustment costs and risk in capital accumulation to explain the evolution of productivity.

Although the papers by Garcia-Santana et al. (2015) and Gopinath et al. (2015) study allocative efficiency of Spanish firms, there are several differences between them and our research that must be highlighted. Both papers use different databases to ours and the analysis is applied to time periods that do not match with ours, although there is some overlap (1995-2007 and 1999-2012, respectively). Moreover, the methodologies used to study misallocation are also different, with the exception of the Olley and Pakes (1996) decomposition in the case of Garcia-Santana et al. (2015).

Riley et al. (2015) study British firms' productivity between 2008 and 2013. The authors find that a big percentage of productivity weakness of UK firms occurred within firms. However, from 2010 until 2013, composition effects (between component, entry and exit) contribute less to aggregate productivity growth than they have done in previous periods (what evidences misallocation of resources).

Their conclusions are achieved by conducting a dynamic decomposition of productivity of UK firms proposed by Diewert and Fox (2010):

$$\begin{aligned} \triangle TFP_t = \sum_{i \epsilon C} \overline{s}_{Ci} \triangle TFP_{it} + \sum_{i \epsilon C} \triangle s_{Cit} (\overline{TFP}_i - \overline{TFP}_C) + \\ \sum_{i \epsilon N} s_{it} (TFP_{it} - TFP_{Ct}) - \sum_{i \epsilon X} s_{it-1} (TFP_{it-1} - TFP_{Ct-1}) \end{aligned} \tag{2}$$

where the subindexes C, N and X stand for subgroups of firms that continue, enter and exit the market, respectively. A bar above a variable indicates an average across time t and *t-1*. $s_{Cit} = \frac{s_{it}}{\sum_{i \epsilon C} s_{it}}$ is firm i's market share within the group of continuing firms. $TFP_{Ct} = \sum_{i \epsilon C} s_{Cit} TFP_{it}$ is the weighted average of TFP for continuing firms.

The first term in expression (2) is the within component (due to a within-firm change in productivity of continuing firms from period *t-1* to t holding market share constant at the average level in *t-1* and t). The second term is the between component (the change in productivity due to changes in market shares among continuing firms, holding productivity of firms constant at their average level in *t-1* and t). The third component is the contribution of firms that enter the market to industry productivity growth, and the fourth term is the contribution of firms that exit. The three last components of the formula are those which can denote misallocation of resources across firms. If the second component is positive, it evidences that more productive firms gain market share at the expense of less productive firms, while if negative it indicates misallocation in market shares between more efficient and less efficient continuing firms (more efficient firms lose market share while less productive firms gain it). If the third component is positive, it means that entrants enter the market with higher productivity than continuing firms, while if negative, it evidences misallocation: entrant firms are contributing negatively to aggregate productivity growth in the industry. If the fourth component is negative, it denotes that firms that exit have lower productivity than survivors, what contributes positively to productivity growth. When the opposite happens, it indicates a negative contribution to allocation of resources and to aggregate productivity growth of the industry.

3 Data and descriptives

3.1 Data

The dataset is obtained from the *Encuesta sobre Estrategias Empresariales* (ESEE) provided by Fundación SEPI. This is an annual survey that contains panel data (an unbalanced panel) about Spanish manufacturing firms with 10 workers or more. The dataset is composed by 1800 firms on average each year, which are classified by industrial sectors, and the data used to perform this work are referred to the period 1992-2013. The ESEE provides detailed information at the firm level about production, financial decisions, profit or loss accounts of firms and balance sheet variables.

The sampling procedure of the ESEE consists of the following. In 1990 firms were chosen using a selective sampling scheme with different participation rates depending on firm size. All firms with more than 200 employees (large firms) were requested to participate and the participation rate reached approximately 70% of the number of firms in the population. Firms that employed between 10 to 200 (SMEs) were randomly sampled by industry and size strata, holding around 5% of the population. The procedure excluded all firms with less than 10 employees. Hence, the coverage of the dataset is different depending on the size group of firms.

The sample of SMEs and large firms is representative of the population of each group. However, in order to replicate the proportion of SMEs in Spain, the sample of these firms has been expanded by a factor of 14 (each SME has been replicated 14 times in the sample, so that from each SME, 13 additional SMEs appear with the same value for all variables as the original firm). Consequently, 97% of the observations belong to SMEs in the final dataset.

The share of labor, labor compensation or sales accounted for by SMEs (over the total accounted for all firms each year in the expanded sample) is quite large (see table 1) and close to the actual share that SMEs account at the national aggregate. The share of SMEs in labor is substantially higher than on sales, what can be probably related to their lower productivity as compared with large firms.

Table 1: Share of labor, compensation of employees and sales accounted for by SMEs

	Labor (effective hours)	Labor compensation	Sales
1992	0.6360	0.5402	0.5373
2006	0.7055	0.6606	0.5859
2012	0.7760	0.7415	0.6884

Source: ESEE and author's calculations.

The ESEE provides us with every variable needed to conduct this research. Among the main variables, we can find the following: firms' sector of activity (firms are classified in 20 sectors), effective number of hours worked (proxying for labor), number of employees, labor compensation, value added and capital, which we adjust by the degree of capacity utilization (see Appendix I for more information about variables and their construction).

3.2 Calculating productivity

In order to calculate firms' productivity, we use as starting point a value-added based Cobb-Douglas production function for which we assume constant returns to scale.

Labor shares (s_L) are calculated for each sector as the mean of the ratio of labor compensation over value added of firms within each sector. As constant returns are assumed, elasticity of output with respect to capital in each sector is 1 minus the labor cost share in that sector (Hsieh and Klenow, 2009, Riley et al., 2015, and Garcia-Santana et al., 2015, take the same approach, and these authors also consider the TFP measure that is presented below).

Total factor productivity (TFP) is measured with the Solow index number approach. TFP for firm i in sector k and year t is defined as:

$$TFP_{ikt}^{Solow} = \frac{VA_{ikt}}{L_{ikt}^{s_L} K_{ikt}^{1-s_L}} \tag{3}$$

where *VA* is firm value added, L is labor input (measured with effective number of hours) and K is capital input (whose calculation method is explained in Appendix I).

Taking logarithms, expression (3) becomes:

$$lnTFP_{ikt}^{Solow} = lnVA_{ikt} - s_L lnL_{ikt} - (1 - s_L) lnK_{ikt} \tag{4}$$

The previous definition of TFP is the benchmark measure of productivity, but a different measure of TFP has been calculated. Levinsohn and Petrin (2003) methodology has also been implemented. It consists of estimating a production function econometrically (for each sector of activity, in this case), without assuming constant returns to scale, and using intermediate inputs (like materials) to control for unobserved productivity. From the estimation of the parameters of the production function, productivity can be predicted. This is a two-stage procedure that is more complex than the simple Solow TFP index, very demanding in terms of data and time consuming, but since data allow us to calculate it, it has been used to check the robustness of the results to different measures of TFP.

3.3 Main descriptives

In order to know about the main features of the data chosen for this research, this subsection is devoted to show and analyze some descriptives. By doing so, we can infer some of the characteristics of Spanish firms and of the aggregate economy, which are important to understand the behavior and evolution of Spanish magnitudes like productivity. Moreover, these descriptives might also suggest some patterns and provide some hints about the degree of allocative efficiency of the Spanish economy, which will be analyzed in Section 4.

The database contains information about firms' exits, if they continue or if the firm has just entered the market. In table 2 it is shown, for the expanded sample, the absolute values and the corresponding percentage of firms that enter, those that exit and continuing firms for each year. It is very likely that entry is misrepresented in this database: notice that the average rate of entry of new firms in the whole period is 0.06% and no new firm has been incorporated to the sample (either new or already existing) from 2002 to 2005 and from 2007 to 2012, except in 2010 when one firm entered. Despite the low rate of entry, we will keep the entry component in our dynamic productivity decomposition in order to assess if we can infer any pattern (even if it is modest) on the contribution of entrants to the allocative efficiency of resources from the data corresponding to years in which there is some entry.

Exit rates are quite large (7.74% on average over the period), but it seems that they are realistic, as this average is close to the 7% exit rate found by Beneito et al. (2016) and it is somehow lower than the 9.7% rate during the seventies and eighties provided by Martín-Marcos and Jaumandreu (2004).

Table 2: Firms by surviving status

	Entry		Exit		Continue		Total
Year	Number	Rate	Number	Rate	Number	Rate	Number
1992	14	0.0008	121	0.0071	17002	0.9921	17137
1993	15	0.0008	1530	0.0839	16681	0.9152	18226
1994	2	0.0001	1718	0.0967	16055	0.9032	17775
1995	0	0.0000	1144	0.0710	14972	0.9290	16116
1996	15	0.0009	1180	0.0707	15490	0.9284	16685
1997	29	0.0015	1195	0.0625	17906	0.9360	19130
1998	14	0.0008	1547	0.0860	16423	0.9132	17984
1999	84	0.0047	1167	0.0647	16798	0.9307	18049
2000	42	0.0023	1554	0.0860	16497	0.9125	18079
2001	14	0.0008	558	0.0332	16219	0.9659	16791
2002	0	0.0000	3331	0.1972	13560	0.8028	16891
2003	0	0.0000	58	0.0043	13502	0.9957	13560
2004	0	0.0000	876	0.0649	12625	0.9351	13501
2005	0	0.0000	1411	0.0755	17290	0.9245	18701
2006	14	0.0007	1199	0.0567	19935	0.9426	21148
2007	0	0.0000	1740	0.0822	19416	0.9178	21156
2008	0	0.0000	2205	0.1037	19068	0.8963	21273
2009	0	0.0000	1970	0.0914	19575	0.9086	21545
2010	1	0.0000	2032	0.0925	19924	0.9074	21957
2011	0	0.0000	2382	0.1195	17543	0.8805	19925
2012	0	0.0000	1555	0.0763	18817	0.9237	20372
Mean	12	0.0006	1451	0.0774	16919	0.9220	18381

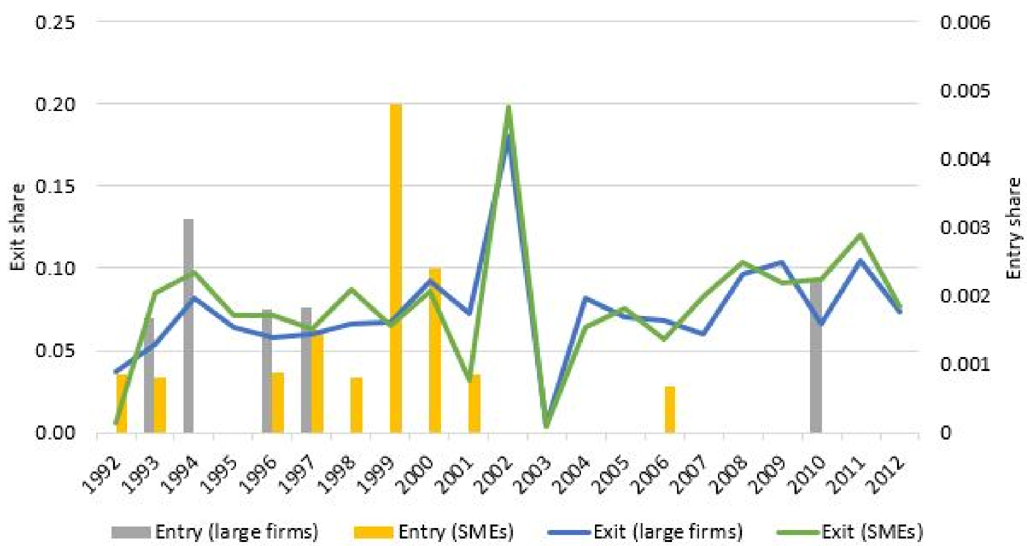
Source: ESEE and author's calculations.

In order to assess the rates of entry and exit by size of firms, we can obtain the descriptive from the not expanded sample (as the sample of SMEs and large firms are representative of the population of firms of each size).

The evolution of entry and exit shares by size of firms is displayed in figure 1. Exit shares of large firms and SMEs follow the same pattern over time, although the exit rate of SMEs is higher most of the years. Exit rates fluctuate between 5 and 10% in most of the period (we find a peak of 20% in 2002 and a sharp drop in the following year), and it seems that an increasing trend emerges from 2005-06 onwards.

Entry rates are much lower and there is not a clear pattern in their evolution. Most entrant firms are SMEs, as it is logical, and from 2002 to the end of the period, there is no entry in the sample (except in 2006 and 2010).

Figure 1: Exit and entry shares by size (not expanded sample)



Source: ESEE and author's calculations.

Generally, the descriptives related to TFP displayed in this subsection are calculated with the unweighted Solow TFP index, although we will highlight results when different under the Olley and Pakes (OP) weighted version. For simplicity, descriptives calculated from Levinsohn and Petrin TFP are not shown unless specified. The results of this TFP measure are very close to those of the Solow TFP index and point to the same direction (unless the opposite is mentioned).

According to every productivity measure, total factor productivity diminished from 1992 to 2013 as table 3 and figure 2 show. From the mid-nineties to 2007, the Spanish economy experienced a boom, with annual GDP growth rates around 3-4% most of the years. However, the evolution of total factor productivity was not so positive. TFP stagnated during that period: it dropped slightly, according to the unweighted Solow TFP index, which was slightly lower in 2007 than it was in 1992, while the weighted TFP measure evidences a slight increase in productivity in the same period. During the crisis, we can observe a high level of correlation between GDP growth and TFP in figure 2, with these two magnitudes decreasing sharply. However, TFP fell at higher rates (in absolute value) than GDP. The deep fall of productivity along the economic crisis is common to every measure of TFP used in this work. It is possible that some misallocation of resources has existed and it might be the reason for the stagnation and poor evolution of productivity in Spain. This will be verified in Section 4. It seems that the negative evolution of TFP finishes in the last subperiod presented in table 3 (2011-2013). This phase is characterized by the improvement in TFP, due to the large increase in this variable from 2012 to 2013.

Notice that just in the first subperiod (1992-2007) the growth rates of weighted and unweighted TFP evolve in opposite directions (unweighted TFP falls while weighted TFP grows). In the rest of subperiods and the whole period, growth rates have the same sign (either positive or negative).

Taking into account that weighted TFP is the aggregation of the unweighted measure plus the covariance term (equation (1)), we can make some conclusions about allocative efficiency in Spain by comparing the TFP growth rates by subperiods (shown at the end of table 3). Unweighted TFP falls but weighted TFP grows from 1992 to 2007, what means that the covariance term has necessarily risen (first evidence of allocation getting better). In the subperiod 2008-2010, weighted TFP drops more than the unweighted measure, so the covariance term has reduced: negative evolution of allocative efficiency. From 2011 to 2013, unweighted TFP growth is larger, so again, allocation gets slightly worse during the last subperiod, although as we will see later, there is an improvement with respect to 2010 levels. Considering the whole period (1992-2013), weighted TFP has reduced less than unweighted TFP, what implies that the covariance term has grown (improvement of allocative efficiency). These results will be analyzed more deeply in Section 4.

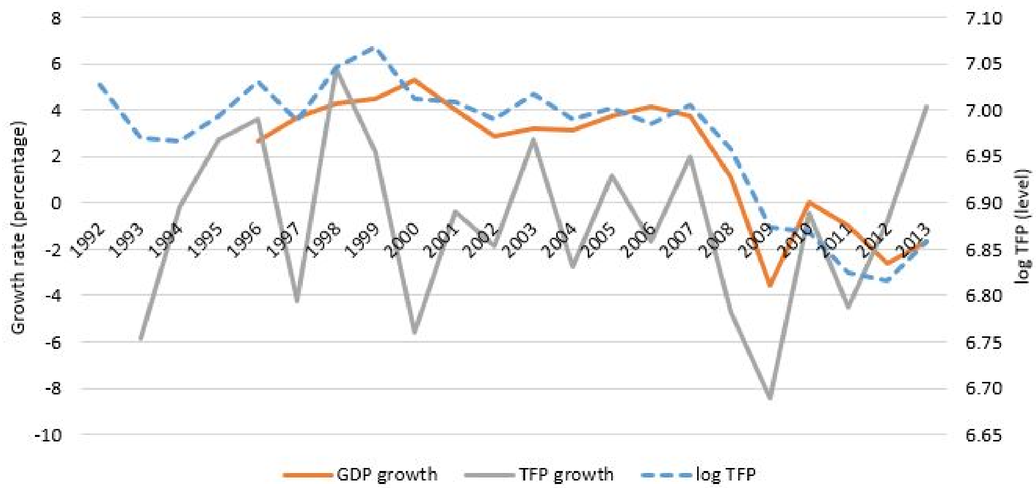
Table 3: Average TFP and growth rate by year

Year	Unweighted TFP (in logs)	Growth rate of TFP (%)	Weighted TFP (in logs) (with OP decomposition)	Growth rate of weighted TFP (%)
1992	7.028		7.095	
1993	6.969	-5.875	7.105	1.027
1994	6.967	-0.199	7.103	-0.179
1995	6.994	2.713	7.178	7.500
1996	7.031	3.637	7.197	1.876
1997	6.988	-4.273	7.115	-8.236
1998	7.046	5.776	7.225	11.005
1999	7.068	2.221	7.221	-0.408
2000	7.012	-5.576	7.168	-5.231
2001	7.009	-0.357	7.175	0.719
2002	6.990	-1.851	7.148	-2.774
2003	7.017	2.739	7.186	3.791
2004	6.990	-2.745	7.193	0.751
2005	7.002	1.183	7.225	3.224
2006	6.985	-1.668	7.213	-1.286
2007	7.005	2.018	7.209	-0.402
2008	6.958	-4.733	7.133	-7.532
2009	6.874	-8.412	7.120	-1.328
2010	6.869	-0.468	6.924	-19.558
2011	6.824	-4.527	7.047	12.260
2012	6.816	-0.777	6.973	-7.412
2013	6.858	4.141	7.066	9.323

	Approximation to average cumulative growth rate of: Unweighted TFP	Weighted TFP
1992-2007	-0.150	0.759
2008-2010	-4.440	-10.443
2011-2013	1.682	0.955
1992-2013	-0.811	-0.137

Source: ESEE and author's calculations.

Figure 2: Unweighted average TFP and GDP evolution

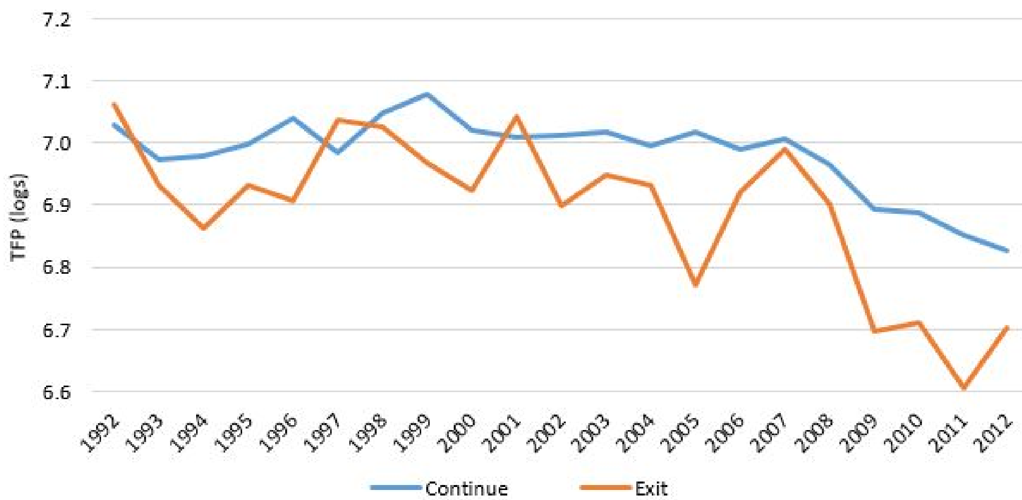


Source: ESEE, Eurostat and author's calculations.

In figure 3 it is displayed the evolution of TFP for continuing and exiting firms. There is a clear difference in levels: as expected, continuing firms have been more productive than exiting ones almost in every period, with the gap becoming larger at the beginning of the crisis (although it seems that the lines tend to approach from 2011 onwards). The average log of TFP for firms that continue over the period is 6.98 while it is 6.89 for those that exit. Although it is not displayed in the figure, the average log of TFP for entrants is the lowest, 6.59 (but as we have seen, there is not very much information about entry in the database). The differences in the mean of TFP of the three groups of firms are statistically significant.

The productivity levels of continuing firms seem to be more stable, with those of exitors fluctuating more. Nevertheless, it is remarkable that their general trend is similar along time: there is a general pattern of stability or slight reduction of TFP until 2004-2005, and a decreasing trend thenceforth. This general trend of productivity is very similar to the one obtained in Gopinath et al. (2015): they find that TFP remains stable (or slightly decreasing) from 1999 to 2007, while since 2007, TFP declines sharply.

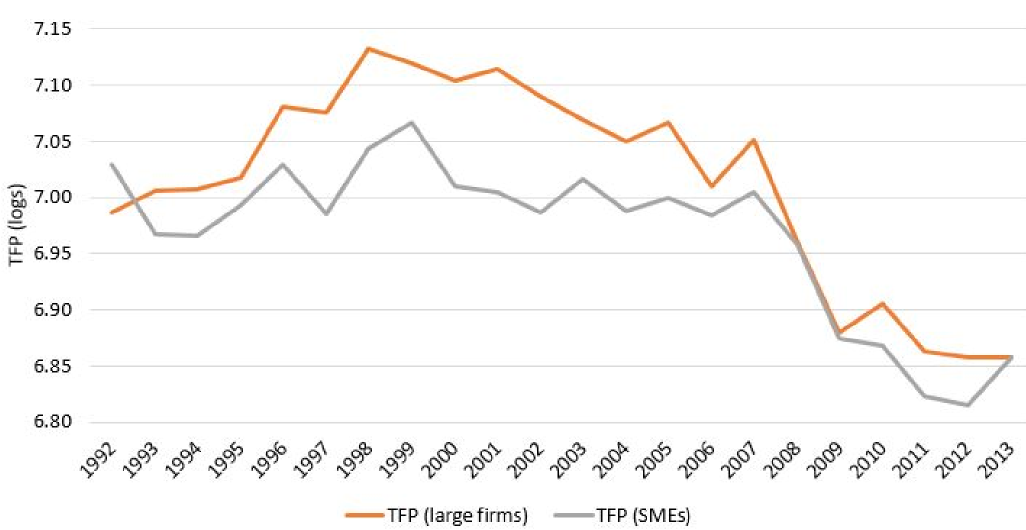
Figure 3: Average TFP evolution by surviving status



Source: ESEE and author's calculations.

If we disaggregate TFP evolution by size of firms, we observe that (again as one would expect) large firms are more productive than SMEs (figure 4), especially from 1992 until the starting of 2000's, when large firms' TFP grows considerably. However, from 2003 onwards, there is an approximation in terms of productivity between both kind of firms, which is accentuated during the economic depression. If instead of the Solow TFP index, we performed this figure with Levinsohn and Petrin TFP measure, we would find a much more accentuated difference in levels of TFP depending on firms' size, being large firms much more productive than SMEs during all the period analyzed. However, the evolution of each kind of firm's TFP is similar with both TFP measures.

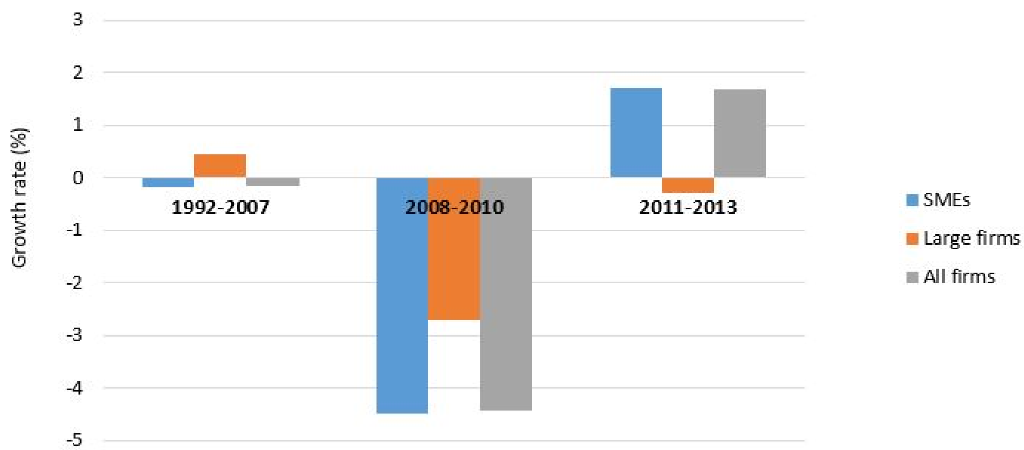
Figure 4: Average TFP evolution by size of firms



Source: ESEE and author's calculations.

During the period 1992-2007, TFP stagnates or diminishes slightly according to the unweighted Solow TFP index measure (0.15% per year if TFP had reduced at a steady rate) due to the drop in the efficiency of SMEs[1], while the compound annual growth rate (CAGR) of large firms' TFP is 0.43%. From 2008 to 2010, TFP of Spanish firms suffer a deep fall (TFP would have decreased on average 4.4% each year if the fall had been steady), being the SMEs those with the largest TFP decline. However, the last period (2011-2013) is characterized by a minor reduction in large firms' TFP (-0.28% annually), while SMEs' CAGR of TFP is 1.7% in the same period. The reason for the decrease in productivity for large firms over the last period, although interesting, is out of the scope of this analysis.

Figure 5: CAGR of TFP by period and size

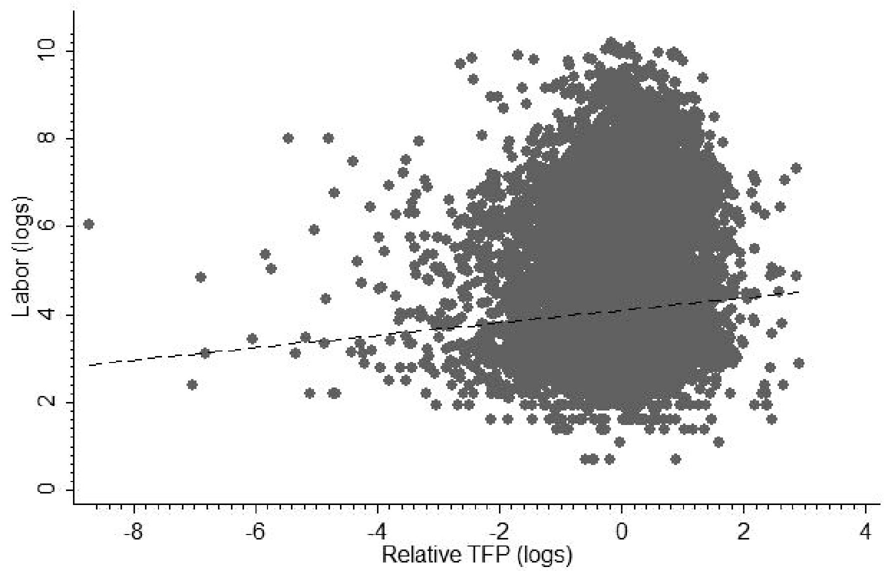


Source: ESEE and author's calculations.

The relationship between size of each firm (measured with labor: effective number of hours worked) and its relative TFP (TFP of each firm with respect to the average TFP of its corresponding sector and year) is displayed in figure 6. The black dashed line indicates the fitted values of the relationship. We find a positive relationship between them, implying that larger firms are in general relatively more efficient, what can be interpreted as a static positive allocation of employment.

[1] Notice that the descriptives of all firms in the economy and the descriptives of SMEs are very close to each other, since the majority of firms in the database are SMEs.

Figure 6: Firm labor vs relative TFP



Source: ESEE and author's calculations.

However, following Riley et al. (2015) the relationship can also be assessed in rates of growth, by a regression of the rate of expansion of individual firms (measured by labor growth) on their productivity change, controlling for time and sector. An interaction term is included to check whether the relationship changed after the crisis.

$$\triangle l_{it} = \gamma \triangle tfp_{it} + \gamma_p D_p \triangle tfp_{it} + \delta_T + \delta_{SEC} + \varepsilon_{it} \ , \tag{5}$$

where lower case variables are variables in logarithms, D_p is a dummy variable that takes the value 1 from 2008 onwards, δ_T and δ_{SEC} stand for a vector of time and industry dummies. The coefficients of the regressors of TFP growth and the interaction term are displayed in table 4.

Although figure 6 shows a positive relationship in levels between firm size and total factor productivity, the estimate of the growth rate of productivity (both with Solow and Levinsohn and Petrin (LP) TFP measures) is negative and significant suggesting an inverse relationship between firm growth and productivity growth (we could interpret this as a first sign of resource misallocation) in the pre-crisis period. The positive sign of the interaction term softens this relationship, but it is still negative and significant, what means that the crisis may be reducing the degree of misallocation in terms of employment. Hence, considering jointly figure 6 and table 4, it can be concluded that the positive relationship between size (or employment) and productivity can be diffusing over time, since there seems to be evidence of misallocation along the whole period. In summary, the positive sign of the relationship between employment and productivity in figure 6 can be interpreted as a static positive allocation of employment, but the regression in table 4 provides evidence of a negative evolution of allocative efficiency of labor that softens with the crisis.

Table 4: Relationship between labor expansion of firms and TFP growth

	Solow TFP index	LP TFP
TFP growth	-0.0287***	-0.0332***
	(0.0008)	(0.0008)
Interaction term	0.0196***	0.0205***
	(0.0013)	(0.0013)

Source: ESEE and author's calculations.
Notes: standard errors between parentheses. Significance at the 1, 5 and 10 percent levels denoted by ***, **, and *.

Next, it is performed a regression of firms' exit on relative TFP and an interaction term of relative TFP with a dummy of large firms (controlling for age) by weighted least squares (weighting by sector value added shares)[2] , to test whether more productive firms are less likely to abandon the market and if the relationship depends on size.

$$exit_{it} = \beta_1 \tilde{tfp}_{it} + \beta_2 D_l \tilde{tfp}_{it} + \beta_3 age + \beta_4 age^2 + \varepsilon_{it} \ , \tag{6}$$

where $exit$ stands for firms' exit of the market, $\tilde{tfp}$ is firms' relative TFP (in logs), D_l is a dummy of large firms and age is the age of the firm.

We conclude that a 1-log-point increase in relative TFP decreases the probability of firms exiting the market by 2.25% on average (or 2.65% in the regression based on Levinsohn and Petrin measure of TFP) as table 5 shows. The interaction term estimate has positive sign, what would indicate that the effect of TFP on exit for large firms is negative but not as strong as for the base category (SMEs). However, the sum of both estimates (total effect for large firms) is not significant at the 10% level (neither it is at 7% in the case of LP TFP), what points that there is no a significant relationship between productivity of large firms and their probability of exiting the market. Moreover, firm's age is negatively related to the probability of exiting the market (the effect of age is not linear, but decreasing).

[2] The estimation method is the same that Hsieh and Klenow (2009) use to study the relationship between firms' exit and relative TFP. The results shown in table 5, indicating a negative relationship between exit and relative TFP, are robust to logit and probit estimations.

Table 5: Regression of exit on relative TFP

	Solow TFP index	LP TFP
Relative TFP	-0.0225***	-0.0265***
	(0.0008)	(0.0008)
Interaction term	0.0175***	0.0204***
	(0.0042)	(0.0035)
Age	-0.0008***	-0.0007***
	(0.0000)	(0.0000)
Squared age	0.0000***	0.0000***
	(0.0000)	(0.0000)

Source: ESEE and author's calculations.
Notes: standard errors between parentheses. Significance at the 1, 5 and 10 percent levels denoted by ***, **, and *.

In principle, counterintuitively, negative correlation between TFP and capital is found, and also between the growth of TFP and capital. A regression of TFP on capital is conducted, including an interaction term of capital and the post-2008 period, and the interaction of capital and a dummy of large firms as explanatory variables.

$$tfp_{it} = \alpha_1 k_{it} + \alpha_2 D_p k_{it} + \alpha_3 D_l k_{it} + \varepsilon_{it} \ , \tag{7}$$

The results of the estimation are displayed in table 6. The estimate of capital is negative and significant at the 1% level. The crisis exacerbates the negative relationship. For large firms, however, the negative correlation is not so strong (but the estimate of the effect for large firms is still significant). These results are robust to different definitions of capital: capital with and without adjusting by the degree of capacity utilization, relative capital (with respect to sector average), capital intensity... This could be evidence of misallocation of capital input, as it is possible that capital is allocated to less productive firms instead than to more productive ones.

In order to check the robustness of these results to the TFP measure, we have applied the same regression procedure to Levinsohn and Petrin TFP. It arises that the relationship between capital and TFP in this case is positive and significant, although correlation is low. Nevertheless, the interaction term of capital and crisis is negative, what makes positive but not significant the aggregate effect of capital on TFP from 2008 onwards. Therefore, after the crisis started, the firms' level of capital would not be related to their productivity.

Gopinath et al. (2015) find positive correlation between capital and productivity in Spain, but decreasing over time, what may suggest the progressive misallocation of capital to less productive firms. Moreover, their model predicts negative and low correlation between the capital/labor ratio and productivity, although data displays positive (but low) correlation among both magnitudes. These results are different from the ones we achieved with the Solow TFP index, but closer to those obtained with Levinsohn and Petrin TFP. However, both the negative evolution of the relationship capital-productivity according to the Solow TFP index (exacerbated by the crisis) and the decreasing positive correlation between capital and productivity according to Levinsohn and Petrin TFP seem to be pointing out an increasing allocative inefficiency in capital (something in agreement with Gopinath et al., 2015, and Garcia-Santana et al., 2015).

In summary, both estimations suggest that the crisis provokes a negative effect of capital on TFP or that the positive relationship breaks from that moment onwards, what could be indicating the deterioration in the allocation of resources. Both regressions estimates coincide as well in the result that capital of large firms affects their TFP less negatively (or more positively) than in the case of SMEs.

Table 6: Results of the regression of TFP on capital

	Solow TFP index	LP TFP
Capital	-0.0626***	0.0059***
	(0.0007)	(0.0014)
Interaction: capital & crisis	-0.0082***	-0.0038***
	(0.0002)	(0.0004)
Interaction: capital & large	0.0166***	0.0217***
	(0.0005)	(0.0009)

Source: ESEE and author's calculations.
Notes: standard errors between parentheses. Significance at the 1, 5 and 10 percent levels denoted by ***, **, and *.

From the descriptive analysis performed in this subsection, we can conclude that there exists some evidence on negative evolution of allocative efficiency, mainly after 2007, with negative evolution of allocative efficiency of labor that softens with the crisis but an increasing allocative inefficiency in capital (exacerbated by the crisis).

4 Results

4.1 Main results

4.1.1 Static decomposition method of Olley and Pakes

We perform the Olley and Pakes decomposition (OP) each year both for the whole manufacturing and for each of the 20 two digit industries in which the ESEE classifies firms. We use equation (1), which is reproduced again below, to perform this decomposition.

$$TFP_t = \frac{1}{N_t}\sum_i TFP_{it} + \sum_i (s_{it} - \overline{s}_t)(TFP_{it} - \overline{TFP}_t)$$

From this equation, we know that the weighted average of productivity (TFP measure of Olley and Pakes) is the result of the addition of the unweighted mean of the productivity measure and the allocative efficiency component (the covariance between productivity and market shares, which in this case, are measured with value-added shares in real terms). Remember that if the covariance term is positive, resources are allocated efficiently, while if negative, it evidences misallocation.

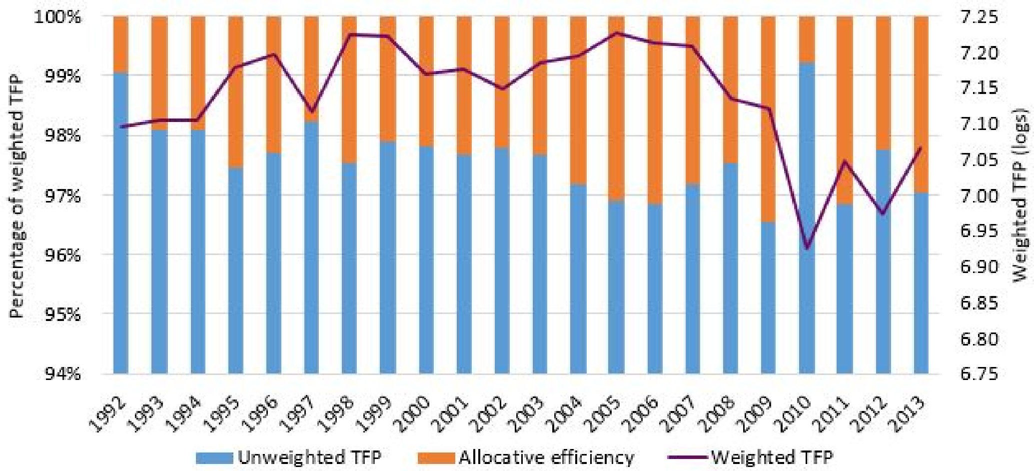
Garcia-Santana et al. (2015) and Gopinath et al. (2015), with different databases for Spain, different time periods (1995-2007 and 1999-2012, respectively) with some overlap with ours, and with different methodologies to ours (although Garcia Santana et al., 2015, also present the Olley and Pakes static TFP decomposition globally comparing the period 2001-2007 with the previous one, 1995-2000), obtain the following as regards TFP and allocative efficiency evolution. On the one hand, and as regards TFP levels, Garcia-Santana et al. (2015) show that TFP levels decrease from 1995 to 2007 (at a decreasing rate). On the other hand, Gopinath et al. (2015) obtain that TFP levels remain stable or slightly decrease from 1999 to 2007 and clearly decrease from 2007 onwards. As regards allocative efficiency evolution, Garcia-Santana et al. (2015) find an increase of misallocation in the period 2001-2007 with respect to the period 1995-2000. Gopinath et al. (2015) use a different methodology to study misallocation, based on the structural model of Hsieh and Klenow (2009), to get that from 1999 to 2012 there is a significant increase in the dispersion of the return to capital across firms, a stable dispersion of the return to labor across firms and, therefore, conclude that the increase of misallocation over time comes mainly from frictions affecting the capital input.

The Olley and Pakes decomposition for the whole Spanish manufacturing is summarized in figure 7: the two components of (weighted) TFP are displayed in percentage terms, and the purple line represents the evolution of weighted TFP (in levels).

From 1992 to 2006 there is a general pattern of improvement in allocative efficiency and simultaneously there is also a general pattern of a modest increase in weighted TFP[3]. Allocative efficiency gets worse from 2006 to 2010 (excluding the year 2009) and this comes in parallel with a decrease in TFP. Finally, from 2010 to 2013 allocative efficiency gets better and this is also paired with an improvement in TFP. Therefore, there seems to be a positive relationship between allocative efficiency evolution and TFP behavior.

[3] Other studies achieve similar conclusions regarding the evolution of TFP. For instance, Pérez and Serrano (2010) find low but positive rate of growth of TFP in manufacturing industries between 1995 and 2007, and Villarroya et al. (2006) obtain that TFP grows or stagnates between 1990's and 2001 in most manufacturing sectors.

Figure 7: TFP decomposition of Spanish manufactures (OP)



Source: ESEE and author's calculations.

The main results of the Olley and Pakes (1996) decomposition of TFP by subperiods and sectors are summarized in table 7 and figure 8.

Firstly, we must highlight the fact that the covariance term (allocative efficiency measure) is always positive, indicating that more productive firms typically have higher market shares, except in the case of vehicles and accessories between 2008-2010 and 2011-2013. This may evidence the existence of misallocation of resources in this specific sector of activity.

The average allocative efficiency of Spanish firms by subperiods ranges between 0.16 and 0.20. This can be interpreted in the following way: allocative efficiency is 16-20% higher than it would have been if all Spanish firms had an equal market share. The allocative efficiency measure is considerably larger if we take the arithmetic average of allocative efficiency of all sectors, which oscillates between 0.25 and 0.27. It implies that intra-sector allocative efficiency is, in general, larger than if we consider all Spanish manufacturing firms as a whole: average allocative efficiency within sectors is 25-27% higher than it would have been if all firms within sectors had an equal share.

Table 7: Average productivity and allocative efficiency by sector and period

	Average productivity (weighted)			Average productivity (unweighted)			Allocative efficiency		
	1992-2007	2008-2010	2011-2013	1992-2007	2008-2010	2011-2013	1992-2007	2008-2010	2011-2013
Meat products	6.820	6.894	6.846	6.609	6.638	6.623	0.210	0.250	0.215
Food and tobacco	6.982	6.864	6.751	6.648	6.558	6.435	0.334	0.307	0.317
Beverages	5.918	5.894	5.476	5.411	5.308	5.267	0.507	0.582	0.210
Textile and clothing	7.307	7.293	7.368	7.044	6.990	7.033	0.263	0.305	0.335
Leather, fur and footwear	7.092	7.037	7.158	6.941	6.936	6.999	0.149	0.101	0.161
Timber	6.999	7.002	6.857	6.834	6.764	6.623	0.163	0.238	0.233
Paper	6.579	6.667	6.707	6.433	6.495	6.514	0.143	0.172	0.192
Printing	7.603	7.349	7.330	7.199	7.103	7.088	0.403	0.248	0.242
Chemical and pharmaceuticals	7.066	6.992	6.866	6.803	6.731	6.683	0.264	0.259	0.182
Plastic and rubber products	7.109	7.012	6.937	6.932	6.822	6.774	0.179	0.190	0.163
Nonmetal mineral products	6.874	6.574	6.539	6.555	6.259	6.149	0.319	0.319	0.390
Basic metal products	6.901	6.686	6.566	6.691	6.497	6.362	0.206	0.189	0.198
Fabricated metal products	7.633	7.612	7.540	7.379	7.209	7.108	0.254	0.403	0.433
Machinery and equipment	7.794	7.818	7.789	7.646	7.638	7.637	0.149	0.180	0.154
Computer products, electronics and optic	7.814	8.241	8.319	7.443	7.657	7.747	0.376	0.585	0.578
Electric materials and accessories	7.574	7.640	7.454	7.385	7.314	7.213	0.195	0.327	0.242
Vehicles and accessories	6.942	6.525	6.921	6.834	6.811	6.956	0.110	-0.284	-0.031
Other transport equipment	7.358	7.554	7.638	7.201	7.440	7.373	0.169	0.112	0.265
Furniture	7.651	7.490	7.604	7.392	7.326	7.281	0.261	0.165	0.324
Other manufacturing	7.258	7.017	6.937	7.036	6.878	6.742	0.225	0.142	0.195
Average of all sectors	7.263	7.150	7.101	7.007	6.901	6.833	0.248	0.256	0.270
Country average (from OP decomposition at the national level)	7.173	7.058	7.027	7.007	6.901	6.833	0.166	0.158	0.195
Number of observations	280929	64775	59114	244561	55620	52753	280929	64775	59114

Source: ESEE and author's calculations.

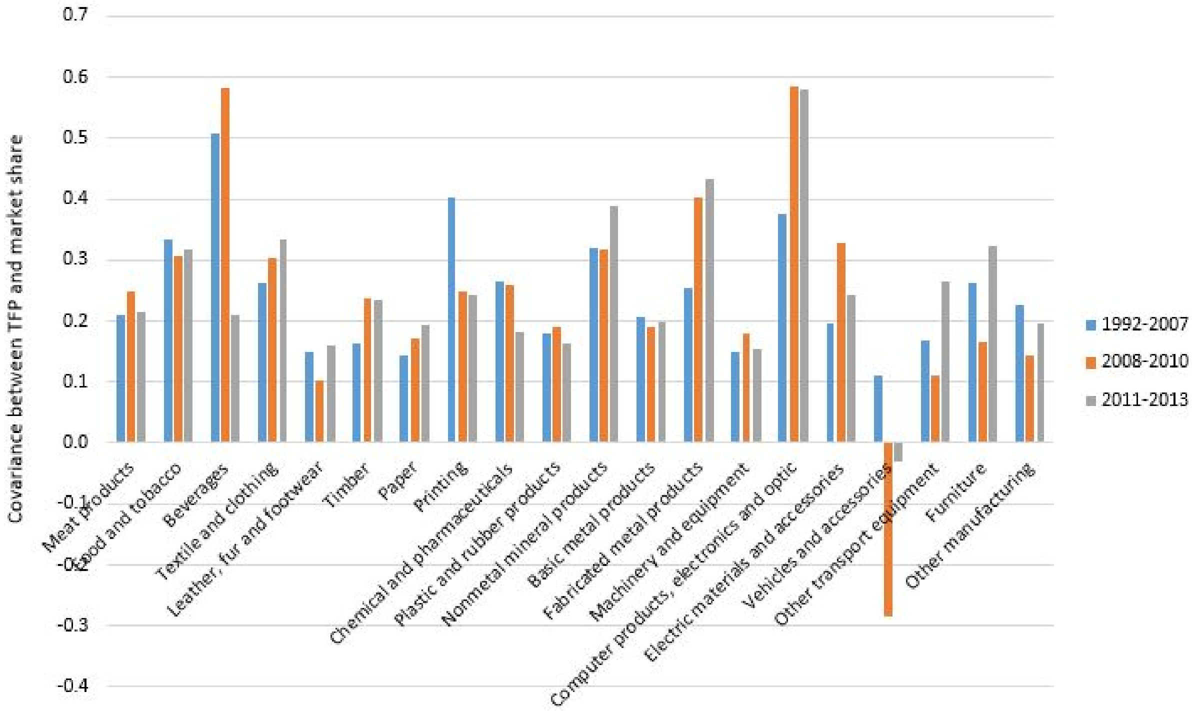
From the Olley and Pakes (1996) TFP decomposition for each of the 20 industries, we obtain the following results. Computer products, electronics and optic; machinery and equipment; furniture; fabricated metal products; electric materials and accessories; other transport equipment; and printing are the sectors with higher average multifactor productivity. However, the top 6 allocative efficient sectors (on average) do not coincide with the previous ones (except the top 1: computer products, electronics and optic; and the third: fabricated metal products). The remaining most efficient sectors are beverages; nonmetal mineral products; food and tobacco; and textile and clothing. The least allocative efficient sectors are vehicles and accessories (the only sector with negative covariance term); leather, fur and footwear; and machinery and equipment (a singular case for being the third less allocative efficient sector and the third more productive one, on average).

Analyzing the evolution within sectors over subperiods, we observe that in 13 of the 20 manufacturing sectors multifactor productivity falls in the aftermath of the crisis, as compared with the first subperiod. From these 13, 9 suffer a reduction in allocative efficiency (although for some more, allocative efficiency rises just marginally).

During the last subperiod (the recovery phase), TFP drops in 13 sectors with respect to the recession period, although only in 8 cases it occurs simultaneously with a reduction in allocative efficiency. As it is observed in table 7, while average weighted (and unweighted) productivity decreases each subperiod with respect to the previous one, average allocative efficiency only reduces mildly in 2008-2010 as compared with 1992-2007 (according to the OP decomposition at the national level), and even grows if we take the arithmetic average of all sectors.

The most striking changes in terms of allocative efficiency occur in the beverages sector, where the covariance between market shares and productivity reduces by more than half in the recovery period. The printing sector suffers a strong reduction of allocative efficiency in the second subperiod as compared to the initial one, to get stabilized afterwards. Fabricated metal products and computer products, electronics and optic sectors follow a similar pattern, characterized by the intense growth of allocative efficiency between 2008-2010 that is almost maintained in the last subperiod. The rest of sectors remain more or less stable in their levels of allocative efficiency, without major changes, and some of them experience a drop during the crisis to recover afterwards at levels close to the initial ones (like food and tobacco; leather, fur and footwear; basic metal products; furniture; or other manufacturing).

Figure 8: Allocative efficiency evolution by sector and period



Source: ESEE and author's calculations.

4.1.2 Dynamic decomposition method of Diewert and Fox

This subsection is devoted to conduct the dynamic decomposition of productivity proposed by Diewert and Fox (2010) (DF) which, in contrast to the static Olley and Pakes (1996) method, allows to disentangle the contribution of firms' entry and exit to the productivity change. This method disaggregates 1-year changes in aggregate sectorial productivity into four components as it was explained in equation (2): the within component (1), the between component (2) (positive if more productive firms gain market share and less productive firms lose market share), the entry (3) and exit (4) components. Recall that the last three components (the external restructuring, which measures the net effect of firm entry and exit and changes in market shares of continuing firms) might evidence the existence of misallocation of resources. The decomposition is applied to each sector individually.

$$\triangle TFP_t = \sum_{i\epsilon C} \overline{s}_{Ci} \triangle TFP_{it} + \sum_{i\epsilon C} \triangle s_{Cit}(\overline{TFP}_i - \overline{TFP}_C) +$$
$$\sum_{i\epsilon N} s_{it}(TFP_{it} - TFP_{Ct}) - \sum_{i\epsilon X} s_{it-1}(TFP_{it-1} - TFP_{Ct-1})$$

Notice that the dynamic decomposition method cannot be applied to sectors' productivity in years 1992 and 2013, because we do not have data on TFP of year 1991 to calculate growth rates, and we do not know whether firms will continue or exit in 2014. Average results by year are displayed in table 8 and figure 9.

Taking the average over the 1-year changes of TFP, from 1993 to 2012, the four components have contributed to the reduction of productivity, which is caused mainly by the reduction of TFP from 2005 to 2010. The average sign of the external restructuring or composition effects (between, entry and exit components) denote misallocation of resources on average during the whole period. According to the column of the external restructuring (calculated adding the between and entry components, and subtracting the exit component), we can affirm that there has existed misallocation of resources in 1994, 1996, 1997, 2000, 2003 and from 2005 until 2012 (except in 2011). These periods match with most of the years where we can appreciate reductions in the allocative efficiency according to the OP measure.

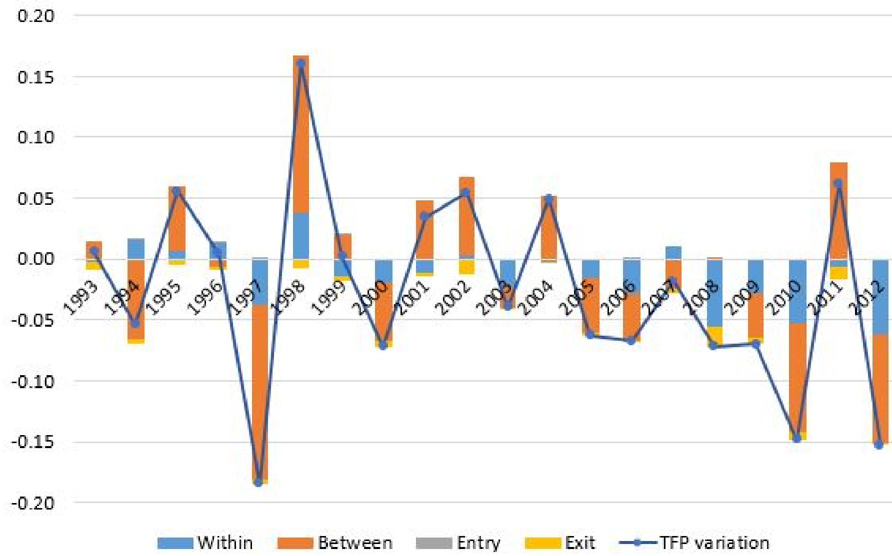
The between component is the one which contributes the most to the evolution of TFP almost every period, and it is negative in 11 of the 20 years for which this dynamic decomposition is performed. The entry component (the third element) is zero most of the years, since there is not much information about entry in the database. For those years when there appear entrant firms in the sample, as they account for a very small proportion of the existing firms, their contribution to productivity growth is negligible but positive 6 of the 9 years for which there are data. The exit component is also close to zero, its contribution to TFP change is minimum, but this component has always a positive sign (what implies some degree of misallocation).

Table 8: DF dynamic decomposition of 1-year changes in TFP (average by year)

Year	Decomposition components				External	△ TFP
	Within	Between	Entry	Exit		
	(1)	(2)	(3)	(4)	(2)+(3)-(4)	(1)+(2)+(3)-(4)
1993	-0.0021	0.0142	0	0.0064	0.0077	0.0056
1994	0.0161	-0.0658	3.09E-07	0.0041	-0.0699	-0.0538
1995	0.0071	0.0530	0	0.0044	0.0486	0.0557
1996	0.0136	-0.0058	2.40E-06	0.0035	-0.0092	0.0044
1997	-0.0367	-0.1448	1.92E-07	0.0033	-0.1481	-0.1848
1998	0.0379	0.1298	-1.93E-05	0.0075	0.1223	0.1602
1999	-0.0146	0.0202	1.65E-05	0.0036	0.0166	0.0020
2000	-0.0195	-0.0473	-1.91E-06	0.0050	-0.0524	-0.0719
2001	-0.0108	0.0479	-1.14E-05	0.0027	0.0452	0.0344
2002	0.0024	0.0649	0	0.0133	0.0517	0.0541
2003	-0.0238	-0.0158	0	0.0000	-0.0158	-0.0395
2004	-0.0024	0.0522	0	0.0010	0.0513	0.0489
2005	-0.0155	-0.0456	0	0.0016	-0.0473	-0.0628
2006	-0.0288	-0.0377	1.42E-06	0.0010	-0.0388	-0.0676
2007	0.0106	-0.0244	0	0.0045	-0.0289	-0.0183
2008	-0.0560	0.0001	0	0.0163	-0.0162	-0.0723
2009	-0.0279	-0.0361	0	0.0058	-0.0419	-0.0698
2010	-0.0534	-0.0889	1.77E-08	0.0062	-0.0950	-0.1485
2011	-0.0064	0.0787	0	0.0100	0.0687	0.0623
2012	-0.0620	-0.0896	0	0.0014	-0.0910	-0.1529
Average of all years	-0.0136	-0.0070	-5.89E-07	0.0051	-0.0121	-0.0257

Source: ESEE and author's calculations.

Figure 9: DF decomposition of 1-year changes in TFP (average by year)



Source: ESEE and author's calculations.

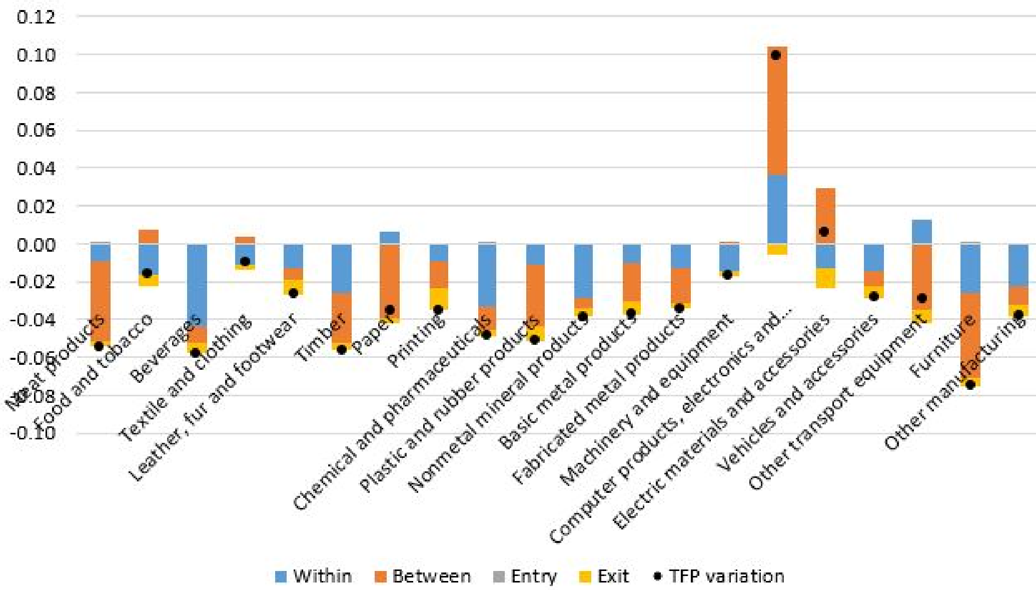
The decomposition's average results for all sectors of activity over the whole period (from 1993 to 2012) are shown in figure 10, and sectorial results by subperiods are displayed in table 9.

The only two sectors whose TFP growth is positive on average from 1993 to 2012 are computer products, electronics and optic; and electric materials and accessories.

Looking at the aggregate composition effects over the whole period, we can conclude that resources have been allocated efficiently, on average, in the following sectors of activity: food and tobacco; textile and clothing; computer products, electronics and optic; and electric materials and accessories. These gains in efficiency are mainly explained by the between component of the decomposition. In the rest of sectors, external restructuring has contributed negatively to productivity.

For the sectors that contain information about firms' entry, the contribution of entrant firms to TFP change is very close to zero, as before. But again, these results on entry should be interpreted cautiously as entry in the ESEE is not necessarily representative of entry in the Spanish manufacturing. In every sector and subperiod, exit has had a negative effect in multifactor productivity change, except in the case of beverages in 2008-2010 and 2011-2012, and computer products, electronics and optic in 2008-2010.

Figure 10: DF decomposition of 1-year changes in TFP (average of sectors, 1993-2012)



Source: ESEE and author's calculations.

From table 9, we observe that the only sector with positive external restructuring every subperiod, i.e. the only sector that is allocative efficient every subperiod, is the computer products, electronics and optic. In 1993-2007, 8 sectors are allocative efficient according to this dynamic decomposition method. However, during the crisis years only two sectors behave in an allocative efficient manner (the one previously mentioned and other manufacturing). The last subperiod is characterized by a general reduction of misallocation, and although only 7 sectors are allocative efficient, the contribution of the between, entry and exit components improves for the majority of them with respect to the crisis period.

Table 9: Decomposition of 1-year changes in TFP (average of sectors by subperiod)

	1993-2007			2008-2010			2011-2012		
	Within	External	△ TFP	Within	External	△ TFP	Within	External	△ TFP
Meat products	-0.0036	-0.0633	-0.0669	-0.0368	-0.0302	-0.0670	0.0077	0.0118	0.0195
Food and tobacco	-0.0075	0.0252	0.0177	0.0007	-0.0553	-0.0547	-0.0904	-0.0562	-0.1466
Beverages	-0.0183	0.0181	-0.0002	-0.1079	-0.1137	-0.2216	-0.0706	-0.0156	-0.0862
Textile and clothing	-0.0099	0.0130	0.0032	-0.0025	-0.0644	-0.0669	-0.0309	-0.0190	-0.0499
Leather, fur and footwear	-0.0093	0.0054	-0.0039	-0.0592	-0.0992	-0.1584	0.0350	-0.0262	0.0089
Timber	-0.0150	-0.0414	-0.0564	-0.0442	-0.0176	-0.0618	-0.0565	0.0105	-0.0460
Paper	0.0088	-0.0356	-0.0268	-0.0007	-0.0502	-0.0509	0.0079	-0.0573	-0.0494
Printing	-0.0057	-0.0129	-0.0186	-0.0061	-0.0708	-0.0770	-0.0398	-0.0587	-0.0985
Chemical and pharmaceuticals	-0.0188	0.0061	-0.0127	-0.0710	-0.0377	-0.1087	-0.0499	-0.1052	-0.1551
Plastic and rubber products	-0.0022	-0.0480	-0.0502	-0.0263	-0.0078	-0.0341	-0.0378	-0.0485	-0.0863
Nonmetal mineral products	-0.0010	0.0007	-0.0002	-0.1183	-0.0348	-0.1531	-0.0371	-0.0345	-0.0716
Basic metal products	0.0340	-0.0053	0.0287	-0.1108	-0.0549	-0.1657	-0.0950	-0.1007	-0.1957
Fabricated metal products	-0.0004	-0.0224	-0.0228	-0.0639	-0.0298	-0.0937	0.0011	-0.0012	-0.0001
Machinery and equipment	-0.0061	-0.0023	-0.0084	-0.0427	-0.0119	-0.0546	-0.0332	0.0124	-0.0209
Computer products, electronics and optic	0.0603	0.0809	0.1412	-0.0469	0.0139	-0.0330	0.0073	0.0157	0.0230
Electric materials and accessories	0.0058	0.0256	0.0314	-0.0717	-0.0073	-0.0790	-0.0884	0.0070	-0.0814
Vehicles and accessories	-0.0014	-0.0368	-0.0381	-0.0873	-0.1291	-0.2164	0.0120	0.3369	0.3488
Other transport equipment	0.0070	-0.0404	-0.0335	0.0539	-0.0467	0.0072	-0.0110	-0.0471	-0.0581
Furniture	-0.0193	-0.0254	-0.0447	-0.0584	-0.2197	-0.2781	-0.0182	0.0865	0.0683
Other manufacturing	-0.0258	-0.0362	-0.0620	0.0230	0.0538	0.0768	-0.0696	-0.0060	-0.0757
Average of all sectors	-0.0014	-0.0097	-0.0112	-0.0439	-0.0507	-0.0945	-0.0329	-0.0048	-0.0376

Source: ESEE and author's calculations.

4.2 Robustness checks

In order to check the robustness of our results to alternative productivity measures, we have replicated both the OP and the DF decompositions with the TFP obtained by the procedure proposed by Levinsohn and Petrin (2003).

Olley and Pakes (1996) static decomposition at the national level displays similar results. The most remarkable change among the two calculations of Olley and Pakes (1996) decomposition method is the difference in levels of TFP and allocative efficiency. In general, allocative efficiency is much larger with Levinsohn and Petrin TFP: while average allocative efficiency for different subperiods at the aggregate Spanish level was around 0.16-0.20 with the Solow TFP index, it ranges between 0.42 and 0.56 with Levinsohn and Petrin TFP. However, the evolution of these magnitudes (weighted TFP, allocative efficiency) are pretty similar to those obtained in Subsection 4.1.1 from Solow TFP.

From the sectorial decomposition, we obtain that the six most productive sectors are, on average, the following: other transport equipment; beverages; leather, fur and footwear; meat products; computer products, electronics and optic; and machinery and equipment. The most allocative efficient, on average, are the same as the six most productive sectors except for the sectors of leather, fur and footwear and machinery and equipment, which are substituted for food and tobacco, and paper. Some sectors appear as top in total factor productivity and allocative efficiency in both (with the Solow TFP index and the Levinsohn and Petrin TFP) OP sectorial static decompositions, but not all of the sectors coincide. In spite of that, the evolution of allocative efficiency in every sector is similar.

Regarding the dynamic decomposition of productivity of Diewert and Fox (2010), results are almost identical independently of the TFP measure used to conduct the analysis. Correlation between each component of the decomposition calculated by both methods is around 98-99%, so the conclusions achieved in Subsection 4.1.2 are robust to the measure of TFP chosen.

5 Conclusions

The aim of this paper is the analysis of the evolution of productivity and misallocation of production factors across manufacturing firms within industries in Spain for the period 1992-2013. In order to achieve our objectives, and using data of Spanish manufacturing firms from the ESEE, a preliminary study with several descriptives has been performed, and afterwards, we have conducted the static decomposition method of productivity of Olley and Pakes (1996) and the dynamic decomposition of Diewert and Fox (2010). From this research, we have obtained the following conclusions.

The period 1992-2013 was characterized by a fall in productivity, although the allocation of resources became more efficient. From 1992 to 2007, in general, there was a stagnation or slight growth of TFP and an increase in allocative efficiency of resources. However, the crisis had a negative impact on these variables, which suffered an intense drop, especially in 2010. Most industries experienced a fall in their TFP and their degree of allocative efficiency during this subperiod. Since 2011, there was an improvement in allocative efficiency levels as compared to 2010, and a rising trend of TFP (although it fell in 2012). Even though, at the end of the period TFP was still far from the levels of productivity before the crisis. On the other hand, some descriptives show evidence of the static allocative efficiency of employment in Spanish firms. However, there seems to be a worsening of allocation of labor until 2008, but this misallocation softened with the crisis. In contrast, the degree of allocative efficiency of capital got worse since the economic depression started (it seems that large firms were less affected by the crisis in terms of allocative efficiency than SMEs). According to the dynamic decomposition of TFP, the between component was, on average, the one which contributed the most to the evolution of TFP and allocative efficiency.

In general, our results are robust to the two TFP measures that have been used (the Solow TFP index and the Levinsohn and Petrin TFP) and also to both productivity decomposition methods.

The implications of the existence of resource misallocation are highly relevant. The inefficient allocation of labor and capital implies the worsening of productivity growth, which is the main engine of economic progress in societies. Therefore, the improvement in the degree of allocative efficiency of labor and capital must be a concern for policy makers. The ultimate reasons for the poor evolution of productivity and allocative efficiency, especially during the crisis, are outside the scope of this research. However, further work could be done to disentangle the key factors behind misallocation of resources in Spanish manufactures, as a way of continuing the present research. Some possible factors that could explain the existence of misallocation or the different degree of allocative efficiency among industries or along time could be: financial frictions (like credit constraints), export intensity, R&D intensity, barriers of entry to the market, the degree of competition, size of the market... After this analysis, policy recommendations could be provided, so as to improve the allocative efficiency of resources, and hence, to increase aggregate productivity.

Finally, it should be acknowledged that the data coming from the ESEE that has been used in this work may have some limitations regarding the development of a dynamic decomposition of productivity, considering the contribution of entry and exit. As we mentioned before, there is not much information about entry of new firms, and these data could not be representative of the actual entry, so we should be cautious in the interpretation of results. For future research, it would be interesting to perform a different dynamic decomposition, less ambitious in terms of getting the entry and exit contribution to productivity growth, given the limitations of the ESEE in this sense.

Appendix I: Main variables

- Age of the firm (in years).
- Deflators:
  - ipcprod0: production deflator (base 2010).
  - ipi2010: industrial price index for each sector of activity (base 2010), obtained from INE.
- Labor: effective number of hours worked.
- Labor compensation: gross wages and salaries, compensations, Social Security contributions paid for by the company, contributions to complementary pension schemes, as well as other social expenses. It is measured in current euros.
- Market share: value added of each firm with respect to total value added of firms belonging to the same sector of activity.
- Materials: sales minus changes in inventories of purchases and external services. It is measured in current euros.
- Number of employees.
- Real sales: sales in real terms (deflated with ipcprod0).
- Sector of activity: each firm is classified in one of the following 20 sectors of activity:

1	Meat products	11	Nonmetal mineral products
2	Food and tobacco	12	Basic metal products
3	Beverages	13	Fabricated metal products
4	Textile and clothing	14	Machinery and equipment
5	Leather, fur and footwear	15	Computer products, electronics and optic
6	Timber	16	Electric materials and accessories
7	Paper	17	Vehicles and accessories
8	Printing	18	Other transport equipment
9	Chemical and pharmaceuticals	19	Furniture
10	Plastic and rubber products	20	Other manufacturing

- Nominal value added.
- Real value added: production in real terms (deflated using ipi2010) minus intermediate inputs in real terms (deflated using ipi2010 for materials and for external services).
- Capital: capital stock in real terms, adjusted by the degree of capacity utilization. Initially, capital stock has been calculated with the following formula:

$$K_t = (1 - \delta)K_{t-1} + I_{t-1}$$

where K_t is capital stock in period t, δ is the depreciation rate, I_{t-1} is investment conducted in period *t-1* (it is assumed that it takes a full time period for the new capital to be ordered, delivered and installed). This assumption is proposed by Olley and Pakes (1996) and Levinsohn and Petrin (2003) to avoid endogeneity problems of capital in the first stage of the production function estimation. Later, capital stock was adjusted by the degree of capacity utilization.

- Year of constitution of the firm.

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