

A decomposition of  
industry-level productivity growth  
in Belgium using firm-level data

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**Abstract** - In this Working Paper the growth in industry-level total factor productivity, i.e. the part of output growth that cannot be accounted for by growth in the production factors, is decomposed using Belgian firm-level data for the period 2000-2008. Decomposition permits to assess to what extent productivity growth in a given industry results from changes in firm-level productivity, from reallocation of market shares between existing firms or from firm entry and exit.

**Abstract** - Deze Working Paper ontleedt de groei van de totale factorproductiviteit op bedrijfstakniveau, i.e. het gedeelte van de outputgroei dat niet toegeschreven kan worden aan de groei van de productiefactoren, op basis van Belgische bedrijfstakgegevens voor de periode 2000-2008. Die ontleding maakt het mogelijk te achterhalen in welke mate de productiviteitsgroei in een bepaalde bedrijfstak afkomstig is van veranderingen in productiviteit op bedrijfsniveau, van de herverdeling van marktaandeel tussen bestaande bedrijven of van de bedrijfstoetredingen en -uittredingen.

**Abstract** - Dans ce Working Paper, la croissance de la productivité totale des facteurs au niveau sectoriel, c'est-à-dire la part de la croissance de l'output qui ne peut pas être expliquée par la croissance des facteurs de production, est décomposée pour la période 2000-2008 sur la base de données d'entreprises belges. La décomposition permet d'évaluer dans quelle mesure la croissance de la productivité dans une branche donnée s'explique par l'évolution de la productivité des entreprises, par une redistribution des parts de marché entre les entreprises existantes ou encore par la création et disparition d'entreprises.

**Jel Classification** - C81, D22, D24, L16

**Keywords** - Total factor productivity, technological efficiency, reallocation, firm entry and exit.

## Executive summary

Total factor productivity (TFP) growth, i.e. the part of output growth that cannot be accounted for by changes in the quantity of inputs (e.g. capital and labour) used to produce goods or services, is generally considered as an indicator of technological change. Given data availability, early empirical studies computed or estimated TFP at the country or industry level. More recently, firm-level or plant-level data have provided insight into how industry-level productivity growth can be explained by business demographics, i.e. firm-level productivity growth, changes in market shares of existing firms (incumbents) and firm exit and entry.

In this paper data on firms that are established in Belgium are used to decompose TFP growth for 12 manufacturing industries over the period 2000-2008. Five components of productivity growth are distinguished. A first component shows the extent to which industry-level TFP growth results from changes in firm-level TFP growth, for given market shares, and thereby provides an indication of overall changes in technological efficiency. A second component shows the extent to which changes in market shares of firms explain industry-level TFP growth. The third component interacts changes in firm-level TFP with changes in market shares and will be positive if – on average- firms with positive (negative) TFP growth witness an increase (decrease) in their market share and negative if the changes have opposite signs. The final two components indicate the effects on industry-level TFP growth of respectively firms that enter the industry and firms that leave the industry (e.g. due to bankruptcy).

The Belgian data show that productivity differences between firms within the same industry are substantial and rather persistent. In most industries, incumbent firms are - on average- more efficient than entrants and the latter are - on average- more efficient than firms that left the industry in the period considered.

The analysis presented in this paper does not consider the determinants of TFP growth<sup>1</sup> but rather decomposes industry-level TFP growth into its underlying components, which reflect intra-industry dynamics. The decomposition indicates that firm-level TFP growth contributed substantially to industry-level TFP growth. Firms that witnessed high TFP growth - rather than high initial TFP levels- appear to have gained market shares at the expense of firms that witnessed low TFP growth. Firm entry contributed positively to industry-level TFP growth but the fact that entrants have above-average TFP is more relevant than the number of firms that enter a given industry.

The main policy conclusion of the present analysis is that changes in firm-level productivity growth may be reinforced or dampened by the reallocation of market shares between firms. The analysis suggests that there could be some conflict between a policy that aims to increase productivity (e.g. through support for the R&D activities of individual firms) or reallocation towards the more efficient firms within an industry (e.g. through deregulation and competition policy) and policies that aim to enhance employment growth, which would actually benefit from reallocation towards less efficient firms. Firms with high TFP growth gained market shares in terms of value added but at the same time appeared to have decreased their relative demand for labour and capital.

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<sup>1</sup> Biatour et al. (2011) recently estimated the impact of the determinants of industry-level TFP for a panel of 21 industries over the period 1988-2007.

## Synthese

De groei van de totale factorproductiviteit (TFP), d.w.z. het gedeelte van de outputgroei dat niet toegeschreven kan worden aan veranderingen in de hoeveelheid inputs (bv. kapitaal en arbeid) die gebruikt worden om goederen of diensten te produceren, wordt doorgaans beschouwd als een indicator voor technologische verandering. Gezien de beschikbaarheid van gegevens, werd de TFP in vroegere empirische studies berekend of geraamd op nationaal of bedrijfstakniveau. Meer recentelijk hebben gegevens op bedrijfs- of vestigingsniveau licht geworpen op de manier waarop de productiviteitsgroei op bedrijfstakniveau verklaard kan worden door bedrijfsdemografie, d.w.z. productiviteitsgroei op bedrijfsniveau, door veranderingen in marktaandeel tussen bestaande (gevestigde) bedrijven en door bedrijfstoetredingen en –uittredingen.

De gegevens van in België gevestigde bedrijven worden in deze paper gebruikt om de TFP op te splitsen voor 12 industriële bedrijfstakken over de periode 2000-2008. Er worden vijf componenten van productiviteitsgroei onderscheiden. Een eerste component toont de mate waarin de TFP-groei op bedrijfstakniveau afkomstig is van veranderingen in de TFP-groei op bedrijfsniveau, bij ongewijzigde marktaandelen, en biedt zo een indicator voor de globale veranderingen in technologische efficiëntie. Een tweede component toont de mate waarin veranderingen in marktaandeel van bedrijven verantwoordelijk zijn voor de TFP-groei op bedrijfstakniveau. De derde component linkt veranderingen in TFP op bedrijfsniveau aan veranderingen in marktaandeel en zal positief zijn wanneer bedrijven met een positieve (negatieve) TFP-groei gemiddeld een toename (afname) van hun marktaandeel laten optekenen en negatief wanneer de veranderingen tegengestelde tekens hebben. De twee laatste componenten tonen de effecten op de TFP-groei op bedrijfstakniveau van respectievelijk de bedrijven die toetreden tot de bedrijfstak en de bedrijven die uittreden uit de bedrijfstak (bv. wegens faillissement).

De Belgische gegevens tonen aan dat de productiviteitsverschillen tussen bedrijven binnen dezelfde bedrijfstak aanzienlijk en eerder blijvend zijn. In het merendeel van de bedrijfstakken zijn gevestigde bedrijven gemiddeld efficiënter dan toetredende bedrijven en zijn die laatste gemiddeld efficiënter dan bedrijven die de bedrijfstak verlaten hebben tijdens de beschouwde periode.

De analyse in deze paper is niet gericht op de determinanten van de TFP-groei<sup>2</sup>, maar splitst de TFP-groei op bedrijfstakniveau op in zijn onderliggende componenten, die de dynamiek binnen de bedrijfstak weerspiegelen. De opsplitsing geeft aan dat de TFP-groei op bedrijfsniveau aanzienlijk heeft bijgedragen tot de TFP-groei op bedrijfstakniveau. Bedrijven met een sterke TFP-groei - i.p.v. een aanvankelijk hoog TFP-niveau – blijken aan marktaandeel te hebben gewonnen ten koste van bedrijven met een zwakke TFP-groei. De bedrijfstoetredingen dragen bij tot de TFP-groei op bedrijfstakniveau, maar het feit dat de TFP van toetredende bedrijven hoger is dan gemiddeld is belangrijker dan het aantal bedrijven dat toetreedt tot een bepaalde bedrijfstak.

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<sup>2</sup> Biatour et al. (2001) raamden onlangs de impact van de determinanten van de TFP op bedrijfstakniveau voor een panel van 21 bedrijfstakken over de periode 1988-2007.

De voornaamste beleidsconclusie van deze analyse luidt dat veranderingen van de productiviteitsgroei op bedrijfsniveau versterkt of afgezwakt kunnen worden door de herverdeling van marktaandeel tussen bedrijven. De analyse wijst erop dat er zich een conflict kan voordoen tussen enerzijds beleidsmaatregelen voor het verhogen van de productiviteit (bv. door ondersteuning van O&O-activiteiten van individuele bedrijven) of van de herverdeling ten gunste van de efficiëntere bedrijven binnen een bedrijfstak (bv. door deregulerings- en concurrentiebeleid) en anderzijds beleidsmaatregelen voor werkgelegenheidsgroei, die eigenlijk baat zou hebben bij de herverdeling ten gunste van minder efficiënte bedrijven. Over de beschouwde periode wonnen bedrijven met een sterke TFP-groei aan marktaandeel in termen van toegevoegde waarde, maar bleek tegelijkertijd hun relatieve vraag naar arbeid en kapitaal te zijn gedaald.

## Synthèse

La croissance de la productivité totale des facteurs (PTF), soit la part de la croissance de l'output qui ne peut pas être expliquée par l'évolution quantitative des inputs (capital et travail) intervenant dans la production de biens et de services, est généralement considérée comme un indicateur du changement technologique. Compte tenu des données disponibles, des études empiriques antérieures calculaient ou estimaient la PTF à l'échelle d'un pays ou d'une branche. La disponibilité de données d'entreprises ou de sites de production permet dorénavant de comprendre comment la croissance de la productivité d'une branche évolue en fonction de la démographie des entreprises, c'est-à-dire la croissance de la productivité des entreprises, les glissements de parts de marché entre entreprises existantes et les créations et disparitions d'entreprises.

Dans cette étude, nous nous sommes basés sur des données d'entreprises implantées en Belgique pour décomposer la croissance de la PTF dans 12 branches d'industrie au cours de la période 2000-2008. Cinq composantes de la croissance de la productivité sont distinguées. La première composante montre dans quelle mesure la croissance de la PTF sectorielle est influencée par l'évolution de la croissance de la PTF des entreprises, à parts de marché données, et nous informe ainsi sur l'évolution globale de l'efficacité technologique. La seconde composante montre dans quelle mesure l'évolution des parts de marché des entreprises influence la croissance de la PTF de la branche. La troisième composante combine les changements dans la PTF des entreprises avec l'évolution des parts de marché ; elle sera positive si – en moyenne - les entreprises ayant une croissance positive (négative) de la PTF voient leurs parts de marché augmenter (diminuer) et négative dans le cas contraire. Les deux dernières composantes mesurent les effets sur la croissance de la PTF de la branche, respectivement, des créations et des disparitions d'entreprises (par exemple suite à une faillite) dans une branche.

L'analyse des données belges révèle que la productivité des entreprises d'une même branche varie sensiblement et que les écarts persistent dans le temps. Dans la plupart des branches, au cours de la période considérée, les entreprises existantes sont en moyenne plus efficaces que celles qui se créent, et ces dernières sont en moyenne plus efficaces que les entreprises qui quittent la branche.

L'analyse présentée dans cette étude ne porte pas sur les déterminants de la croissance de la PTF<sup>3</sup> sectorielle mais en identifie les composantes sous-jacentes, lesquelles reflètent la dynamique interne de la branche. La décomposition montre que la croissance de la PTF des entreprises a contribué sensiblement à la croissance de la PTF des branches. En outre, les entreprises affichant une croissance élevée de la PTF – plutôt qu'une PTF élevée à l'origine – ont gagné des parts de marché au détriment d'entreprises enregistrant une faible croissance de la PTF. Enfin, les créations d'entreprise contribuent positivement à la croissance de la PTF de la branche, principalement en raison du fait que les entreprises nouvellement créées ont une PTF supérieure à la moyenne (davantage qu'en raison du nombre de créations d'entreprises dans une branche donnée).

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<sup>3</sup> Biatour et al. (2011) ont récemment estimé l'impact des déterminants de la PTF pour un panel de 21 branches sur la période 1988-2007.

La principale conclusion de cette analyse est que l'évolution de la croissance de la productivité des entreprises peut être renforcée ou freinée par une redistribution des parts de marché entre entreprises. L'analyse met en évidence de possibles conflits entre, d'une part, les politiques visant à accroître la productivité (par exemple via un soutien aux activités de R&D ou à des entreprises individuelles) ou une redistribution des parts de marché au profit d'entreprises plus efficaces au sein d'une branche (via la politique de dérégulation et de compétition) et, d'autre part, des politiques d'emploi qui conduiraient à une redistribution des parts de marché au profit des entreprises moins efficaces. Au cours de la période étudiée, les entreprises affichant une croissance élevée de leur PTF ont gagné des parts de marché en termes de valeur ajoutée mais ont parallèlement réduit leur demande relative de capital et de travail.



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# 1. Introduction

Total factor productivity (TFP) is generally considered as a measure of technological efficiency and TFP growth as a proxy of disembodied technological change, although a number of measurement issues hamper this straightforward interpretation (see e.g. Hulten 2000, 2009). Early empirical studies considered TFP at the country or industry level. Due to easier access to (government) databases and increased computer performance in processing large data sets, from the 1980s onwards scholars started using firm-level and plant-level data to analyse productivity within industries. Bartelsman and Doms (2000) summarized the stylized facts from the early micro-level empirical work (predominantly focused on the US):

- Large productivity differences between firms and plants within the same industry,
- Productivity differences appear to be rather persistent,
- Entry and exit plays an important role in industry-level productivity growth,
- Entrants do not seem to be more efficient than incumbents at entry,
- There does not seem to be any correlation between employment changes and productivity changes.

As pointed out by Bailey, Hulten and Campbell (1992), firm-level data clearly refute the assumption that industries are composed of identical and perfectly competitive firms. Firm-level data permit to assess to what extent industry-level productivity growth can be explained by within-industry dynamics such as firm-level productivity growth, reallocation of market shares between existing firms (incumbents) and the entry and exit of firms. Even if the productivity of individual firms would not change in a given industry, industry-level productivity may change substantially due to changes in the market shares of firms with different productivity levels. Decomposing industry-level productivity growth into its underlying components using firm-level data provides some insight into effects of within-industry dynamics that cannot be revealed by using industry-level or country-level data.

Using US Bureau of the Census data on manufacturing plants from 1963 up to 1987, Baily, Hulten and Campbell (1992) found strong movement of firms up as well as down the productivity distribution. Entrants and firms leaving a given industry also differed substantially in productivity, i.e. not all entrants had high productivity levels and not all firms that stopped their activities had low productivity. Entry and exit appeared to have been of only minor importance for productivity growth in the US industries that were analysed. A large part of industry-level productivity growth was explained by reallocation, i.e. increases (decreases) in the output shares of high-productivity (low-productivity) plants. Haltiwanger (1997) found that reallocation occurred in terms of productivity growth, i.e. firms with positive (negative) productivity growth gained (lost) market shares rather than in terms of productivity levels. A decomposition of productivity growth in the US telecommunications equipment industry over the period 1974-1987 by Olley and Pakes (1996) indicated that – in this specific industry – reallocation of capital (including firm entry and exit) towards more efficient firms was a more important driver of productivity growth than firm-level productivity growth.

In a survey of decomposition studies, Foster, Haltiwanger and Krizan (2001) concluded that results with respect to the impact of within-industry reallocation on industry-level productivity growth varied across studies which they explained by possible cyclical and industry-specific effects but also by

differences in the methods used to decompose productivity growth. Conclusions on the role played by firm entry and exit appear to depend on the horizon over which changes are considered. Effects of net entry appear to be more substantial in the long run than in the short run. A decomposition of TFP growth in four-digit US manufacturing industries, over the period 1977-1987, indicated that the within component (firm-level TFP growth) explained 50 up to 65% – depending on the method of decomposition – and net entry another 25% of industry-level TFP growth. The sign of the reallocation component (TFP growth due to changes in market shares of firms) was negative when using the decomposition proposed by Baily, Hulten and Campbell (1992) but positive when using the decomposition proposed by Griliches and Regev (1995). The latter method has the advantage that it considers the average over a number of years at the beginning and at the end of the period that is considered and is therefore likely less sensitive to measurement errors or cyclical effects. However, the method does not consider the interaction between firm-level TFP growth and changes in market shares, as a result of which the within component will be biased.

Altomonte (2010) decomposed labour productivity growth for four EU countries between 2000 and 2008. In France and Italy, the interaction term was negative, i.e. firms witnessing positive (negative) productivity growth lost (gained) market shares (expressed in terms of employment). In the UK, the interaction term was also negative but this effect was, in contrast with Italy and France, offset by a larger positive reallocation component. On the other hand, there was little evidence of substantial firm-level productivity growth in the UK. In Sweden, all components of TFP growth were positive. Altomonte pointed out possible conflicting policy aims, as creating jobs – in view of creating a more inclusive society – could have a negative impact on productivity growth if jobs are created in firms with low-productivity (growth). His results suggest that this could be the case for France and Italy.

Syverson (2010) reviewed firm-level studies that appeared since the survey by Bartelsman and Doms (2000). The focus of the empirical work seems to have shifted from the assessment of the strong and persistent productivity differences within industries to explanations of why firms actually differ so much. Syverson discussed differences in management practices (e.g. human resources) and quality, differences in the skills of workers or the quality (vintage) of capital goods, IT equipment and software, R&D and innovation, learning-by-doing, firm structure (e.g. degree of centralization or integration) as well as some external drivers of productivity (e.g. spillovers and competition). Although some progress has been made in explaining the substantial productivity differences between firms, Syverson concluded that more firm-level data (e.g. on management, prices and intangible capital) and more analysis are needed to provide convincing answers. He also argued that whereas micro-level data permit to tackle issues that cannot be considered when using industry-level or country-level data, there are also more measurement and data problems in measuring productivity at the firm or plant level than at higher levels of aggregation. As firm-level output is mostly deflated using industry-level deflators, potential differences in (the evolution of) output prices are ignored. If the differences in output prices of firms within the same industry reflect differences in product quality, this will rightly be reflected in productivity differences. However, if price differences result from differences in the market power of firms or differences in products (markets), firm-level TFP will be a biased indicator of technological efficiency.

In this paper Belgian firm-level data on 12 manufacturing industries are used to decompose industry-level TFP growth over the period 2000-2008 into five components, a component reflecting overall changes in technological efficiency, a component reflecting the impact of changes in market shares of individual firms, an interaction term and finally two components reflecting the impact of respectively firm entry and firm exit.

Section 2 describes the two alternative TFP measures that have been used in the analysis. Section 3 discusses the procedure to decompose industry-level TFP into five components. In section 4.1 the firm-level data used for the decomposition are described and section 4.2 reports the results of the decomposition of TFP growth. Section 5 provides some conclusions.

## 2. Total factor productivity

Total factor productivity growth is defined as the residual of output growth after accounting for changes in the inputs that are used in production. Although due to measurement errors, aggregation and misspecification bias caution is warranted, TFP growth is generally considered to provide a reasonable measure of technological change (see e.g. Hulten 2000, 2009).

Several alternative methods can be used to compute or estimate TFP at the firm level. All methods are known to have advantages as well as drawbacks and no single method appears to dominate under all circumstances (e.g. Van Biesebroeck 2007, Martin 2008 and Basu et al. 2009). In this paper, two alternative TFP measures are considered, one derived from computation using the index approach and one that results from Ordinary Least Squares (OLS) estimation of a production function

Following Good, Ishaq Nadiri and Sickles (1996) firm-level productivity, relative to a representative firm, can be computed using an index approach:

$$\begin{aligned} \text{TFP}_{it} = & \left[ (y_{it} - y_t^*) + \sum_{s=2}^t (y_s^* - y_{s-1}^*) \right] \\ & - \left[ \frac{1}{2} \sum_{j=1}^n (S_{ijt} + S_{jt}^*) (x_{ijt} - x_{jt}^*) + \frac{1}{2} \sum_{j=1}^n \sum_{s=2}^t (S_{j,s}^* + S_{j,s-1}^*) (x_{j,s}^* - x_{j,s-1}^*) \right] \end{aligned} \quad (1)$$

Value added (in logs) of firm  $i$  in period  $t$  is denoted by  $y_{it}$ ,  $S$  is the share of each of the  $n$  production factors in total costs and  $x_{ijt}$  the log of the quantity of factor  $j$  used in the production of firm  $i$  in period  $t$ . The superscript  $*$  refers to the representative firm (e.g.  $y^*$  is the log output of the representative firm). Caves, Christensen and Tretheway (1983) argued for the use of the industry mean of each variable as the value for the representative firms. The index contains a component reflecting the change in TFP of a firm relative to the productivity of the representative firm (i.e. efficiency) and a component reflecting the evolution in the productivity of the representative firm over time (technological change). Van Biesebroeck (2007) compared the robustness of the index approach to alternative methods such as production function estimation and data envelopment analysis when accounting for heterogeneity in factor prices (wages) and optimization error, measurement error and heterogeneity in production technology. When the assumption of a common production technology for all firms is relaxed, the index approach outperforms the other methods.

The rather straightforward computation of productivity using the index approach appears to result in reliable estimates unless measurement errors are substantial. As the latter may indeed be the case for firm-level data, firm-level TFP resulting from Ordinary Least Squares (OLS) estimation of a Cobb-Douglas production function has been used to check the robustness of the results of the analysis based on the index-based TFP measure:

$$y_{it} = \alpha^L l_{it} + \alpha^K k_{it} + \sum_{i=2}^T \alpha_i D_i + \varepsilon_{it} \quad \theta = \widehat{\alpha^L} + \widehat{\alpha^K} \quad (2)$$

$$\rightarrow \text{TFP}_{it} = \sum_{i=2}^t \alpha_i D_i + \varepsilon_{it}$$

Where  $l_{it}$  and  $k_{it}$  are the logs of labour and capital input respectively and  $D_t$  are year dummies. The latter reflect the industry average efficiency level in a given year. The sum of the year dummies up a given year and the firm-specific residual provide the firm-level TFP. The advantage of the estimation is that  $\theta$ , the degree of returns to scale, is not imposed to be constant. In the computation of a TFP index the share of capital is mostly simply considered as 1 minus the share of labour, which imposes constant returns to scale. As a result index-based TFP may mistake increasing returns to scale for technological efficiency.

### 3. Decomposition of total factor productivity

Using the computed or estimated TFP levels of individual firms, industry-level TFP can be decomposed<sup>1</sup>. Foster, Haltiwanger and Krizan (2001) proposed a decomposition of the TFP growth for a given industry  $i$  into five components:

$$\begin{aligned} \Delta TFP_{i,t} = & \sum_{g \in G} \Delta TFP_{ig} S_{ig,t-1} + \sum_{g \in G} (TFP_{ig,t-1} - TFP_{i,t-1}) \Delta S_{ig,t} + \sum_{g \in G} \Delta TFP_{ig,t} \Delta S_{ig,t} \\ & + \sum_{n \in N} (TFP_{in,t} - TFP_{i,t-1}) S_{in,t} - \sum_{s \in S} (TFP_{is,t-1} - TFP_{i,t-1}) S_{is,t-1} \end{aligned} \quad (3)$$

The first component is the sum - for each firm of the group of incumbents (existing firms)  $G$  that are active in industry  $i$ - of TFP growth multiplied by the given firm's market share  $S$  (in terms of output or value added) in year  $t-1$ , i.e. without taking into account changes in market shares. The second term is the sum of the product of the change in the market share of each incumbent firm and the gap of that firm's TFP with respect to the mean TFP level in the industry ( $TFP_i$ ) in the previous year, i.e. not accounting for changes in efficiency. The third term is the sum of the interaction of changes in TFP with changes in market shares. It will be positive if incumbents with positive (negative) TFP growth increase (decrease) their market share and negative if TFP growth and market share growth have the opposite sign. The fourth component considers the impact of all firms that entered the industry (group  $N$ ), i.e. the sum of the gap of each entrant's TFP with respect to the mean TFP in the industry multiplied with the entrant's market share (in year  $t$ ). The final component reflects the effect of firms that left the industry (group  $S$ ), i.e. the sum of the TFP gap of a firm that leaves the industry multiplied with its market share (both obviously in the year before the firm left the industry). The last component is included with a negative sign as the effect of a firm that leaves the industry on industry-level TFP growth is negative (positive) if its TFP was above (below) the industry mean in the year prior to its exit. Foster, Haltiwanger and Krizan (2001) discuss some alternative procedures to decompose productivity growth. As mentioned in the introduction, using averages of the variables over a number of years at the beginning and at the end of the period that is considered, has the advantage that it is likely more robust to measurement errors but has the disadvantage that the within-industry effect and the interaction effect (respectively the first and the third term in equation 2) cannot be distinguished. Equation 2 has been used to decompose Belgian industry-level TFP growth.

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<sup>1</sup> The decomposition actually consists in the aggregation of the different components for individual firms.



## 4. Empirical analysis

In section 4.1 we describe the firm-level data that have been used and provide a first descriptive analysis of the evolution and distribution of TFP. In Section 4.2 the results of the decomposition of industry-level TFP growth between 2000 and 2008 are reported for 12 manufacturing industries.

### 4.1. Data sources and descriptive analysis

The firm-level data used in our analysis were retrieved from the BELFIRST database (Bureau Van Dijk Electronic Publishing), which contains detailed information (e.g. annual accounts and balance sheet) on companies that are incorporated under Belgian law with an obligation to deposit an annual account (complete scheme or abbreviated scheme for small firms)<sup>2</sup>. The edition of BELFIRST used in our analysis provided data over the period 2000-2008. Data on value added, the capital stock (total fixed assets) and labour (total hours worked) were used to compute firm-level TFP with the index approach (equation 1) and alternatively to derive TFP from an Ordinary Least squares (OLS) estimation of a production function. The TFP measure is therefore based on value added and not on output (turnover). TFP based on gross output (turnover) also considers the effects of intermediate input factors (e.g. energy and materials) on technological efficiency but such a measure was not considered as this would reduce considerably the number of observations due to missing values for turnover and intermediate inputs (e.g. for small firms). Data were retrieved for 13 manufacturing industries. Table 1 shows the list of the industries that were considered with their respective classification code (NACE BEL-2008), the number of firms and TFP growth between 2000 and 2008, computed (index) and estimated (OLS).

Table 1 List of manufacturing industries

NACE BEL (2008)	INDUSTRY	Number of firms	TFP growth 2000-2008 (Index)	TFP growth 2000-2008 (OLS)
10-12	FOOD, BEVERAGES AND TOBACCO	1092	0.27	0.17
13-15	TEXTILES, LEATHER AND FOOTWEAR	498	0.66	0.37
16	WOOD AND CORK	313	0.43	0.04
17-18	PULP, PAPER, PRINTING AND PUBLISHING	607	0.16	0.37
19	COKE, REFINED PETROLEUM AND NUCLEAR FUEL	19	0.34	2.51
20-21	CHEMICAL PRODUCTS	349	0.12	0.04
22	RUBBER AND PLASTICS	275	0.58	0.45
23	OTHER NON-METALLIC MINERAL PRODUCTS	441	0.06	0.01
24-25	BASIC METALS AND FABRICATED METAL PRODUCTS	1528	-0.04	-0.02
26-27	ELECTRICAL AND OPTICAL EQUIPMENT	378	0.14	0.46
28	MACHINERY N.E.C. (NOT ELSEWHERE CLASSIFIED)	502	0.32	0.18
29-30	TRANSPORT EQUIPMENT	139	0.02	0.02
31-32	MANUFACTURING N.E.C. AND RECYCLING	329	-0.03	-0.07

<sup>2</sup> All companies operating under Belgian law have to deposit an annual account. Small firms (defined by thresholds of number of employees, turnover and total assets) can deposit an account in abbreviated form, which for instance implies that they do not have to report their turnover.

As data on value added and capital are expressed in current prices in the BELFIRST database, they have been deflated using NACE two-digit industry deflators from Belgian National accounts data. To avoid a bias due to outliers, observations for TFP that lie outside the range of the median plus or minus three times the inter-quartile range have been excluded from the analysis, i.e. a rather conservative exclusion of outliers (although extreme values are clearly due to measurement errors and misclassification, entrants may witness strong growth and these should preferably not be considered as outliers).

Figure 1 shows the evolution of computed TFP (Index) and estimated TFP (OLS) over the period 2000-2008 (the level in benchmark year 2000 set at 1) for each of the 13 manufacturing industries. The two alternative measures result in rather similar trends in most industries although at the end of the period the patterns diverge in some industries, with highly improbable changes in the estimated OLS in industry 16 (Wood and cork) and in the TFP (index and OLS) in industry 19 (Coke, refined petroleum and nuclear fuel). In a number of industries TFP appears to have dropped substantially in 2008, e.g. industry 24-25 (basic metals and fabricated metal products). This may be explained by the fact that Belgian companies, in the wake of the global recession, more generally than in other OECD countries retained their employees in response to falling demand, probably due to government-supported short-time work schemes (see OECD 2010). Total factor productivity is known to behave pro-cyclically as a result of changes in capacity utilization or labour hoarding, i.e. firms retain workers given their valuable skills or due to high severance indemnities even as sales growth slows down in times of economic recession (Hulten 2000, Rotemberg and Summers 1990 and Wen 2004).

Figure 2 shows the distribution of computed firm-level TFP (index) and estimated firm-level TFP (OLS), after exclusion of outliers, for each of the 13 manufacturing industries for the year 2008 relative to the 2000 level. The distribution results from a non-parametric (kernel) estimation (kdensity procedure in STATA). With some exceptions, notably industry 19 (Coke, refined petroleum and nuclear fuel), the distribution of computed TFP and estimated TFP is fairly similar. The distribution based on computed TFP appears to be more evenly spread (e.g. smaller peak) than the distribution based on estimated TFP, which may be explained by the fact that the latter takes into account non-constant returns to scale and thereby results in a more pronounced distinction in terms of technological efficiency.<sup>3</sup> In line with previous empirical studies, the figure reveals enormous differences in TFP across firms within the same industry. A reasonable share of firms witnessed a decrease in their productivity level between 2000 and 2008 (ratio smaller than 1). Del Gatto, Mion and Ottaviano (2006) and Mayer and Ottaviano (2008) argued that the distribution of productivity within industries can be approximated rather well by a Pareto distribution. Figure 2 shows that in most industries the bulk of firms can be found at the left side of the distribution whereas the long right tail indicates that a relatively small number of firms have productivity well above the industry average. It is clear that TFP is certainly not normally distributed between firms in the same industry.

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<sup>3</sup> The OLS estimates of the scale elasticity suggest increasing returns to scale in most industries.

**Figure 1 Evolution of industry-level TFP (OLS and Index) over the period 2000-2008**  
*Benchmark year 2000= 1*

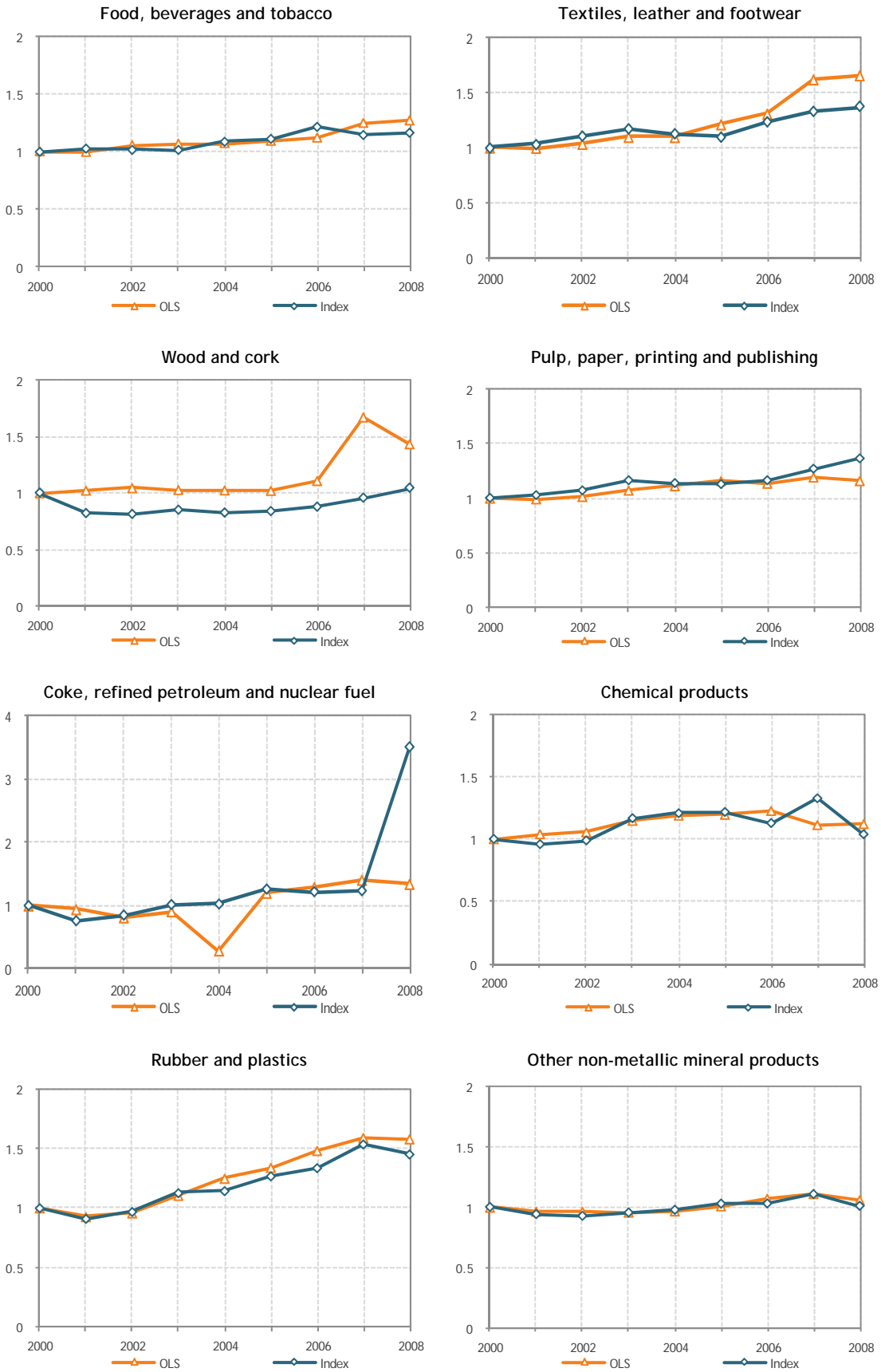
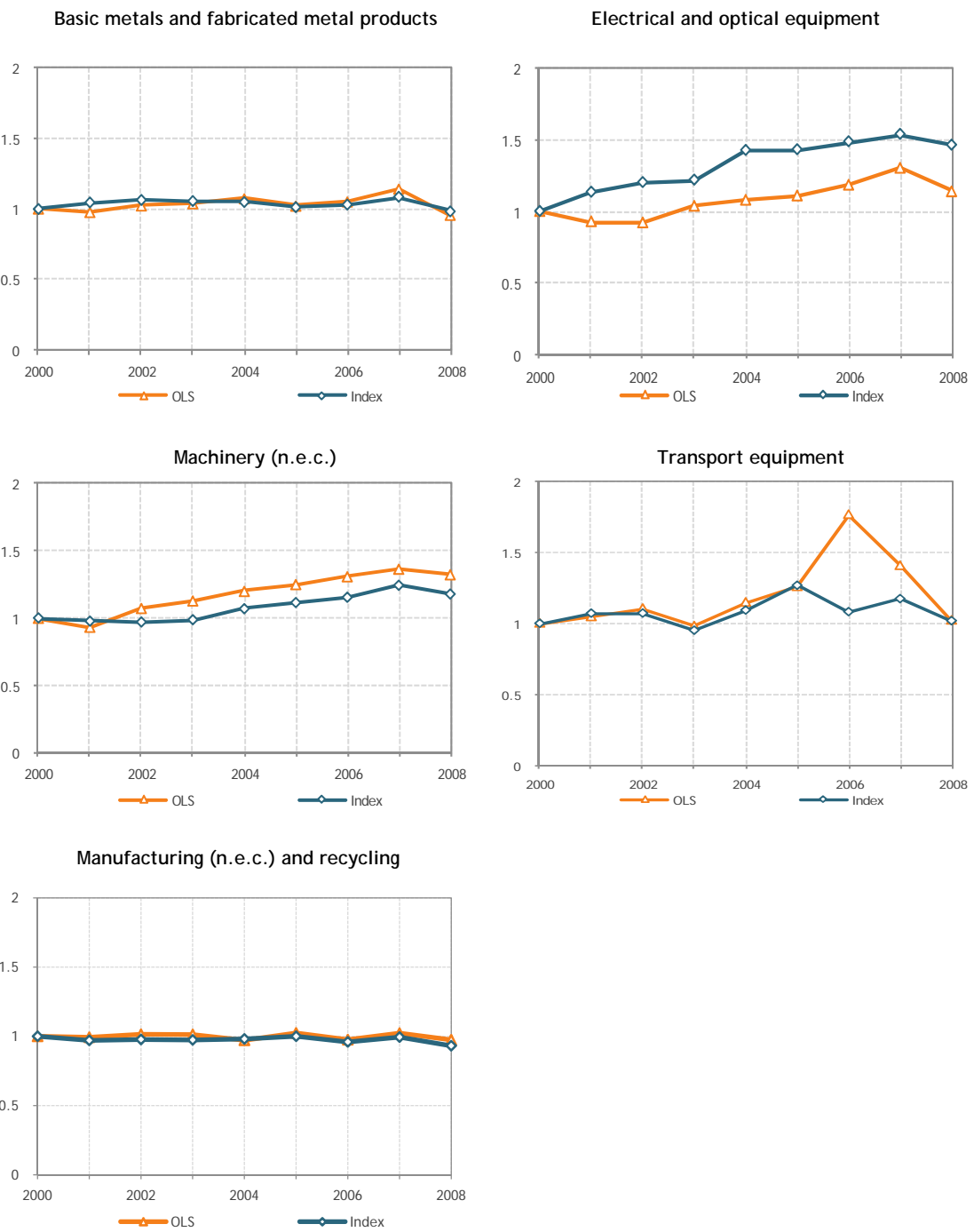


Figure 1 continued



Note: The figure shows the evolution in the levels of computed TFP (Index) and estimated TFP (OLS) for 13 manufacturing industries. For both TFP measures the level is set to 1 in 2000.

Figure 2 Distribution of TFP (OLS and Index) for 13 manufacturing industries  
2008

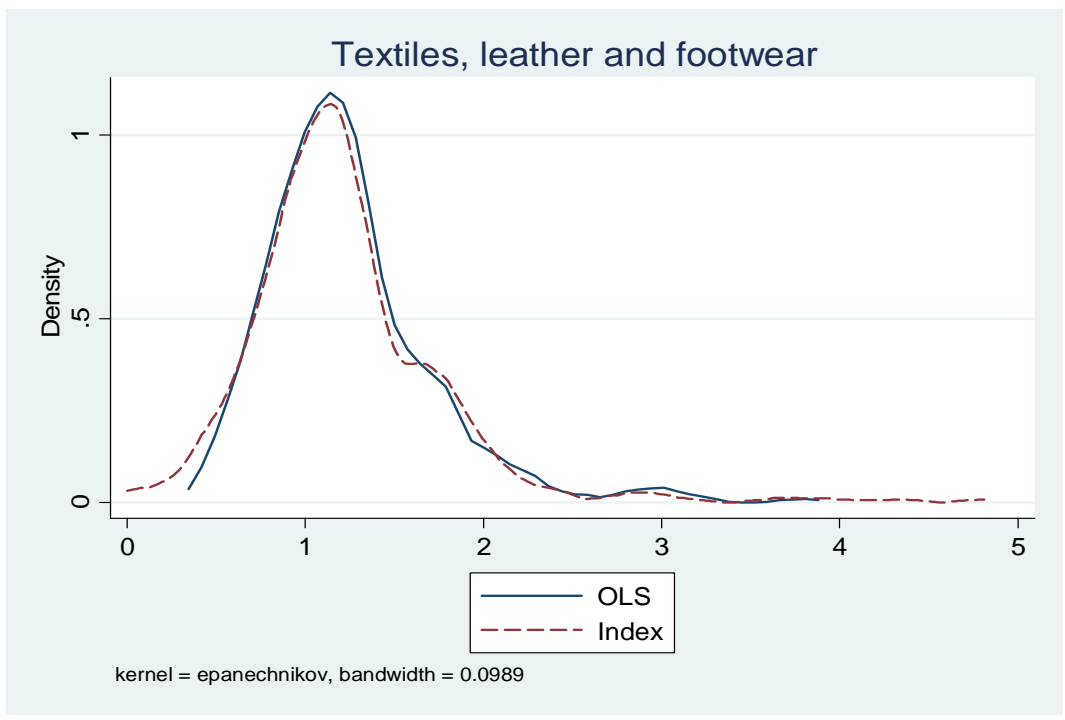
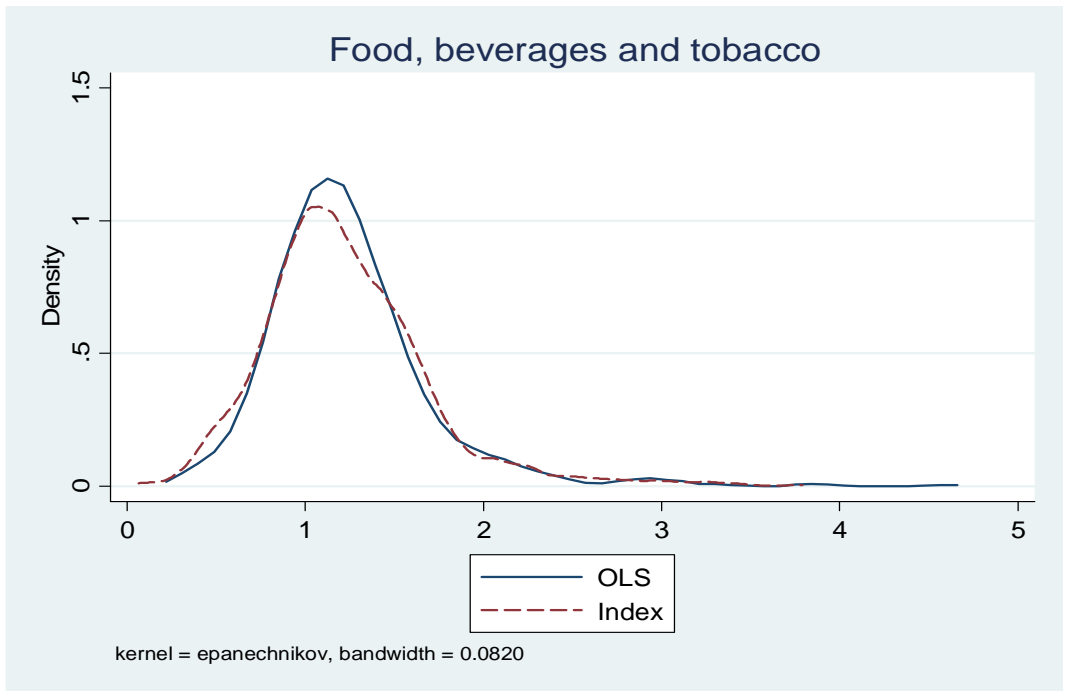


Figure 2 continued

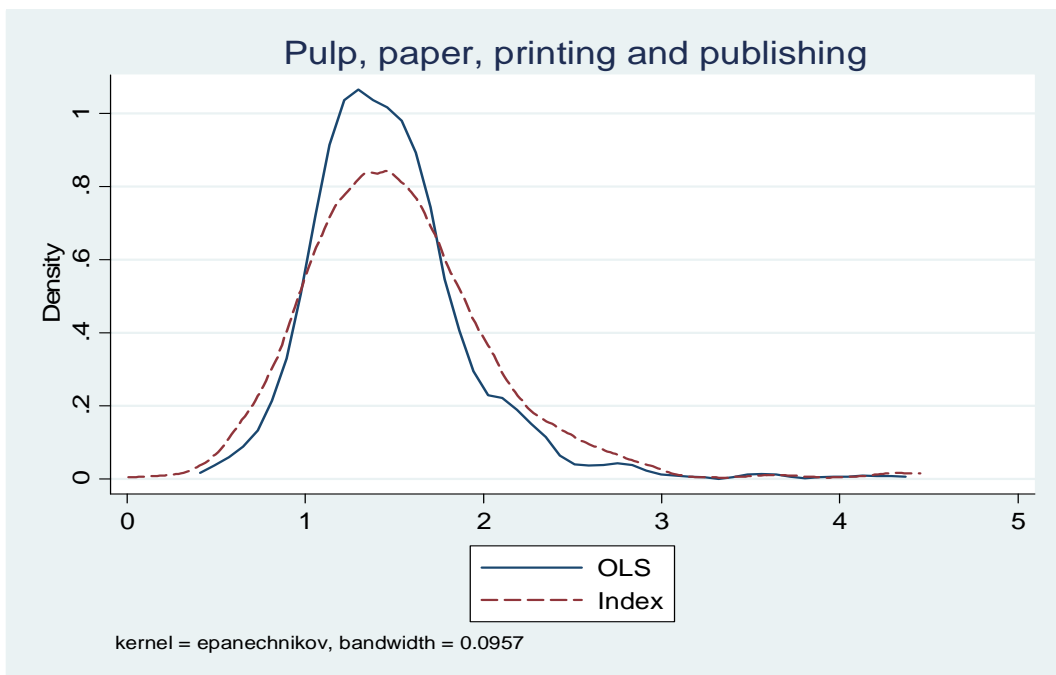
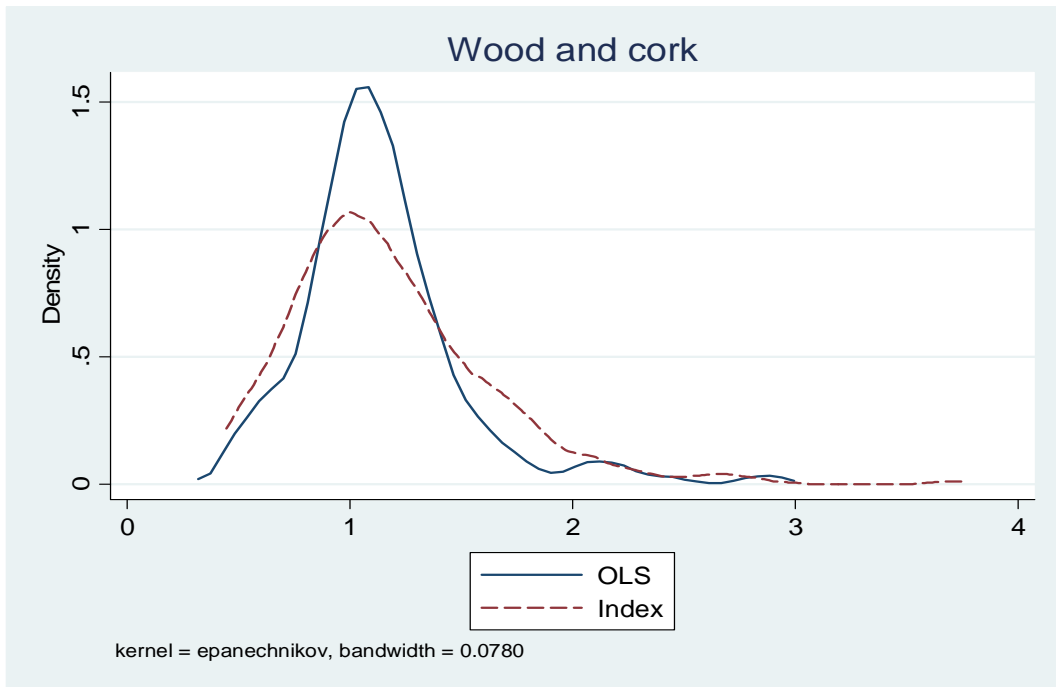


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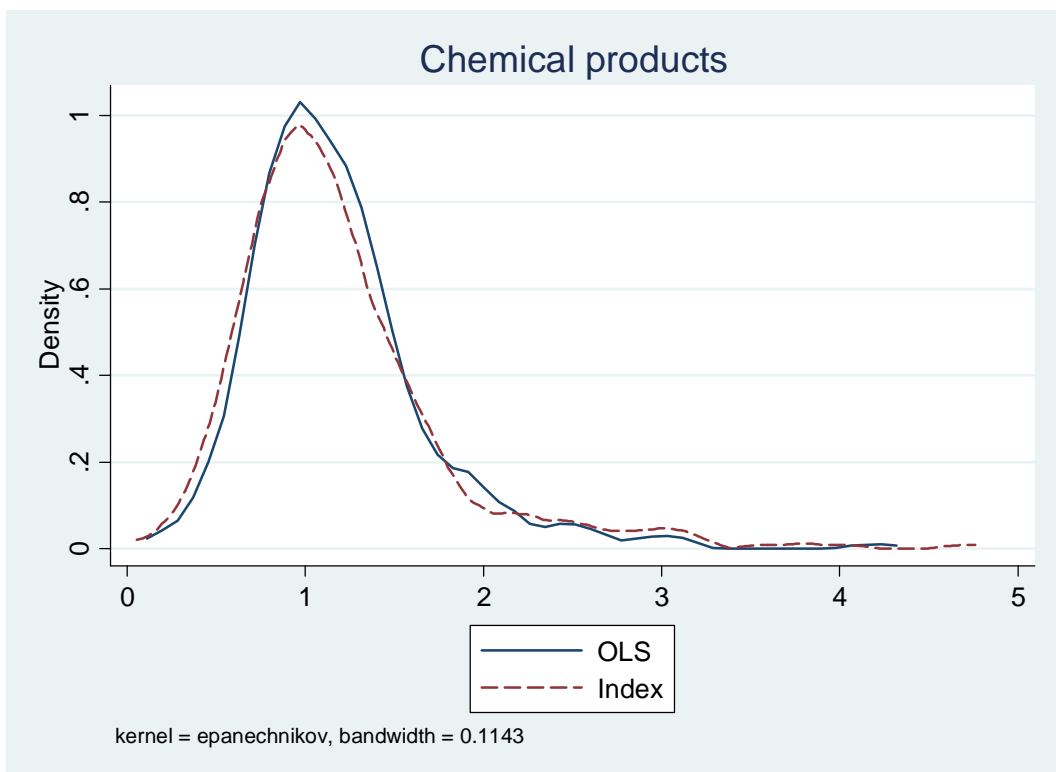
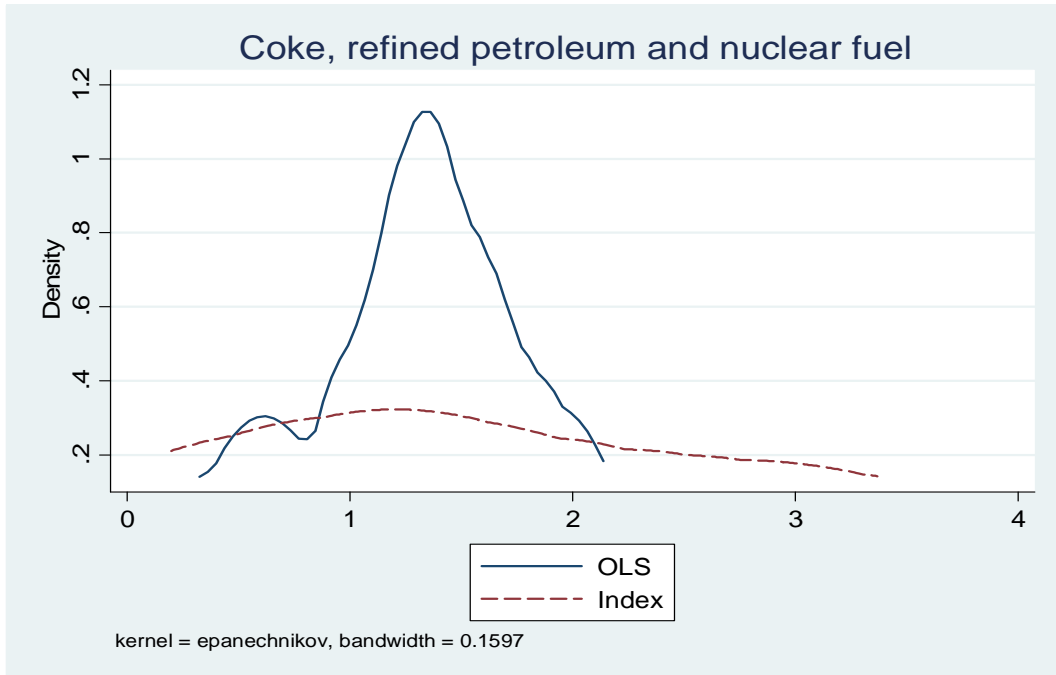


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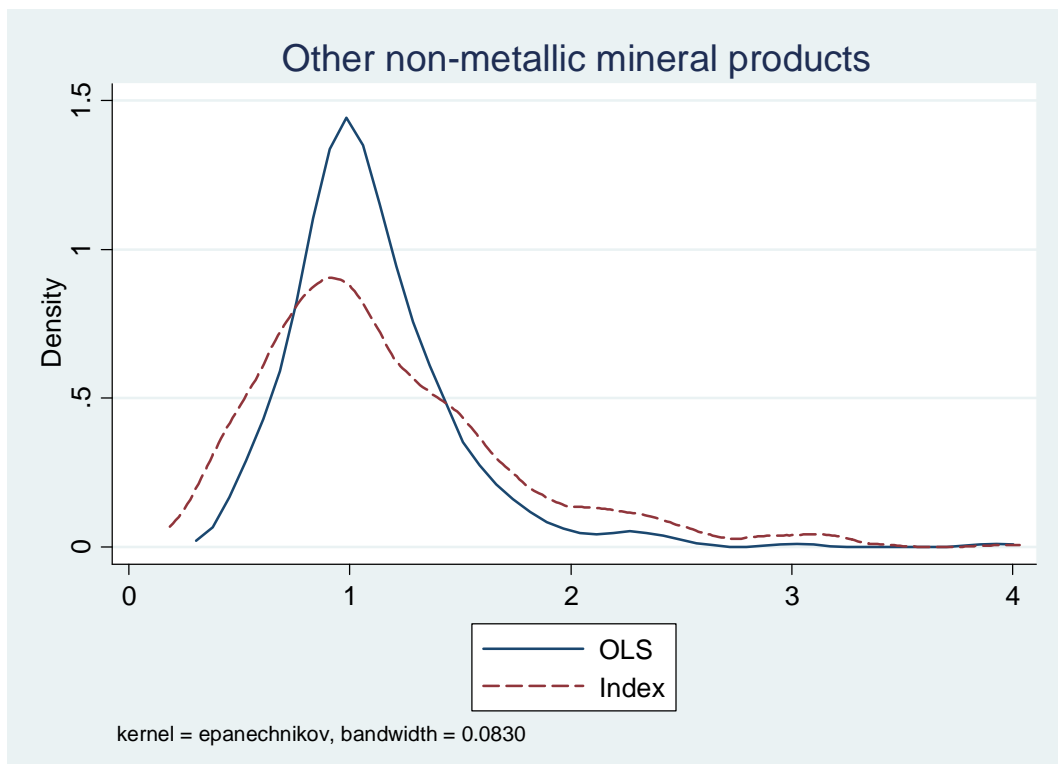
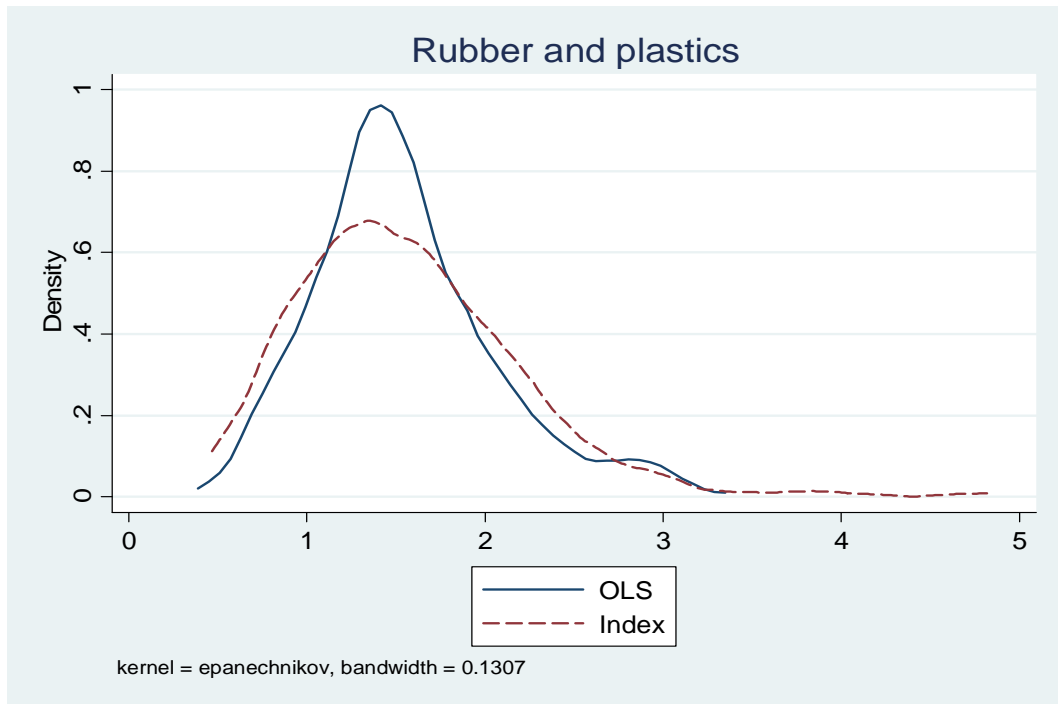




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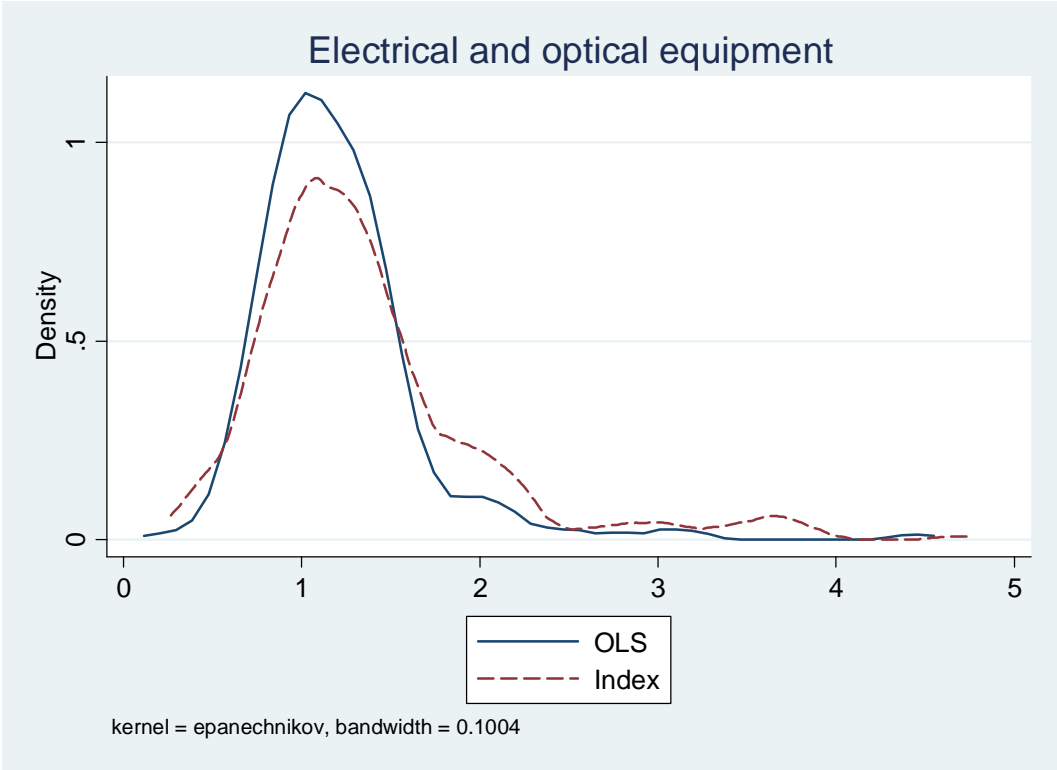
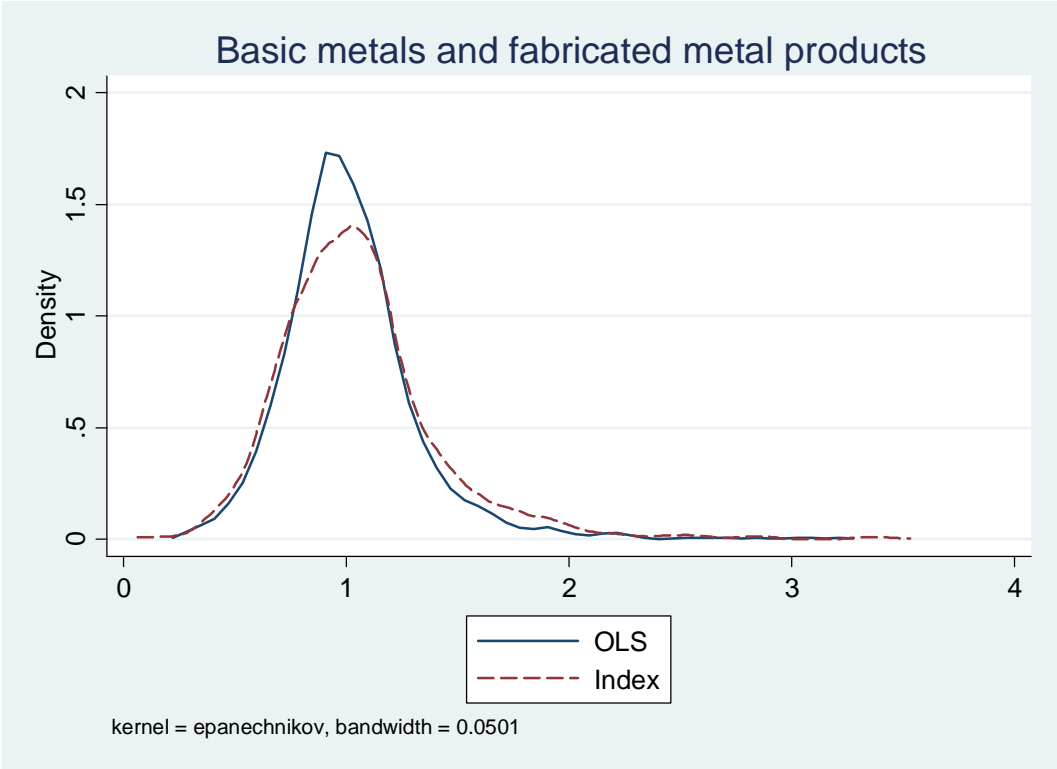


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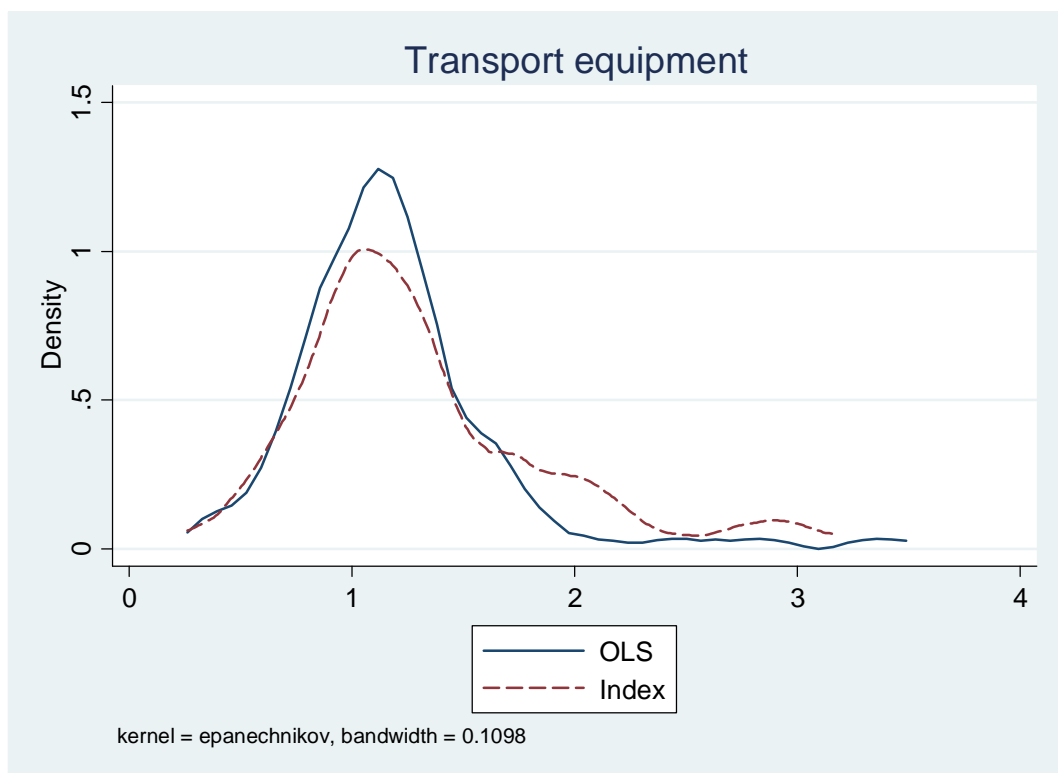
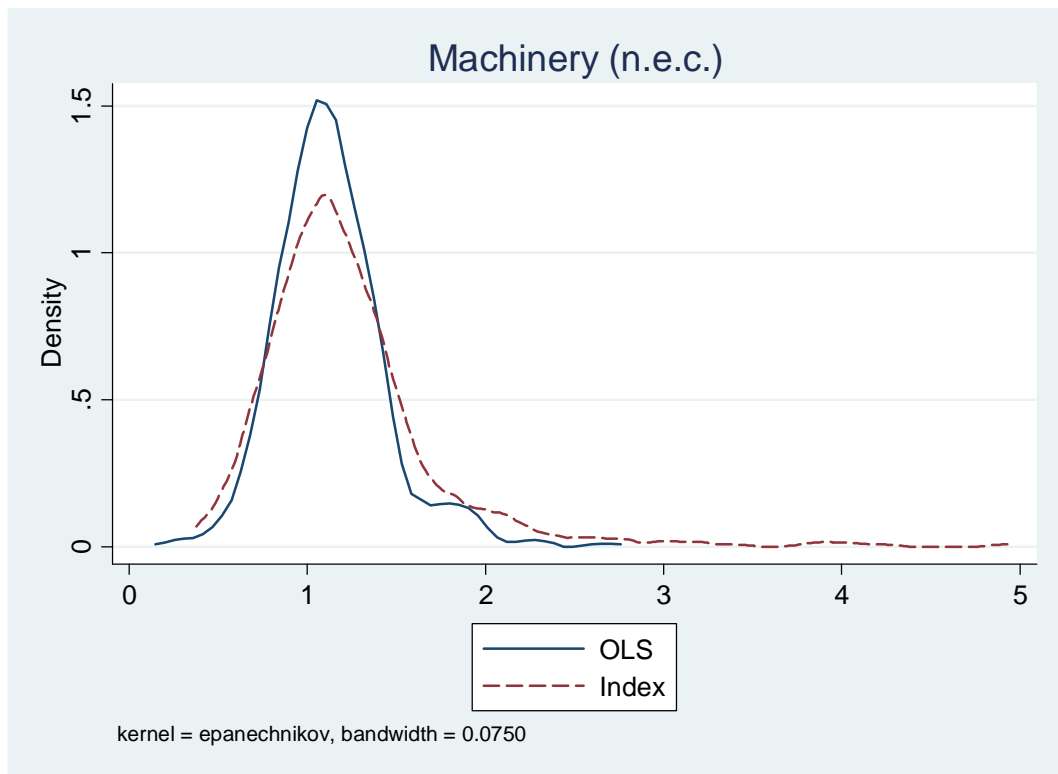
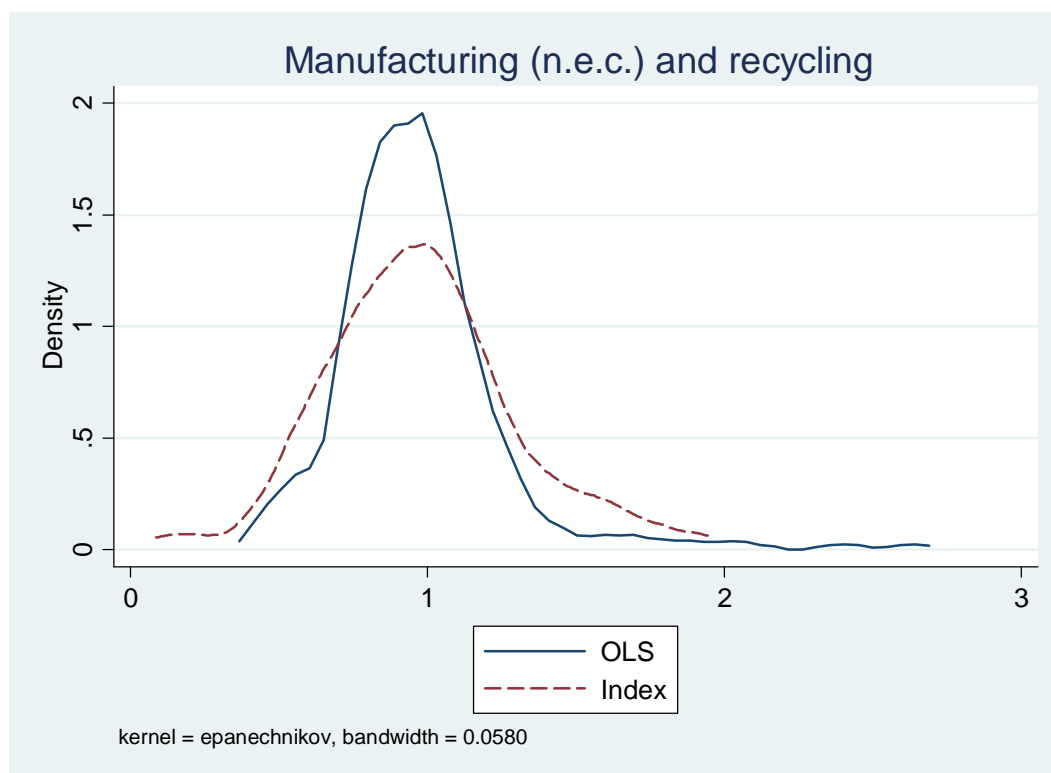


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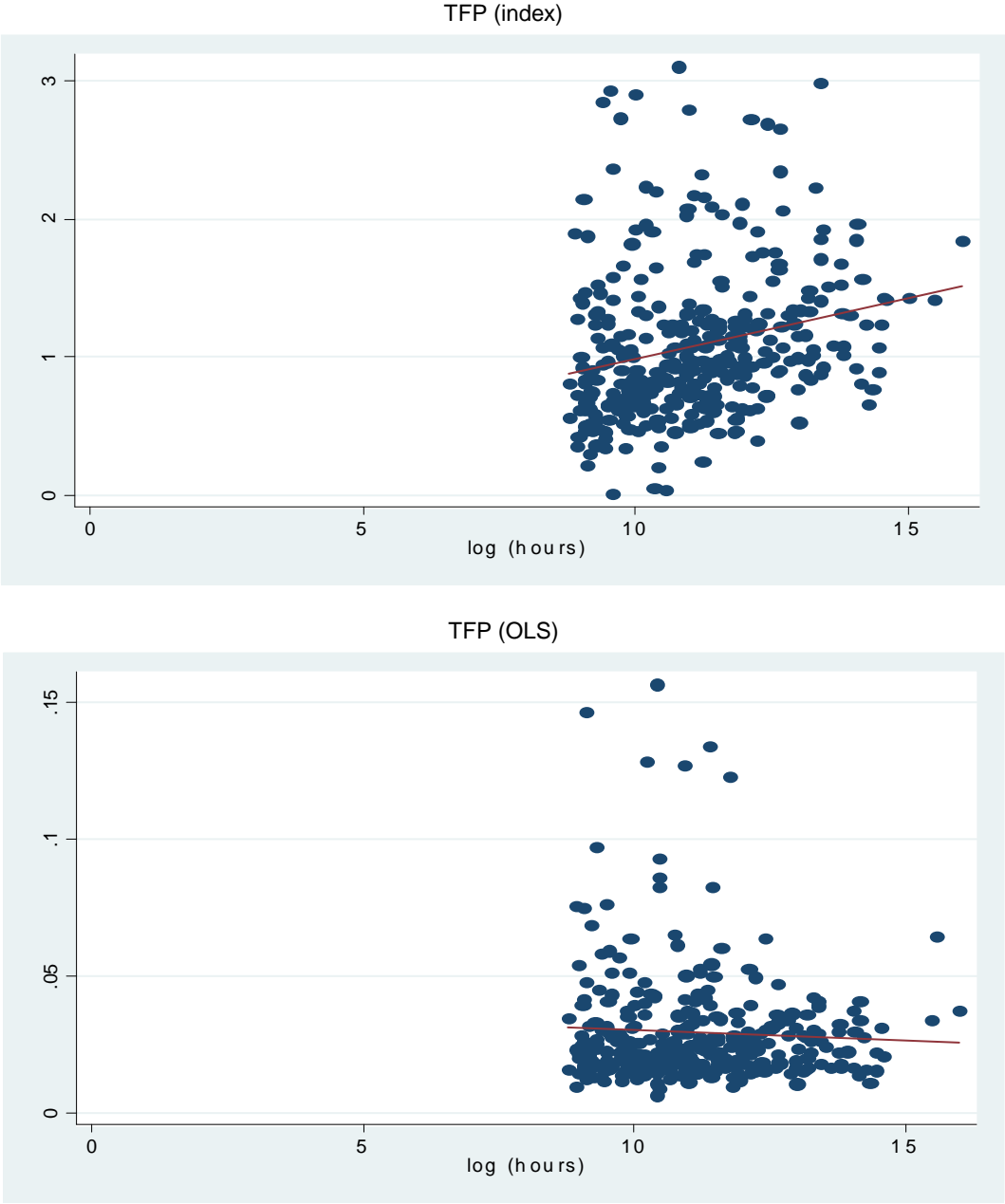


Note: The kernel density plot provides a non-parametric estimate of the underlying density function of firm-level TFP in the given industry (using the STATA procedure `kdensity`). The continuous line shows TFP resulting from Ordinary Least Squares estimation of a production function and the dashed line shows TFP computed with the index formula (equation 1). See table 1 on page 7 for full description of the industries.

Figure 3 compares the link between firm-level TFP and firm size (hours worked) in industry 20-21 (chemical products), between computed TFP (index) and estimated TFP (OLS). Computed TFP suggests a (statistically significant) positive link between TFP and firm size but there is no statistically significant link when considering estimated TFP (the pattern is similar in other industries). This seems to indicate that estimated TFP accounts for returns to scale whereas the TFP index does not. The latter TFP measure – to some extent- appears to mistake returns to scale (i.e. allocation efficiency) for technological efficiency. On the other hand, the estimation of a production function imposes a common technology on all firms within a given industry. As the estimation requires a sufficiently large number of observations, the level of industry aggregation is often rather high and the assumption of common production technology therefore untenable.

Figure 4 shows the distribution of TFP for the four largest subsectors in three large industries, i.e. *food, beverages and tobacco*; *chemical products* and *basic metals and fabricated metal products*, both for computed TFP (index) and estimated TFP (OLS). There are substantial differences between subsectors within the same aggregate industry, most notably in *food, beverages and tobacco* and *chemical products*. At least for these industries the assumption of a common technology seems rather problematic. The figure also shows that the dispersion in productivity between firms in the same industry is not an artefact of industry aggregation as the differences do not disappear at lower levels of aggregation.

Figure 3 Link between firm size (number of hours worked) and TFP in chemicals  
2008



Note: The levels of computed TFP (Index) and estimated TFP (OLS) are not reflected in relative terms in the figure and can therefore not be compared.

Figure 4 TFP distribution (2008) for the four largest subsectors in three large industries  
2008

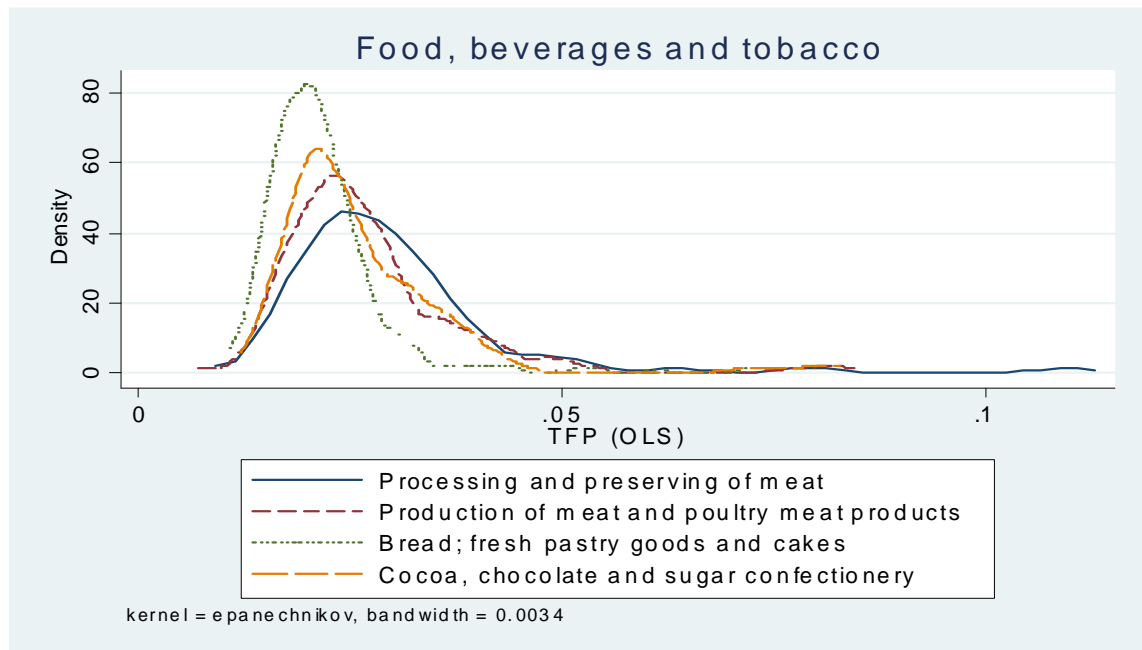
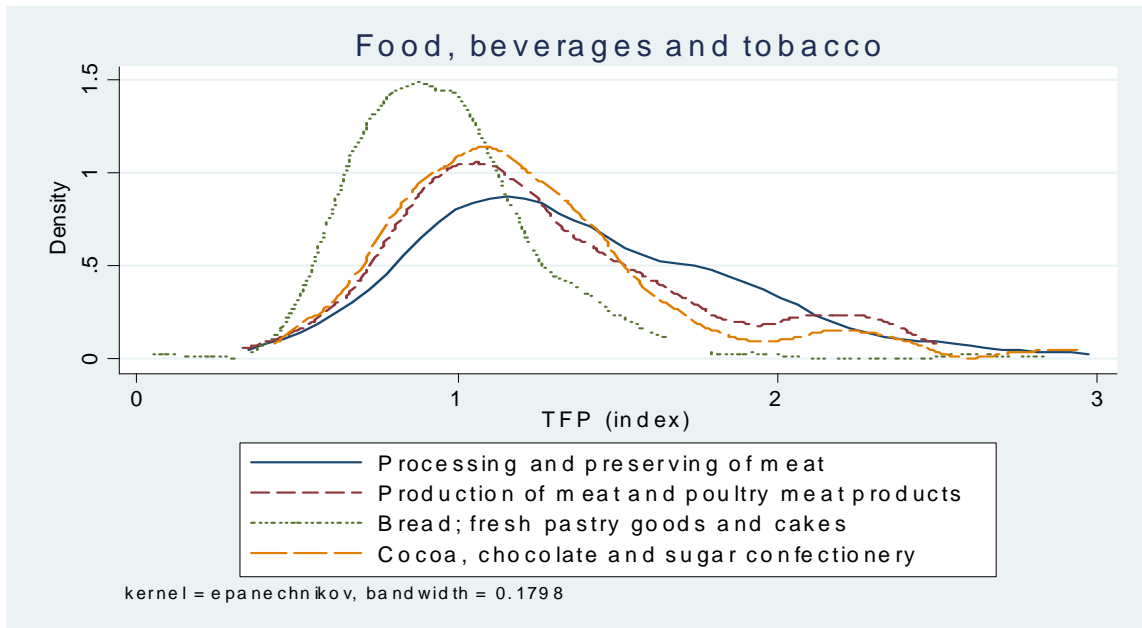


Figure 4 continued

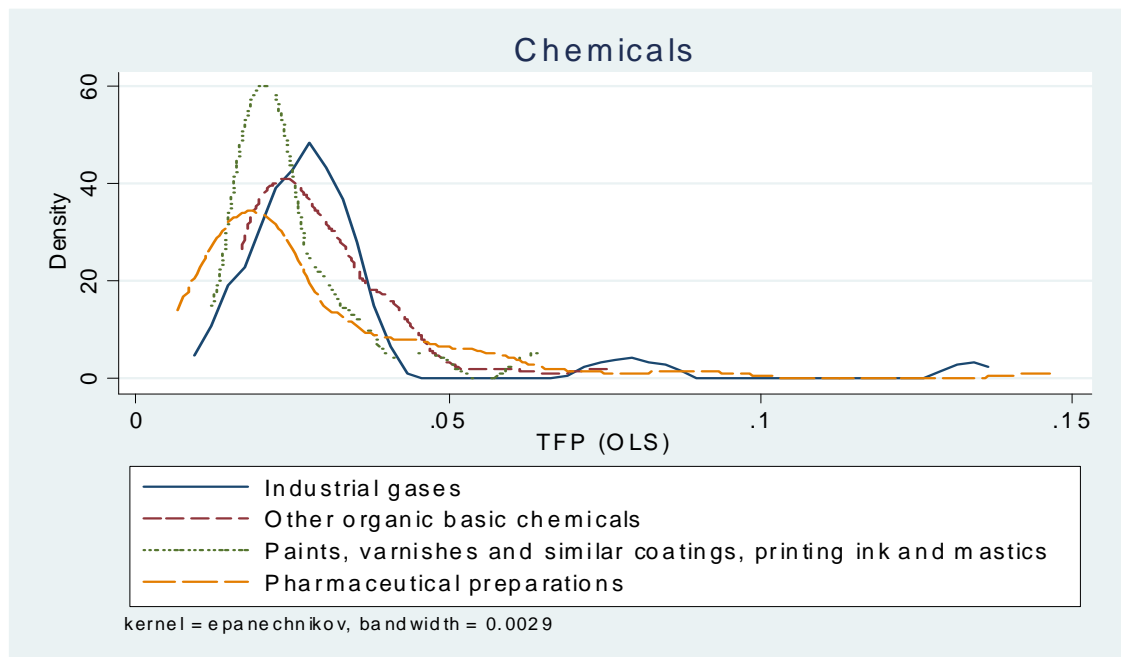
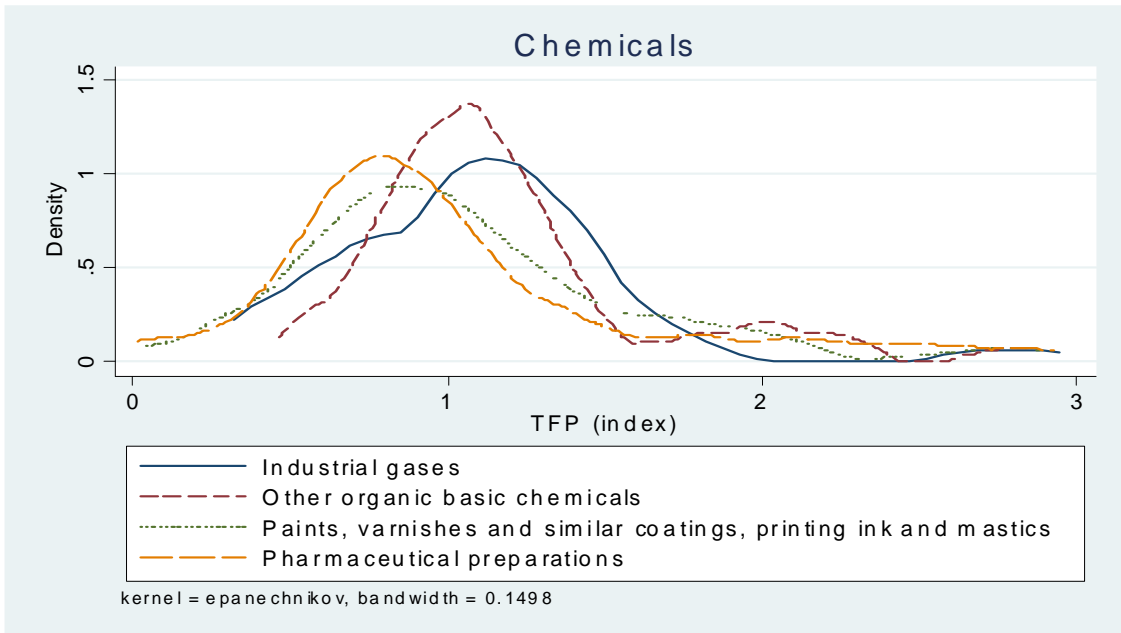
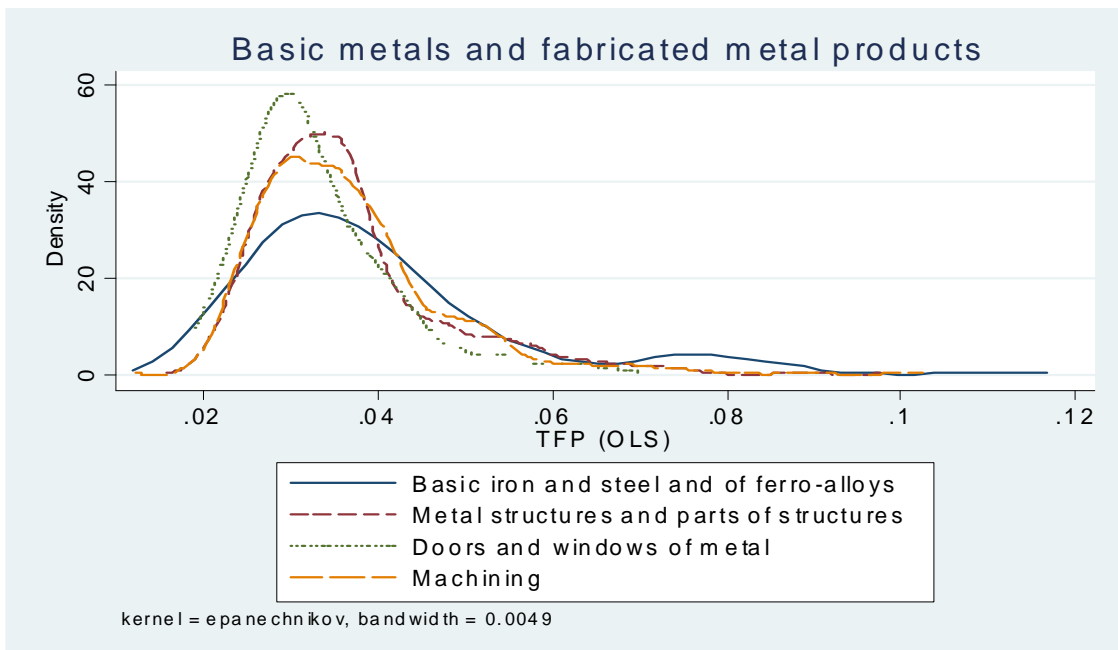
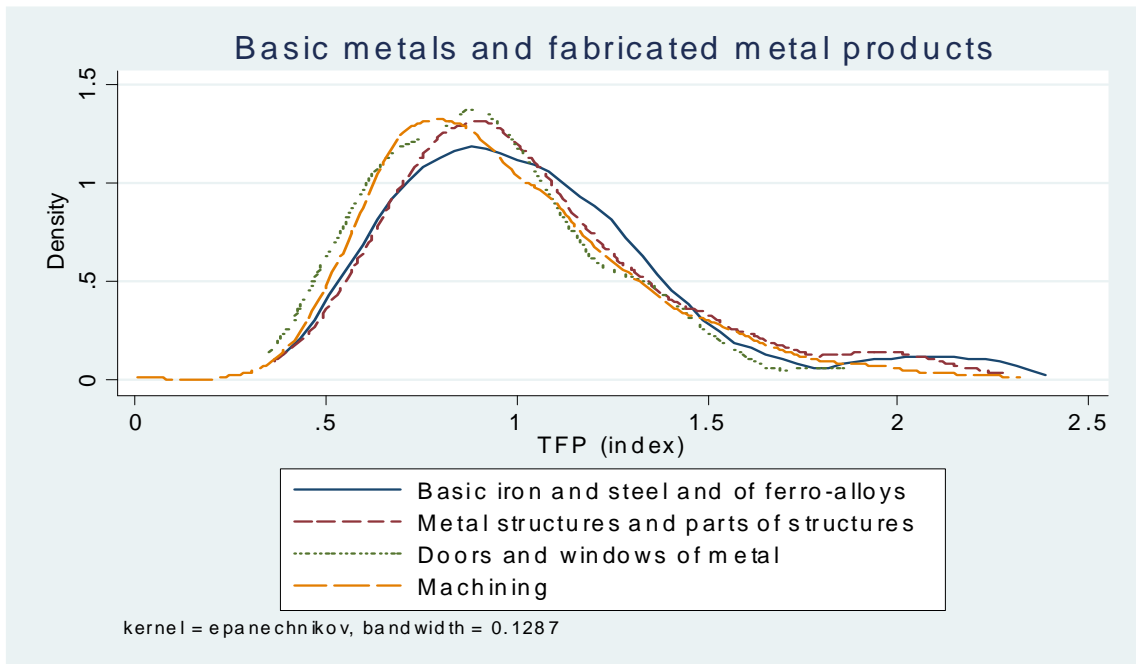


Figure 4 continued



This result is in line with previous findings of large heterogeneity between firms in the same industry, even at low levels of aggregation (e.g. Bartelsman and Doms 2000). Figure 4 also confirms the possible bias in computed TFP due to potential increasing returns to scale. Whereas, according to computed TFP, a number of firms in *cocoa, chocolate and sugar confectionery* appear to be at the top of the TFP distribution in *food, beverages and tobacco*, they are not according to estimated TFP, which accounts for non-constant returns to scale. The same pattern is found for the subsector *other organic basic chemicals* in *chemical products*. Both subsectors are the most capital intensive subsector in their respective industries. Figure 4 again appears to indicate that computed TFP tends to mistake allocation efficiency (increasing returns to scale) for technological efficiency. Accounting for increasing returns to scale, estimated TFP (OLS) results in a more pronounced distinction of the most efficient firms, as reflected in the long right tail of the TFP distribution. As computed TFP is more appropriate when a common production technology is not likely, there is a trade-off between computed and estimated TFP according to the importance of within-industry heterogeneity on the one hand and returns to scale on the other hand. Testing the robustness of the decomposition to the use of both alternative TFP measures therefore seems warranted. Analysis at a lower level of aggregation than the two-digit NACE is in many industries not very meaningful given the rather small number of firms in subsectors.

Figure 5 shows the TFP (index) distribution by industry for incumbents (firms established before 2000), firms that entered the industry after 2000 and firms that left the industry between 2000 and 2008. There are substantial differences across manufacturing industries in the ranking of TFP between the three groups of firms. Given the small number of observations and the odd evolution and distribution of TFP, as shown in figures 1 and 2, industry 19 (coke, refined petroleum and nuclear fuel) has not been considered for further analysis. In industries 10-12 (food, beverages and tobacco), 16 (wood and cork), 17-18 (pulp, paper, printing and publishing) and 20-21 (chemical products), the incumbents appear technologically more efficient than entrants and much more efficient (prior to exit) than firms that left the industry. In industries 13-15 (textiles, leather and footwear), 22 (rubber and plastics), 26-27 (electrical and optical equipment) and 28 (machinery n.e.c.), the firms that left the industry were less efficient (prior to exit) than incumbents and entrants but there was no clear distinction between the latter two groups. In industries 23 (other non-metallic mineral products) and 24-25 (basic metals and fabricated metal products) there was no clear distinction between entrants and firms that left the industry but both groups were less efficient than the incumbents although in industry 24-25 the right tail of the TFP distribution of entrants was close to the right tail of incumbent firms. In industry 31-32 (manufacturing n.e.c and recycling) firms that left the industries appeared to have been more efficient prior to their exit than incumbent firms and entrants.

Baily, Hulten and Campbell (1992) pointed out the high persistence in productivity differences between firms in the same industry. Table 2 reports transition matrices for 12 manufacturing industries (leaving out industry 19). The transition matrices show the probability of a firm moving between quartiles of the TFP (index) distribution<sup>4</sup>, using the Belgian firm-level data over the period 2000-2008.

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<sup>4</sup> Quartiles result from a split into four parts of the distribution, i.e. the first quartile of the TFP distribution contains the 25% of the firms with the lowest TFP levels and the fourth quartile the 25% of firms with the highest TFP.



Figure 5 Distribution of TFP (index) broken down by incumbents, entrants and firms that exited the industry

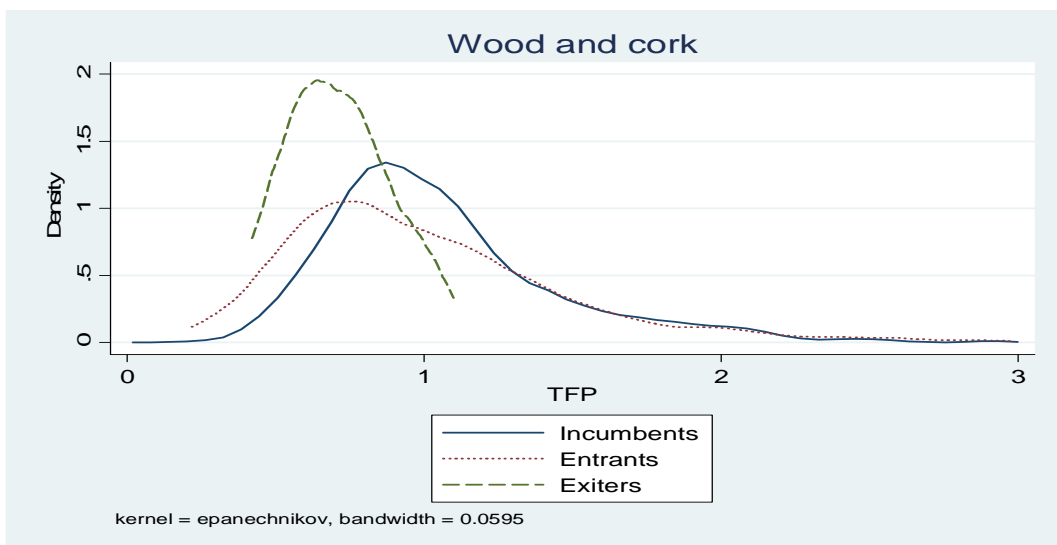
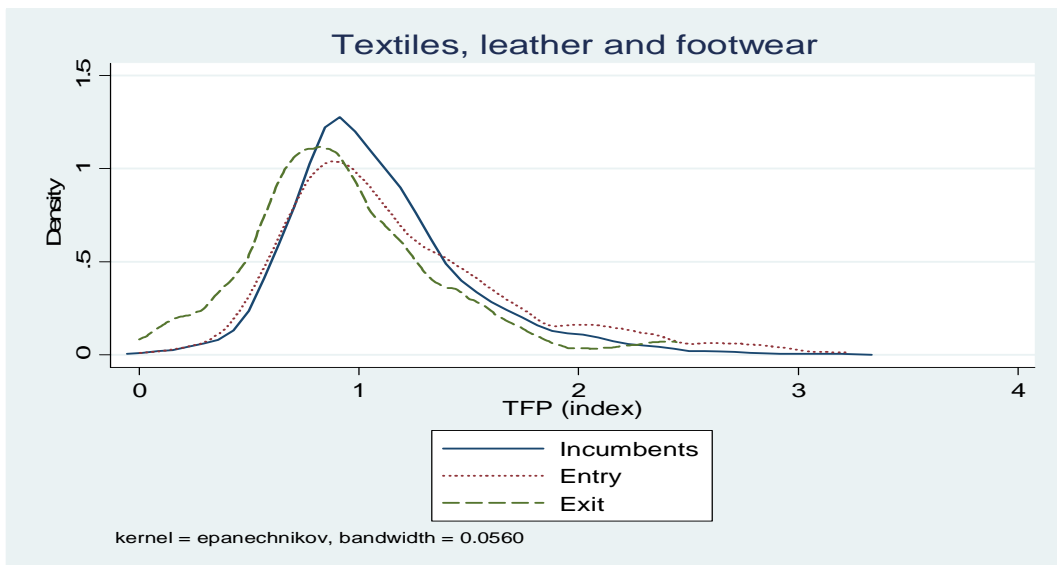
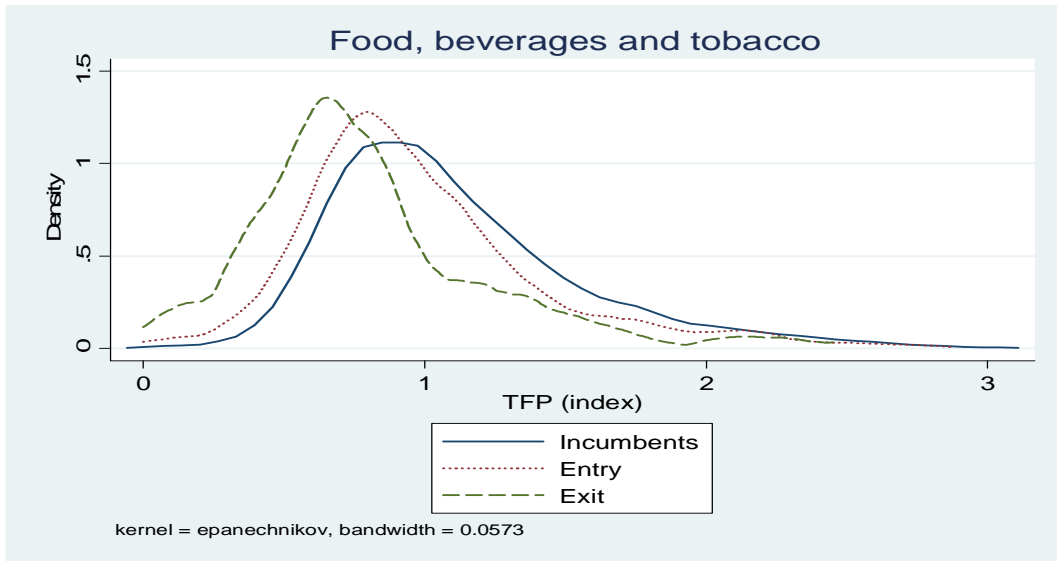


Figure 5 continued

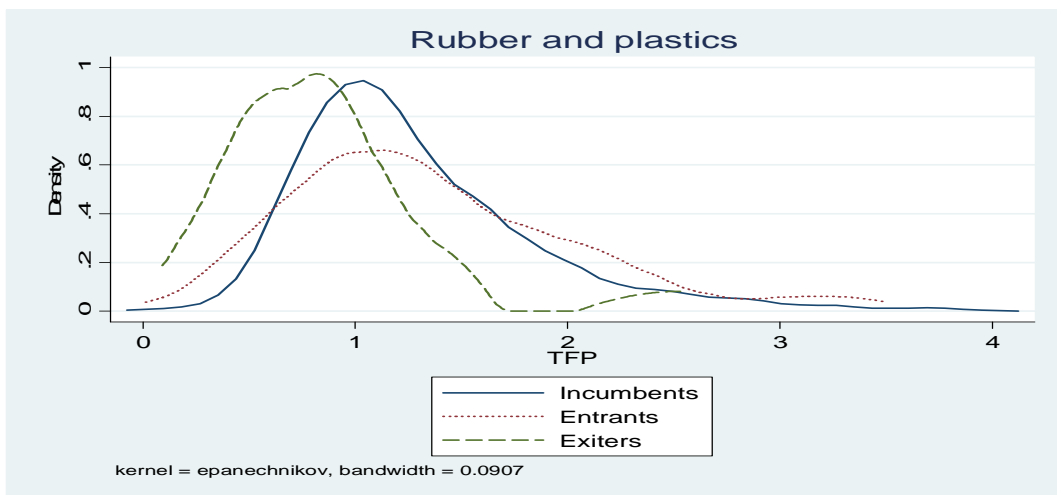
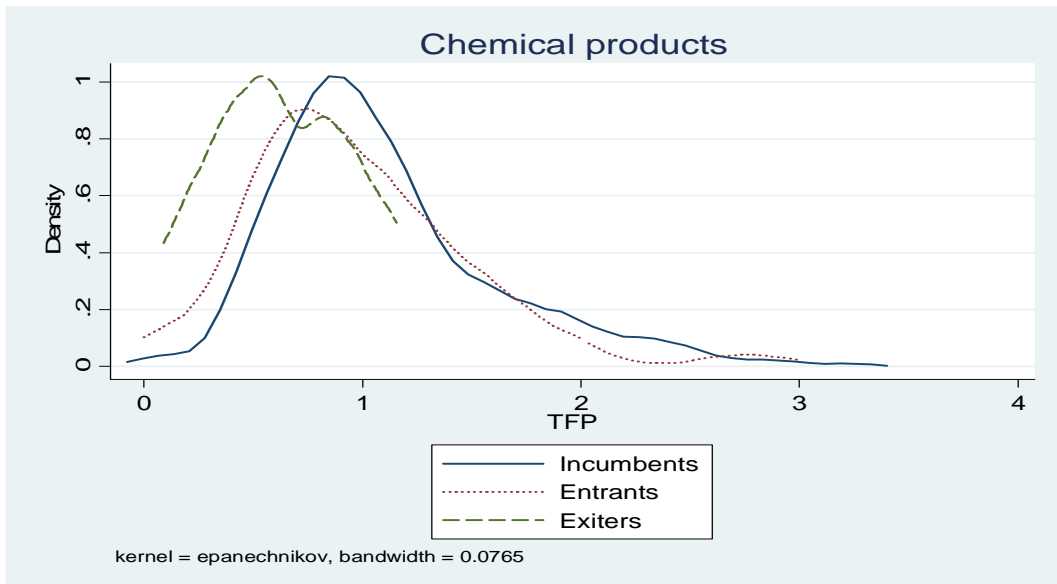
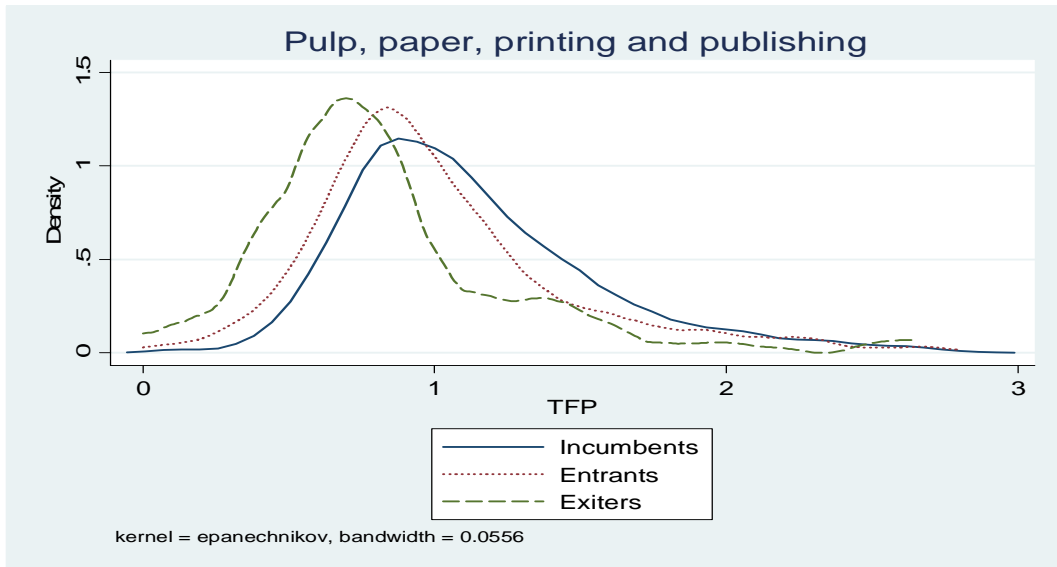


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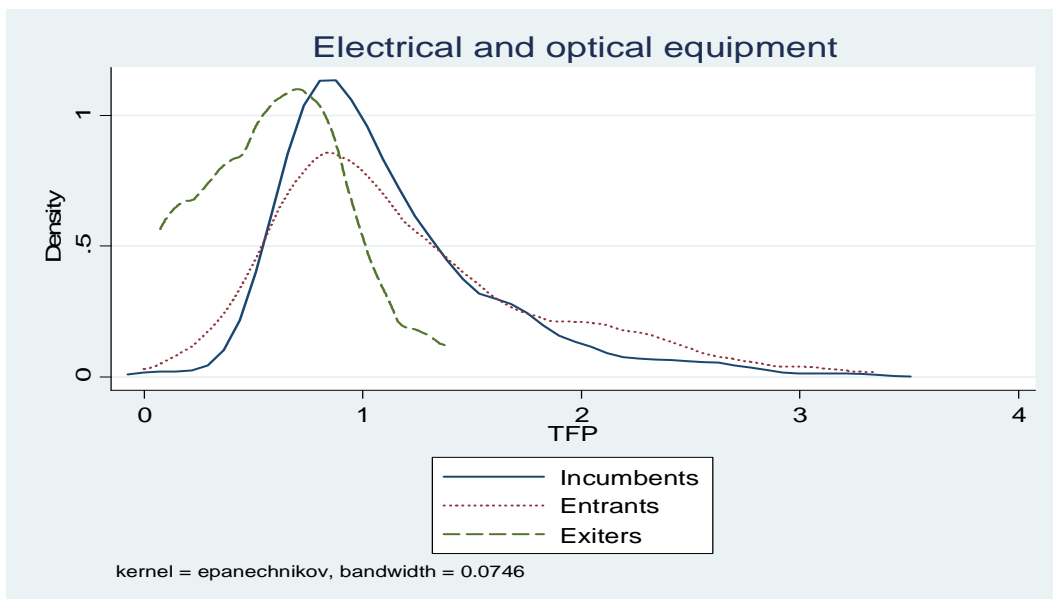
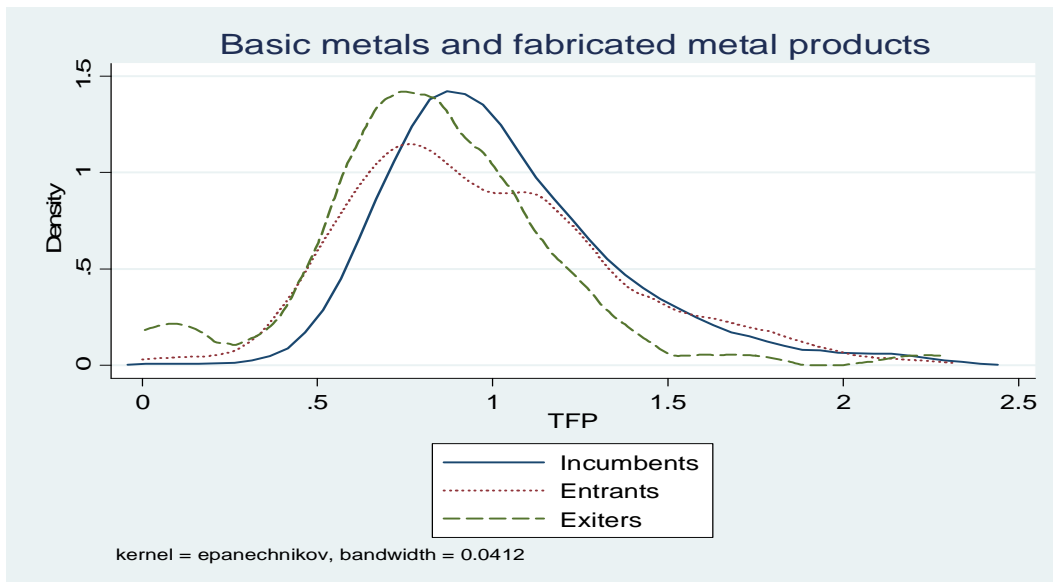
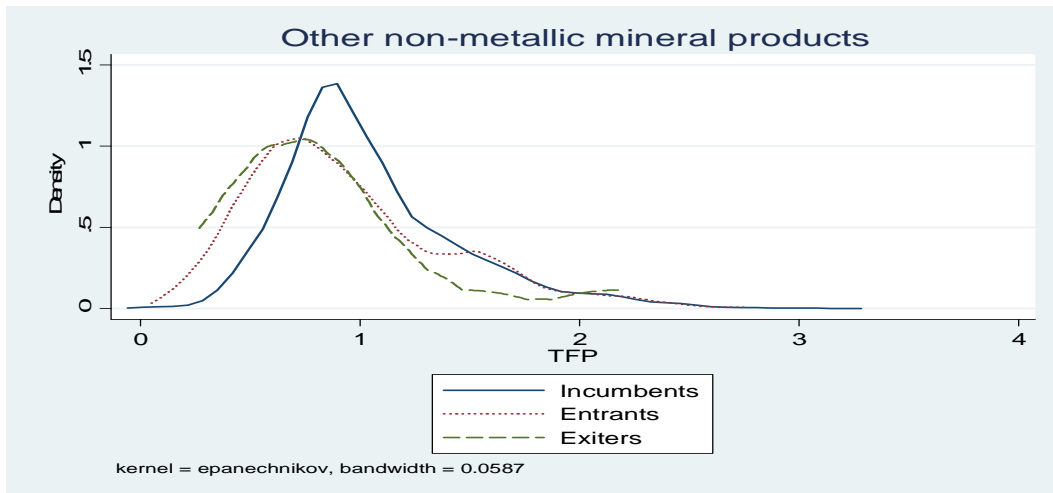
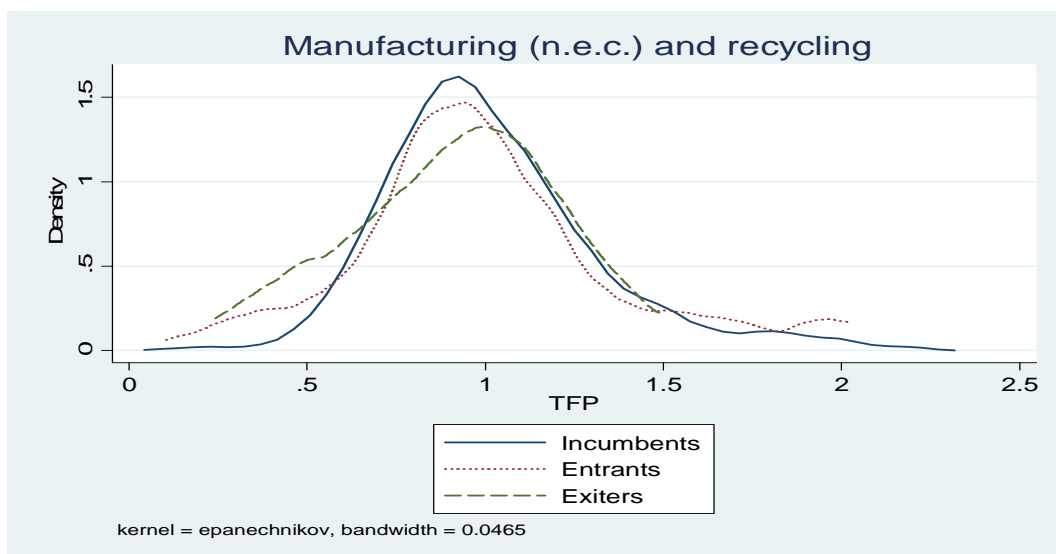
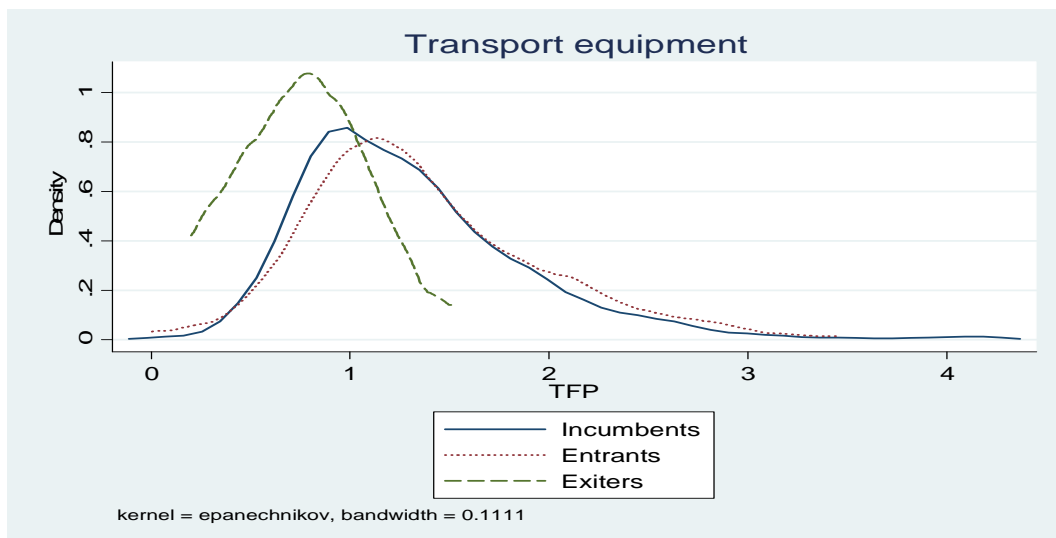
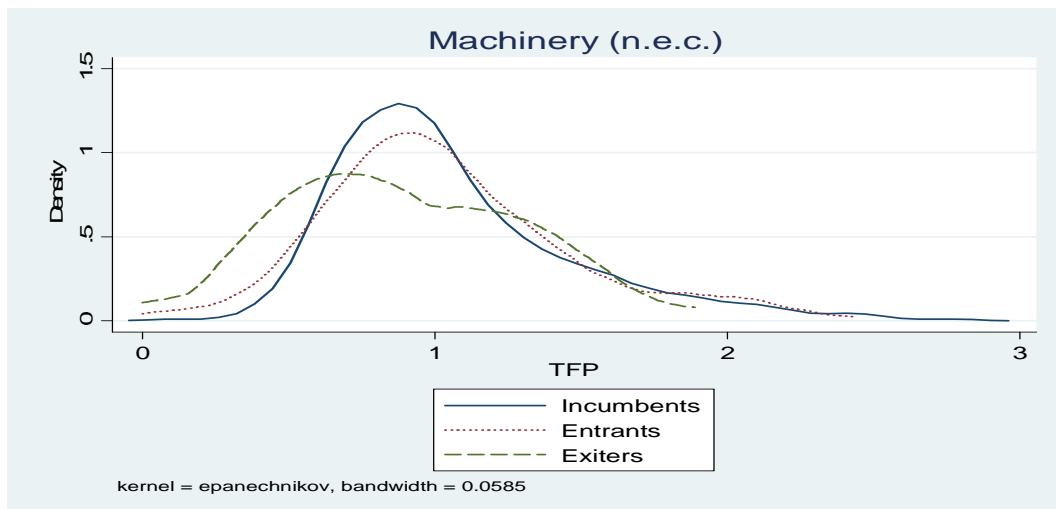


Figure 5 continued



The kernel density plot provides a non-parametric estimate of the TFP (index) distribution of respectively incumbent firms, firms that entered and firms that left the industry over the period 2000-2008.

Taking, for example, industry 10-12 (food, beverages and tobacco), the table indicates that of the 2091 firms that started in the lowest quartile of the TFP distribution, 1362 (65.14%) remained in the lowest quartile, 539 (25.78%) moved up one quartile, 137 (6.55%) moved up to the second highest quartile and only 53 (2.53%) reached the highest quartile. At the other end of the distribution 1420 of the 2032 (69.88%) that started in the highest quartile were still there at the end of the period and only 65 (3.20%) ended up in the lowest quartile. In all industries the diagonal of the transition matrix has the highest number of firms for a given quartile (row), i.e. the probability that a firm in a given quartile of the TFP distribution remained in the same quartile over the period considered was higher than the probability that it moved up or down. For the firms in the lowest and highest quartiles the probability of staying in the same quartile exceeded 50%, i.e. the probability was higher than the three other probabilities combined. If firms moved in the TFP distribution, by and large it was either one quartile up or one quartile down.

Table 2 Transition matrices of inter-quartile movements in TFP (index) distribution  
2000-2008

Food, beverages and tobacco					
Quartile	1	2	3	4	Total
1	1362 (65.14)	539 (25.78)	137 (6.55)	53 (2.53)	2091 (100.00)
2	498 (23.09)	1026 (47.57)	538 (24.94)	95 (4.40)	2157 (100.00)
3	159 (7.36)	457 (21.16)	15051 (48.66)	496 (22.82)	2237 (100.00)
4	65 (3.20)	123 (6.05)	424 (20.87)	1420 (69.88)	2032 (100.00)
Total	2084 (24.69)	2145 (25.41)	2150 (25.47)	2061 (24.42)	8440 (100.00)

Textiles, leather and footwear					
Quartile	1	2	3	4	Total
1	737 (67.68)	241 (22.13)	78 (7.16)	33 (3.03)	1089 (100.00)
2	258 (23.14)	549 (49.24)	257 (23.05)	51 (4.57)	1115 (100.00)
3	79 (6.73)	250 (22.14)	541 (47.92)	262 (23.21)	1129 (100.00)
4	35 (3.30)	70 (6.59)	244 (22.98)	713 (67.14)	1062 (100.00)
Total	1106 (25.16)	1110 (25.26)	1120 (25.48)	1059 (24.10)	4395 (100.00)

Wood and cork					
Quartile	1	2	3	4	Total
1	419 (71.38)	115 (19.59)	40 (6.81)	13 (2.21)	587 (100.00)
2	105 (17.68)	327 (55.05)	132 (22.22)	30 (5.05)	594 (100.00)
3	31 (5.18)	127 (21.24)	321 (53.68)	119 (19.90)	598 (100.00)
4	24 (4.20)	39 (6.82)	107 (18.71)	402 (70.28)	572 (100.00)
Total	579 (24.63)	608 (25.86)	600 (25.52)	564 (23.99)	2351 (100.00)

Pulp, paper, printing and publishing					
Quartile	1	2	3	4	Total
1	864 (38.52)	300 (23.79)	66 (5.23)	31 (2.46)	1261 (100.00)
2	249 (19.53)	630 (49.41)	336 (26.35)	60 (4.71)	1275 (100.00)
3	75 (5.86)	270 (21.09)	629 (49.14)	306 (23.91)	1280 (100.00)
4	59 (4.80)	83 (6.75)	262 (21.32)	825 (67.13)	1229 (100.00)
Total	1247 (24.72)	1283 (25.43)	1293 (25.63)	1222 (24.22)	5045 (100.00)

## Coke, refined petroleum and nuclear fuel

Quartile	1	2	3	4	Total
1	14 (56.00)	8 (32.00)	1 (4.00)	2 (8.00)	25 (100.00)
2	6 (26.09)	11 (47.83)	4 (17.39)	2 (8.70)	23 (100.00)
3	3 (11.54)	5 (19.23)	16 (61.54)	2 (7.69)	26 (100.00)
4	1 (4.55)	0 (0.00)	6 (27.27)	15 (68.18)	22 (100.00)
Total	24 (25.00)	24 (25.00)	27 (28.13)	21 (21.88)	96 (100.00)

## Chemical products

Quartile	1	2	3	4	Total
1	519 (74.68)	137 (19.17)	21 (3.02)	18 (2.59)	695 (100.00)
2	124 (17.22)	422 (58.61)	153 (21.25)	21 (2.92)	720 (100.00)
3	30 (4.21)	134 (18.82)	420 (58.99)	128 (17.98)	712 (100.00)
4	16 (2.38)	24 (3.57)	121 (18.01)	511 (76.04)	672 (100.00)
Total	689 (24.62)	717 (25.62)	715 (25.54)	678 (24.22)	2799 (100.00)

## Rubber and plastics

Quartile	1	2	3	4	Total
1	391 (70.87)	197 (21.99)	52 (5.80)	12 (1.34)	545 (100.00)
2	113 (19.96)	307 (54.24)	125 (22.08)	21 (3.71)	566 (100.00)
3	35 (6.11)	121 (21.12)	313 (54.62)	104 (18.15)	573 (100.00)
4	11 (2.04)	17 (3.16)	103 (19.14)	407 (75.65)	538 (100.00)
Total	550 (24.75)	562 (25.29)	567 (25.52)	543 (24.44)	2222 (100.00)

## Other non-metallic mineral products

Quartile	1	2	3	4	Total
1	635 (70.87)	197 (21.99)	52 (5.80)	12 (1.34)	896 (100.00)
2	166 (18.34)	481 (53.15)	221 (24.42)	37 (4.09)	905 (100.00)
3	62 (6.84)	185 (20.40)	459 (50.61)	201 (22.16)	907 (100.00)
4	24 (2.72)	49 (5.56)	179 (20.29)	630 (71.43)	882 (100.00)
Total	887 (24.71)	912 (25.40)	911 (25.38)	880 (24.51)	3590 (100.00)

## Basic metals and fabricated metal products

Quartile	1	2	3	4	Total
1	2116 (71.25)	651 (21.92)	127 (4.28)	76 (2.56)	2970 (100.00)
2	551 (18.32)	1511 (50.23)	777 (25.83)	169 (5.62)	3008 (100.00)
3	184 (6.10)	691 (22.93)	1458 (48.37)	681 (22.59)	3014 (100.00)
4	110 (3.80)	188 (6.50)	656 (22.68)	1939 (67.07)	2893 (100.00)
Total	2961 (24.91)	3041 (25.59)	3018 (25.39)	2865 (24.11)	11885 (100.00)

## Electrical and optical equipment

Quartile	1	2	3	4	Total
1	516 (70.68)	155 (21.23)	41 (5.62)	18 (2.47)	730 (100.00)
2	162 (21.74)	402 (53.96)	152 (20.40)	29 (3.89)	745 (100.00)
3	42 (5.60)	166 (22.13)	389 (51.87)	153 (20.40)	750 (100.00)
4	15 (2.12)	27 (3.81)	168 (23.70)	499 (70.38)	709 (100.00)
Total	735 (25.05)	750 (25.56)	750 (25.56)	699 (23.82)	2934 (100.00)

Machinery (n.e.c.)					
Quartile	1	2	3	4	Total
1	738 (72.14)	214 (20.92)	53 (5.18)	18 (1.76)	1023 (100.00)
2	209 (20.02)	538 (51.53)	251 (24.04)	46 (4.41)	1044 (100.00)
3	64 (6.15)	238 (22.98)	547 (52.60)	190 (18.27)	1040 (100.00)
4	21 (2.14)	49 (4.99)	192 (19.55)	720 (73.32)	982 (100.00)
Total	1032 (25.24)	1040 (25.43)	1043 (25.51)	974 (23.82)	4089 (100.00)

Transport equipment					
Quartile	1	2	3	4	Total
1	186 (71.81)	51 (19.69)	16 (6.18)	6 (2.32)	259 (100.00)
2	57 (21.35)	128 (47.94)	68 (25.47)	14 (5.24)	267 (100.00)
3	18 (6.43)	65 (23.21)	134 (47.86)	63 (22.50)	280 (100.00)
4	5 (1.95)	20 (7.81)	60 (23.44)	171 (66.80)	256 (100.00)
Total	266 (25.05)	264 (24.86)	278 (26.18)	254 (23.92)	1062(100.00)

Manufacturing (n.e.c.) and recycling					
Quartile	1	2	3	4	Total
1	476 (68.85)	152 (22.13)	41 (5.97)	21 (3.06)	687 (100.00)
2	142 (20.49)	344 (49.64)	170 (24.53)	37 (5.34)	693 (100.00)
3	48 (6.94)	153 (22.11)	330 (47.69)	161 (23.27)	692 (100.00)
4	31 (4.73)	41 (6.26)	149 (22.75)	434 (66.26)	655 (100.00)
Total	694 (25.54)	690 (25.30)	690 (25.30)	653 (23.95)	2727 (100.00)

Note: The table shows the probability that firms that started in a given quartile of the productivity distribution (first column) ended in one of the four possible quartiles of the distribution (2<sup>nd</sup> up to 5<sup>th</sup> column). For each quartile the first line shows the number of firms and the second line the share in the total number of firms that started in the given quartile. The distribution that is considered is the one for computed TFP (index) after elimination of outliers. Transition matrices based on estimated TFP (OLS) indicate even a higher degree of persistence.

If anything, transition matrices based on estimated TFP (OLS) suggest even higher persistence than the transition matrices based on computed TFP as reported in table 2. Table 3 considers the total factor productivity of firms that entered or left a given industry between 2000 and 2008. For entrants the table shows in which quartile of the TFP distribution (index) they ended up two years after their entry (taking into account a start-up period) whereas for firms that left the industry the table shows the quartile to which they belonged one year prior to their exit. In seven industries the largest share of entrants are still found, two years after entry, in the lowest quartile of the TFP distribution. In industry 23 (other non-metallic mineral products) the share of entrants in the first quartile is even as high as 45.16%. On the other hand, the largest share of entrants (joint 1st place with the first quartile) is found in the highest quartile in industries 17-18 (pulp, paper, printing and publishing) and 26-27 (electrical and optical equipment) whereas in industries 28 (machinery n.e.c.) and 29-30 (transport equipment) the entrants appeared to be closer to the industry median than to the low or high end of the TFP distribution. The quartile shares of firms that left the industry was clearly more skewed towards the low end of the TFP distribution. In nine of the 13 manufacturing industries, the largest share of exiting firms was found in the lowest quartile, one year prior to their exit with the share being as high as 66.67% in 29-30 (transport equipment) and 61.11% in 22 (rubber and plastics). The results appear to be in line with Baily, Hulten and Campbell (1992) who found evidence, for the US, of high-productivity as well as low-productivity entrants. Although in some industries a reasonable number of exiting firms belonged to the highest TFP quartile prior to their exit, the productivity of exiting firms was overall below av-

erage and the bimodal pattern – i.e. low-productivity as well as high-productivity firms leaving the industry – reported by Baily, Hulten and Campbell (1992) is not found in the Belgian data. When considering estimated TFP (OLS) rather than computed TFP, a larger number of entrants can be found in the higher quartiles of the industry TFP distribution. For example, in industry 26-27 (electrical and optical equipment) only 17.65% of entrants belonged to the first quartile of the distribution of estimated TFP and 31.37% belong to the highest quartile. The position of firms that left the industry, on the other hand, appears to be even more skewed towards the lower quartiles of the distribution for estimated TFP compared to computed TFP, e.g. 60% of firms that left industry 26-27 belonged to the lowest quartile of the distribution of estimated TFP one year prior to exit, compared to 54.17% when considering the distribution of computed TFP. These results again indicate that estimated OLS accounts for non-constant returns to scale and may therefore provide a less biased indicator of technological efficiency.

A probit estimation<sup>5</sup> indicates that in many industries, lagged TFP is an important determinant of the probability of firms to exit a given industry. If a firm belonged to the third or the fourth quartile of the industry TFP distribution it was far less likely to exit than if it belonged to the lowest quartile. Other factors that appear to explain the exit probability are the capital stock (the higher the capital stock the lower the probability) and to a lesser extent the age of the firm. The probability that a firm that entered after 2000 exited before 2008 was considerable, ranging from 4% in industry 23 (other non-metallic mineral products) to 13% in industry 13-15 (textiles, leather and footwear) but a variable reflecting the fact that a firm entered between 2000 and 2008 was not statistically significant in the estimation of the exit probability.

Table 3 Quartiles of the TFP distribution of firms that entered or exited between 2000 and 2008  
(2 years after their entry) and quartiles of firms that left the industry (1 year prior to their exit)

Food, beverages and tobacco		
Entry (quartile 2 years after entry)	Number of firms	%
1	76	40.00
2	52	27.37
3	35	18.42
4	27	14.21
Exit (quartile 1 year prior to exit)		
1	37	52.86
2	17	24.29
3	9	12.86
4	7	10.00

<sup>5</sup> The results of a probit estimation similar to the one reported by Olley and Pakes (1996) are not reported but available upon request.



## Textiles, leather and footwear

Entry (quartile 2 years after entry)	Number of firms	%
1	16	35.56
2	14	31.11
3	6	13.33
4	9	20.00
Exit (quartile 1 year prior to exit)		
1	23	31.08
2	24	32.43
3	13	17.57
4	14	18.92

## Wood and cork

Entry (quartile 2 years after entry)	Number of firms	%
1	12	31.58
2	9	23.68
3	8	21.05
4	9	23.68
Exit (quartile 1 year prior to exit)		
1	7	43.75
2	2	12.50
3	5	31.25
4	2	12.50

## Pulp, paper, printing and publishing

Entry (quartile 2 years after entry)	Number of firms	%
1	15	28.85
2	12	23.08
3	10	19.23
4	15	28.85
Exit (quartile 1 year prior to exit)		
1	20	35.09
2	14	24.56
3	16	28.07
4	7	12.28

## Chemical products

Entry (quartile 2 years after entry)	Number of firms	%
1	15	36.59
2	9	21.95
3	9	21.95
4	8	19.51
Exit (quartile 1 year prior to exit)		
1	6	46.15
2	4	30.77
3	1	7.69
4	2	15.38

## Rubber and plastics

Entry (quartile 2 years after entry)	Number of firms	%
1	11	32.35
2	8	23.53
3	7	20.59
4	8	23.53
Exit (quartile 1 year prior to exit)		
1	11	61.11
2	4	22.22
3	3	16.67
4	0	0

## Other non-metallic mineral products

Entry (quartile 2 years after entry)	Number of firms	%
1	28	45.16
2	11	17.74
3	10	16.13
4	13	20.97
Exit (quartile 1 year prior to exit)		
1	8	44.44
2	3	16.67
3	4	22.22
4	3	16.67

## Basic metals and fabricated metal products

Entry (quartile 2 years after entry)	Number of firms	%
1	74	30.83
2	55	22.92
3	47	19.58
4	64	26.67
Exit (quartile 1 year prior to exit)		
1	41	35.65
2	32	27.83
3	22	19.13
4	20	17.39

## Electrical and optical equipment

Entry (quartile 2 years after entry)	Number of firms	%
1	18	30.51
2	11	18.64
3	12	20.34
4	18	30.51
Exit (quartile 1 year prior to exit)		
1	13	54.17
2	9	37.5
3	2	8.33
4	0	0

## Machinery (n.e.c.)

Entry (quartile 2 years after entry)	Number of firms	%
1	13	20.31
2	19	29.69
3	17	26.56
4	15	23.44
Exit (quartile 1 year prior to exit)		
1	12	38.71
2	6	19.35
3	9	29.03
4	4	12.9

## Transport equipment

Entry (quartile 2 years after entry)	Number of firms	%
1	2	9.52
2	9	42.86
3	6	28.57
4	4	19.05
Exit (quartile 1 year prior to exit)		
1	6	66.67
2	2	22.22
3	-	-
4	1	11.11

## Manufacturing (n.e.c.) and recycling

Entry (quartile 2 years after entry)	Number of firms	%
1	4	16
2	11	44
3	8	32
4	2	8
Exit (quartile 1 year prior to exit)		
1	7	28
2	6	24
3	8	32
4	4	16

Note: The table shows the quartile of the TFP distribution (index) in which firms that entered the industry in the period 2000-2008 were two years after they started their activities and the quartile of the TFP distribution in which firms that left the industry were one year prior to their exit.

As mentioned in the introduction, Bartelsman and Doms (2000) concluded from their survey of firm-level and plant-level studies (mostly based on US data) that there does not appear to be a long-run correlation between changes in productivity and changes in employment. Table 4 shows the correlation between the annual growth in the TFP level (index and OLS) of firms and the annual growth in their share in the total hours worked in a given industry. The last line for each industry shows the correlation when considering growth between 2000 and 2008 in the TFP level and the share of hours worked. When statistically significant, the correlation is most often negative, especially for estimated TFP (OLS), which accounts for possible non-constant returns to scale. Considering estimated TFP, long-run correlation (i.e. 2000-2008) is statistically significant and negative in eight of the twelve

manufacturing industries. TFP growth appears to be negatively correlated with changes in the capital stock as well as with the share of labour in value added. On the other hand, TFP growth was positively correlated with changes in firms' shares in the industry value added and with growth in average wages. Productivity growth of firms seems to provide market rents that are shared between workers (in terms of higher wages) and shareholders (higher profits) but also in a relative decrease in the demand for labour and capital. A rise in average wages may also result from the substitution of high-skilled workers for low-skilled workers but the data do not permit to assess whether this indeed happened. The correlations do suggest that there may - as recently argued by Altomonte (2010)- be some conflict between policies that aim to raise technological efficiency and policies that aim to increase employment in manufacturing industries.

Biatour et al. (2011) found that industries with high growth in TFP also witnessed a rapid increase in the dispersion of TFP levels across countries. The correlation, across Belgian industries, between TFP growth over the period 2000-2008 and the standard deviation of the TFP distribution within industries is also positive and statistically significant (0.62 for computed TFP and 0.52 for estimated TFP).

Table 4 Correlation between TFP growth and growth in the share of total hours worked

Food, beverages and tobacco		
	TFP (index)	TFP (OLS)
2001	-0.02	-0.17*
2002	-0.02	-0.07*
2003	0.07*	-0.02
2004	0.03	-0.05
2005	-0.04	-0.17*
2006	-0.04	-0.12*
2007	-0.05	-0.13*
2008	-0.10*	-0.13*
2000-2008	-0.07	-0.25*
Textiles, leather and footwear		
	TFP (index)	TFP (OLS)
2001	0.04	-0.05
2002	0.05	0.01
2003	-0.01	-0.10*
2004	-0.02	0.08
2005	0.00	-0.02
2006	0.06	-0.06
2007	-0.02	-0.06
2008	-0.02	-0.13*
2000-2008	0.05	-0.04

## Wood and cork

	TFP (index)	TFP (OLS)
2001	0.07	-0.11
2002	0.00	-0.11
2003	-0.05	-0.26*
2004	0.02	-0.13*
2005	0.01	-0.09
2006	-0.03	-0.09
2007	-0.05	-0.19*
2008	0.09	-0.24*
2000-2008	-0.05	-0.15*

## Pulp, paper, printing and publishing

	TFP (index)	TFP (OLS)
2001	-0.10*	-0.21*
2002	-0.10*	-0.17*
2003	-0.01	-0.06
2004	-0.04	-0.11*
2005	-0.07	-0.11*
2006	-0.03	-0.04
2007	-0.07	-0.20*
2008	0.01	-0.01
2000-2008	-0.13*	-0.18*

## Chemical products

	TFP (index)	TFP (OLS)
2001	-0.01	-0.07
2002	-0.05	-0.08
2003	-0.02	-0.02
2004	0.08	-0.07
2005	0.00	-0.23*
2006	-0.11*	-0.26*
2007	0.03	0.17*
2008	-0.04	-0.02
2000-2008	-0.02	-0.14*

## Rubber and plastics

	TFP (index)	TFP (OLS)
2001	0.09	-0.14*
2002	-0.02	-0.05
2003	0.20*	-0.04
2004	-0.03	-0.19*
2005	0.02	-0.29*
2006	-0.02	-0.03
2007	0.03	-0.14*
2008	-0.02	-0.10
2000-2008	-0.06	-0.19*

## Other non-metallic mineral products

	TFP (index)	TFP (OLS)
2001	0.08	-0.02
2002	-0.08	-0.09
2003	-0.12*	-0.03
2004	-0.03	-0.09
2005	-0.12*	-0.07
2006	-0.03	-0.11*
2007	-0.05	-0.11*
2008	-0.04	-0.08
2000-2008	0.06	-0.12*

## Basic metals and fabricated metal products

	TFP (index)	TFP (OLS)
2001	0.02	-0.04
2002	-0.02	0.00
2003	-0.02	-0.04
2004	-0.01	-0.05
2005	0.02	-0.01
2006	0.03	-0.03
2007	-0.03	-0.07*
2008	-0.04	-0.10*
2000-2008	-0.01	-0.03

## Electrical and optical equipment

	TFP (index)	TFP (OLS)
2001	0.07	-0.01
2002	-0.05	-0.01
2003	0.02	-0.03
2004	-0.09	-0.04
2005	-0.01	-0.30*
2006	-0.04	-0.10
2007	-0.10	-0.22*
2008	-0.11	-0.22*
2000-2008	-0.06	-0.04

## Machinery (n.e.c.)

	TFP (index)	TFP (OLS)
2001	-0.01	-0.07
2002	-0.02	-0.10*
2003	-0.08	-0.17*
2004	0.00	-0.06
2005	-0.01	-0.08
2006	-0.02	-0.07
2007	-0.01	-0.08
2008	0.01	-0.02
2000-2008	-0.04	-0.08

Transport equipment		
	TFP (index)	TFP (OLS)
2001	0.04	-0.14
2002	-0.04	-0.01
2003	-0.08	-0.08
2004	0.00	-0.05
2005	-0.12	-0.04
2006	-0.08	-0.25*
2007	0.00	-0.09
2008	0.05	0.04
2000-2008	-0.03	-0.12

Manufacturing (n.e.c.) and recycling		
	TFP (index)	TFP (OLS)
2001	-0.30*	-0.13*
2002	-0.27*	-0.16*
2003	-0.16*	-0.15*
2004	0.00	-0.11
2005	0.13*	-0.08
2006	0.00	-0.22*
2007	-0.08	-0.25*
2008	-0.15*	-0.07
2000-2008	0.12*	-0.10

Note: The table shows the correlation between the annual TFP growth of firms and the annual growth in the firms' share in the total hours worked in the industry. The last line (2000-2008) shows the correlation for growth rates between 2000 and 2008.

## 4.2. Decomposition

The decomposition of industry-level TFP growth in manufacturing industries over the years 2000-2008 was done using equation (2), which results in five components: firm-level TFP growth (within), reallocation, interaction, entry and exit. There were a substantial number of missing values for incumbent firms which complicate the decomposition. If for a given firm TFP could be computed or estimated for year  $t$  but not for year  $t-1$  this could be due to the fact that the firm has entered the industry in year  $t$  but also that some data for an incumbent firm (i.e. a firm that was established before 2000) for year  $t-1$  were missing. Clearly, the latter should not be counted as an entrant. In a similar vein, if TFP is available for a given firm in year  $t-1$  but not in year  $t$ , firms that left the industry in year  $t$  were distinguished from incumbent firms for which no data were available in year  $t$ . Only firms for which data permitted to establish whether firms were really entering or had really left the industry were considered as such and the other were not considered in the analysis. The results of the decomposition of TFP growth are reported in table 5 for the years 2001-2008, both for growth based on computed TFP (index) and estimated TFP (OLS). Table 5 indicates substantial differences between industries in the relative importance of the five components, but also over time. The within component, which was the largest component of industry-level TFP growth in most industries, was negative in a number of years. If taken at face value, a negative component would seem to suggest technological regress within firms in a given industry. Although disruption during the installation and fine-tuning of new machinery and equipment could explain a temporary fall in firm-level productivity (e.g. Syverson 2010), the fact that the

within component is often negative in years of slow economic growth - especially in 2008 when 10 out of the 12 industries witnessed a negative within component- suggests a more likely explanation for the negative within component, i.e. the well-known cyclical behaviour of TFP due to lower capacity utilization and labour hoarding in years of slowing demand as discussed in section 4.1. The results of the decomposition are rather sensitive to whether computed or estimated TFP is considered. Especially in industries 10-12 (food, beverages and tobacco), 22 (rubber and plastics) and 24-25 (basic metals and fabricated metal products) the results for both alternative TFP measures diverge dramatically, with a strong negative correlation between the different computed components. As these industries are relatively large, heterogeneity in production technology across firms is rather likely (see figure 4). Computed TFP (index) may therefore be more reliable than estimated TFP (OLS) which is known to provide less reliable results under production technology heterogeneity. On the other hand, as mentioned before, computed TFP ignores possible non-constant returns to scale, which are accounted for in estimated TFP.

Table 5 Results of decomposition of industry-level TFP growth  
2001-2008

Food, beverages and tobacco					
TFP (index)	within	reallocation	interaction	entry	exit
2001	-0.00234	-0.05304	0.02375	0.00096	-0.00069
2002	0.03151	-0.00087	0.02731	0.00039	-0.00057
2003	-0.07099	-0.03571	0.0308	0.00628	-0.00036
2004	0.13977	0.01088	0.03808	0.00763	-0.00001
2005	0.02103	-0.02629	0.02257	0.01114	-0.00061
2006	0.1942	0.02669	0.04198	0.00994	0
2007	-0.14655	-0.05668	0.03031	0.0123	-0.00069
2008	0.02461	0.00806	0.03227	0.01626	0.00017
TFP (OLS)	within	reallocation	interaction	entry	exit
2001	0.00014	-0.00043	0.00058	-0.00003	-0.00001
2002	0.00088	-0.00038	0.00039	-0.00003	-0.00001
2003	0.00029	-0.00036	0.00055	0.00028	0
2004	-0.00004	-0.00044	0.0005	0.00052	0
2005	0.00053	-0.00025	0.00038	0.0006	-0.00001
2006	0.00082	-0.00045	0.00031	0.00072	0
2007	0.00208	-0.00017	0.00101	0.00106	0
2008	0.00124	-0.00041	0.00064	0.00009	0
Textiles, leather and footwear					
TFP (index)	within	reallocation	interaction	entry	exit
2001	0.02871	-0.02727	0.0284	-0.00103	-0.00031
2002	0.04458	-0.00714	0.04378	-0.00182	-0.00086
2003	0.0397	-0.00809	0.02016	0.00024	-0.00015
2004	-0.01715	-0.00295	0.02165	-0.00237	-0.001
2005	-0.05631	-0.01967	0.03072	-0.00077	-0.00026
2006	0.12107	-0.00592	0.01859	0.00961	-0.00109
2007	0.08341	-0.01039	0.02514	0.00462	0.00169
2008	-0.00842	0.00961	0.03468	0.02402	-0.00689



TFP (OLS)	within	reallocation	interaction	entry	exit
2001	0.00074	-0.0006	0.00115	-0.00006	-0.00003
2002	0.0007	-0.0006	0.00142	-0.00008	-0.00004
2003	0.00178	-0.00003	0.00065	-0.00006	0
2004	-0.00188	-0.00107	0.00206	0.00034	-0.00003
2005	-0.00056	-0.00018	0.00117	0.0003	-0.00001
2006	0.00485	-0.00042	0.0004	0.00029	-0.00008
2007	0.00615	0.00104	0.00123	0.00111	-0.00004
2008	-0.00186	0.00266	0.00089	0.00077	-0.00002

## Wood and cork

TFP (index)	within	reallocation	interaction	entry	exit
2001	0.0246	-0.00441	0.03127	-0.00145	-0.00044
2002	-0.02077	-0.01538	0.02302	0.00137	-0.00244
2003	0.01681	-0.02066	0.0314	0.00243	-0.00275
2004	-0.00544	-0.0112	0.02493	-0.00582	-0.00251
2005	-0.02654	-0.02006	0.02279	-0.00751	0.00018
2006	0.09308	-0.02627	0.01623	-0.01167	-0.00128
2007	0.094	-0.00526	0.03395	-0.02011	-0.00254
2008	-0.10874	-0.09257	0.06625	0.00754	-0.0012
TFP (OLS)	within	reallocation	interaction	entry	exit
2001	0.0009	0.00007	0.00115	0.00003	0
2002	-0.00017	-0.00024	0.00117	0.00028	-0.00009
2003	-0.00056	-0.00123	0.00128	0.00045	0
2004	-0.00122	0.00012	0.00107	0.00044	-0.0001
2005	-0.00106	-0.00043	0.00091	-0.00003	0.00001
2006	0.00476	-0.00027	0.00109	0.00045	-0.00007
2007	0.00513	-0.00165	0.0001	0.00012	-0.00001
2008	-0.01986	0.00843	-0.00285	0.00036	-0.00006

## Pulp, paper, printing and publishing

TFP (index)	within	reallocation	interaction	entry	exit
2001	0.01786	-0.01837	0.04192	-0.00042	0.0015
2002	0.0464	-0.0222	0.03371	-0.00057	-0.00214
2003	0.07414	-0.01109	0.0181	-0.00054	0.00002
2004	0.0305	-0.00101	0.02102	0.00124	0.00004
2005	-0.00761	-0.02214	0.01534	-0.00012	-0.00009
2006	0.05295	-0.02237	0.02418	0.00028	-0.00128
2007	0.05212	-0.00394	0.01347	0.00507	0.00017
2008	0.04344	0.00249	0.03369	0.01567	-0.00321
TFP (OLS)	within	reallocation	interaction	entry	exit
2001	-0.00056	-0.00039	0.00095	-0.00004	-0.00001
2002	0.00111	-0.00048	0.0005	-0.00003	-0.00002
2003	0.00175	-0.00068	0.00035	0.00033	-0.00001
2004	0.00056	-0.00072	0.00108	0.00083	0
2005	0.00087	-0.00004	0.00095	0.00076	-0.00001
2006	-0.0009	-0.00037	0.00058	0.00071	0
2007	0.0005	-0.00039	0.00104	0.00121	-0.00001
2008	0.00016	-0.00043	0.00081	0.00018	0.00001

## Chemical products

TFP (index)	within	reallocation	interaction	entry	exit
2001	-0.0423	-0.02606	0.02373	0.00202	-0.00108
2002	0.03658	-0.03725	0.02255	-0.00198	-0.00016
2003	0.09032	-0.02574	0.00912	-0.00283	-0.00011
2004	0.00954	-0.11543	0.0278	0.0143	-0.00101
2005	-0.01329	-0.00522	0.03505	0.00606	0
2006	-0.09017	0.0133	0.02664	0.01335	0
2007	-0.06206	-0.09249	0.02223	0.01654	-0.00006
2008	-0.10449	0.0267	0.05196	-0.00118	-0.00044
TFP (OLS)	within	reallocation	interaction	entry	exit
2001	0.00098	0.00045	0.0006	-0.00008	0.00098
2002	0.00031	-0.00036	0.00053	-0.00009	0.00031
2003	0.0015	0.00059	0.00061	-0.00006	0.0015
2004	0.00075	0.00021	0.00017	0.00056	0.00075
2005	-0.00013	0.00025	0.00025	0.00032	-0.00013
2006	-0.0001	-0.00165	0.00278	0.00046	-0.0001
2007	-0.00515	-0.00246	0.00344	0.00044	-0.00515
2008	-0.00053	-0.00038	0.00141	0.0007	-0.00053

## Rubber and plastics

TFP (index)	within	reallocation	interaction	entry	exit
2001	-0.12645	-0.04862	0.04748	0.00906	0.00017
2002	0.05719	-0.00192	0.0205	0.00187	-0.0021
2003	0.17965	-0.01552	0.03824	0.00091	0.00081
2004	0.03593	-0.00553	0.02973	-0.00375	-0.0001
2005	0.11644	-0.02183	0.0209	0.03375	-0.00086
2006	0.08433	-0.01287	0.02485	0.02189	-0.00095
2007	0.21571	0.00855	0.02872	0.02659	-0.00018
2008	-0.07022	-0.01882	0.04014	0.01811	-0.0004
TFP (OLS)	within	reallocation	interaction	entry	exit
2001	-0.00312	0.00025	-0.00002	-0.00002	-0.00001
2002	0.0013	-0.00074	0.00045	0.00014	-0.00001
2003	0.00434	-0.00048	0.00067	0.00054	0.00001
2004	0.00276	0.00022	0.00084	0.00182	0
2005	0.0032	-0.00008	0.00066	0.00113	-0.00002
2006	0.00399	0.00045	0.00088	0.00107	-0.00002
2007	0.00342	-0.00016	0.00077	0.00084	-0.00001
2008	-0.00036	0.00007	0.00062	0.00133	0

## Other non-metallic mineral products

TFP (index)	within	reallocation	interaction	entry	exit
2001	-0.03964	-0.02606	0.03224	-0.0043	0
2002	-0.03508	-0.02648	0.02094	-0.00461	-0.00071
2003	-0.00816	-0.01163	0.01671	-0.00232	-0.00006
2004	0.01859	-0.01179	0.01328	0.0009	0.00117
2005	0.04788	-0.0108	0.00907	-0.0005	0
2006	-0.01463	0.0005	0.02103	-0.00361	-0.0007
2007	0.09502	-0.01445	0.01317	-0.0041	0.00009
2008	-0.1441	0.01015	0.01938	-0.01739	-0.00087
TFP (OLS)	within	reallocation	interaction	entry	exit
2001	-0.00103	-0.00147	0.00116	0.00006	0
2002	-0.00062	-0.00019	0.00099	-0.00004	0
2003	-0.00069	-0.00044	0.00068	-0.00006	0
2004	0.00016	-0.00011	0.00049	0.00004	0.00001
2005	0.00181	-0.00074	0.00039	0.00043	0
2006	0.00223	-0.00015	0.00064	0.0009	-0.00001
2007	0.00267	-0.00065	0.00063	0.00004	0
2008	-0.00356	0.00037	0.00064	-0.00025	0

## Basic metals and fabricated metal products

TFP (index)	within	reallocation	interaction	entry	exit
2001	0.04092	-0.03196	0.03727	0.00058	-0.00027
2002	0.00701	-0.00396	0.02252	-0.00079	0.00031
2003	-0.01628	-0.01943	0.01817	0.00938	-0.00034
2004	-0.02782	-0.01167	0.0329	0.00677	-0.00029
2005	-0.05078	-0.01608	0.04211	0.00199	-0.00011
2006	0.00571	-0.00295	0.04668	0.00778	-0.00066
2007	0.01899	-0.01885	0.01302	0.02305	-0.00009
2008	-0.14754	-0.03738	0.04611	0.02014	-0.00041
TFP (OLS)	within	reallocation	interaction	entry	exit
2001	-0.0027	-0.00176	0.0026	0.00005	-0.00001
2002	0.00124	-0.00051	0.00148	0.00001	-0.00001
2003	-0.00035	-0.0002	0.00055	0.00025	-0.00002
2004	0.00136	-0.00032	0.00071	0.00012	-0.00001
2005	-0.00275	-0.00031	0.00129	0	-0.00002
2006	-0.00068	0.00192	0.00084	0.00014	-0.00001
2007	0.00368	-0.00038	0.0006	0.00099	0
2008	-0.00915	-0.00245	0.00282	0.00047	-0.00002

## Electrical and optical equipment

TFP (index)	within	reallocation	interaction	entry	exit
2001	0.05073	-0.03957	0.03285	0.02588	0
2002	0.04801	-0.01979	0.01647	0.04225	-0.00039
2003	-0.01398	0.02977	0.0215	0.10521	-0.00035
2004	0.12559	-0.03158	0.00721	0.08003	-0.00005
2005	-0.01936	-0.01431	0.018	0.08457	-0.0003
2006	0.04388	-0.01258	0.01404	0.08534	-0.00028
2007	0.09352	-0.01604	0.00773	0.05643	-0.00025
2008	-0.09305	0.01169	0.02484	0.03074	-0.00032
TFP (OLS)	within	reallocation	interaction	entry	exit
2001	-0.00094	-0.00011	0.00082	-0.00015	0
2002	-0.00062	-0.0007	0.00087	0.00019	0
2003	-0.00025	0.00038	-0.00013	0.0016	0
2004	0.00107	-0.00068	0.00044	0.0013	0
2005	0.00006	-0.00007	0.00056	0.00134	0
2006	0.00154	-0.00002	0.00025	0.00172	0
2007	0.00472	-0.00021	-0.00019	0.00116	-0.00001
2008	-0.00452	-0.00024	0.00067	0.00051	-0.00001

## Machinery (n.e.c.)

TFP (index)	within	reallocation	interaction	entry	exit
2001	-0.03905	-0.00269	0.02211	0.00022	-0.00032
2002	-0.0318	-0.00554	0.02255	0.00264	0.00025
2003	0.02912	-0.02531	0.02636	0.00198	-0.00049
2004	0.0407	0.00409	0.05061	0.00059	-0.00117
2005	0.0326	-0.0143	0.02011	0.00379	0.0002
2006	0.01382	-0.0162	0.0247	0.00388	-0.00013
2007	0.07871	-0.00369	0.01418	0.02464	-0.00032
2008	-0.07433	0.00373	0.02395	0.01318	-0.00006
TFP (OLS)	within	reallocation	interaction	entry	exit
2001	-0.00285	-0.00046	0.0008	0.00002	-0.00002
2002	-0.00059	-0.00029	0.00048	0.00014	0.00001
2003	0.00119	-0.00056	0.00071	0.00012	-0.00002
2004	0.00175	0	0.00135	0.00006	0
2005	0.0019	-0.00038	0.00055	0.00027	0
2006	0.00178	0.00028	0.00059	0.00029	0
2007	0.00167	-0.00047	0.00038	0.0006	-0.00001
2008	-0.00195	0.00076	0.00034	0.00036	0

## Transport equipment

TFP (index)	within	reallocation	interaction	entry	exit
2001	0.07136	-0.02811	0.0544	-0.00016	-0.00042
2002	-0.02723	-0.01685	0.04782	0.00078	-0.00003
2003	-0.15613	-0.0364	0.03544	-0.00088	0.00004
2004	0.1645	-0.00634	0.02326	0.01338	-0.00004
2005	0.21907	-0.00603	0.03084	0.00905	-0.00022
2006	-0.13644	0.01619	-0.00839	-0.00251	-0.00123
2007	0.09944	-0.02089	0.04737	0.0054	-0.0046
2008	-0.19547	-0.06927	0.05702	0.009	-0.00009
TFP (OLS)	within	reallocation	interaction	entry	exit
2001	0.00126	-0.00014	0.00044	-0.00001	-0.00002
2002	0.00102	-0.00035	0.00071	-0.00001	0
2003	-0.00374	-0.00023	0.00051	-0.00001	0
2004	0.00423	0.00026	0.00098	0.00066	0
2005	0.00399	-0.00087	0.00131	0.00007	0
2006	0.0074	0.001	0.00881	0.0004	-0.00003
2007	0.00316	-0.00009	0.00321	0.00079	0
2008	-0.00379	-0.00269	0.00002	0.00065	0

## Manufacturing (n.e.c.) and recycling

TFP (index)	within	reallocation	interaction	entry	exit
2001	-0.04386	-0.01004	0.01434	-0.0045	-0.00017
2002	-0.02156	-0.01072	0.01737	-0.00264	0.00081
2003	0.00413	-0.00226	0.02051	-0.00239	0.00035
2004	-0.01749	-0.00898	0.01953	-0.00272	-0.00132
2005	-0.00702	-0.00548	0.02217	-0.00117	-0.0001
2006	-0.05222	-0.01286	0.01302	-0.00113	-0.00092
2007	0.0149	0.00256	0.01101	0.00305	-0.00392
2008	-0.05874	-0.00243	0.01341	-0.00096	-0.00014
TFP (OLS)	within	reallocation	interaction	entry	exit
2001	-0.00059	-0.00013	0.00046	0.00023	0.00003
2002	-0.00038	-0.00026	0.0005	0.00005	0.00004
2003	-0.00013	-0.00027	0.00048	-0.00001	0
2004	-0.0011	-0.00004	0.00058	0.00008	-0.00003
2005	0.00014	0.00021	0.00056	0.0001	-0.00002
2006	-0.00225	-0.00025	0.00034	0.00005	0.00001
2007	0.0009	0.00032	0.00028	0.00015	0
2008	-0.00224	-0.00006	0.00041	0.00003	-0.00002

Note: The table shows the results of a decomposition of industry-level TFP growth using equation 2. The within component provides an indication of the part that is accounted for by changes in firm-level productivity. The reallocation denotes the changes in industry-level TFP growth that result from changes in firms' market shares. The third component is the interaction of changes in firm-level TFP and firms' market shares. The entry component shows the impact of entrants and the final component the effect of firms that left the industry in the period 2000-2008.

Figure 6 shows the averages for each industry, over the period 2001-2008, of the five components for a decomposition of computed industry-level TFP growth (index) and figure 7 shows the averages for a decomposition of estimated industry-level TFP growth (OLS).

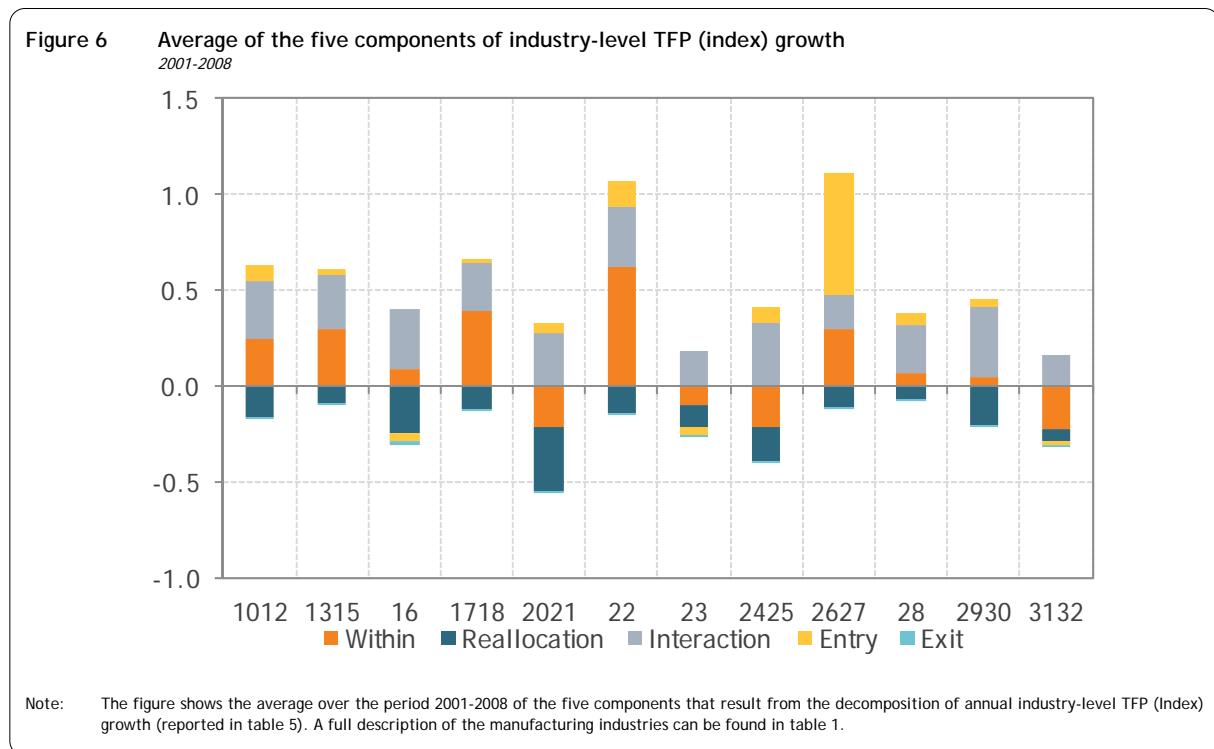
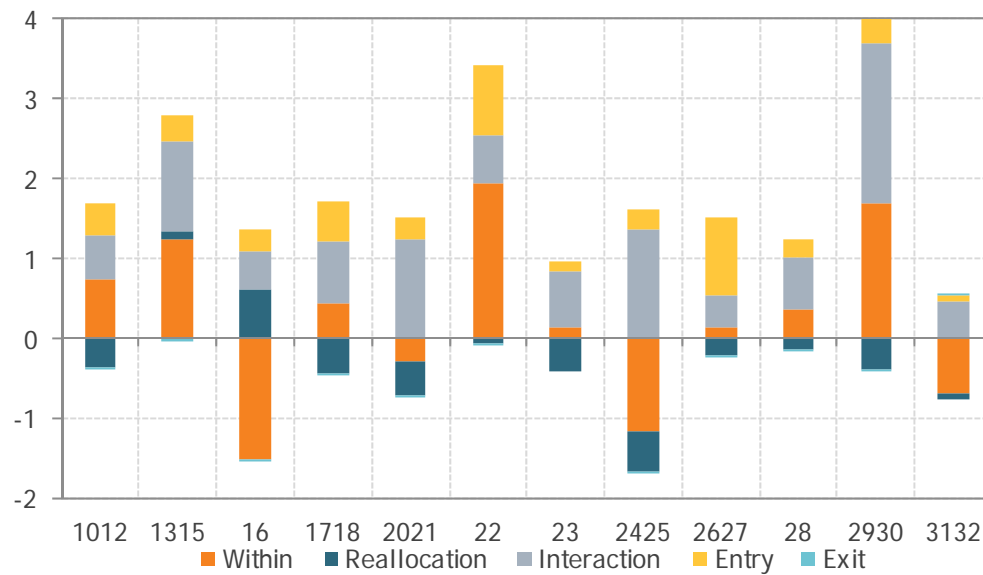


Figure 6 suggests that the interaction component is dominant in many industries. This component is rather substantial and positive in all industries, which implies that firms with positive (negative) TFP growth - on average- appear to have gained (lost) market shares. The importance of the within component is somewhat blurred by averaging over all years. This can be seen in table 5 but maybe more clearly in figure 8 which shows, for a selection of industries, the annual components of the decomposition of TFP growth (TFP index). The within component is clearly the most cyclical factor, i.e. positive in years of high economic growth and often negative in years of slow growth (notably in 2008). Figure 6 suggests almost no role for the within component in industry 29-30 (transport equipment), but as figure 8 shows this component was predominant in all years but also highly cyclical. Maybe somewhat more surprisingly, reallocation appears to have, on average, been negative in all industries. This indicates that firms with above (below) average TFP levels lost (gained) market shares. The negative reallocation component and the positive interaction component seem to indicate convergence in TFP, i.e. high-productivity incumbents witnessed slow growth in TFP and market shares and low-productivity incumbents witnessed high growth in TFP and market shares. A negative reallocation component and a substantial positive interaction component was also found for US manufacturing industries by Haltiwanger (1997) and Foster, Haltiwanger and Krizan (2001). As mentioned in the introduction, when using a decomposition procedure along the lines of Griliches and Regev (1995), the latter found a positive reallocation component. Although this method may result in a biased within component, Foster, Haltiwanger and Krizan (2001) argued that is likely to be less sensitive to measurement errors than the method that allows for the distinction between reallocation according to TFP levels (second term in equation 2) and reallocation according to TFP growth (third term in equation 2).

**Figure 7** Average of the five components of industry-level TFP (OLS) growth  
2001-2008



Note: The figure shows the average over the period 2001-2008 of the five components that result from the decomposition of annual industry-level TFP (OLS) growth (reported in table 5). A full description of the manufacturing industries can be found in table 1.

Whereas the impact of firm exit was negligible in all industries, firm entry seems to have contributed positively to industry-level TFP growth and the effect was considerable in some industries, especially in industry 26-27 (electrical and optical equipment). As can be seen in figure 8, the firm entry component was positive and substantial in all years in this industry. Although there are some obvious differences between the results of decomposition based on computed TFP and estimated TFP (e.g. the strong negative within component in industry 16 in the OLS decomposition), comparing figure 6 to figure 7, overall conclusions seem fairly similar with perhaps an even more important positive role for firm entry when considering the results of the decomposition based on estimated TFP (OLS).

Figure 8, which provides a graphical representation of the five components resulting from a decomposition of industry-level TFP (index) growth as reported in table 5, for a selection of four industries, reveals some common features but also strong differences between industries. The cyclical pattern of the within component and the strongly negative within component in 2008 is apparent in all four industries as is the generally positive interaction component and the negative reallocation component. The most notable difference is the strong entry component in industry 26-27 (electrical and optical equipment). There was a positive correlation between the entry component and industry-level TFP growth as shown in table 6, which reports the correlation between the averages of the five components and industry-level TFP growth for computed TFP (index) and estimated TFP (OLS). The components have been divided by TFP growth as in absolute terms the components will be higher (lower) the higher (lower) TFP growth is. Both alternative TFP measures provide different conclusions with even opposing signs for the reallocation and the exit components.

Figure 8 Annual components of TFP (index) growth decomposition for a selection of industries

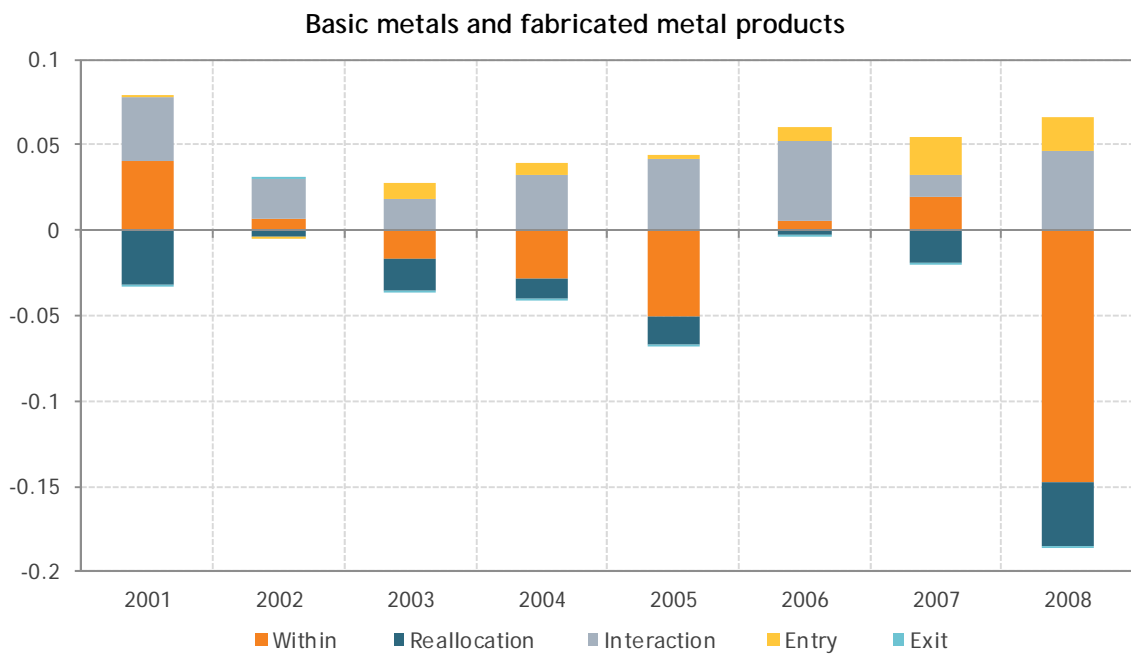
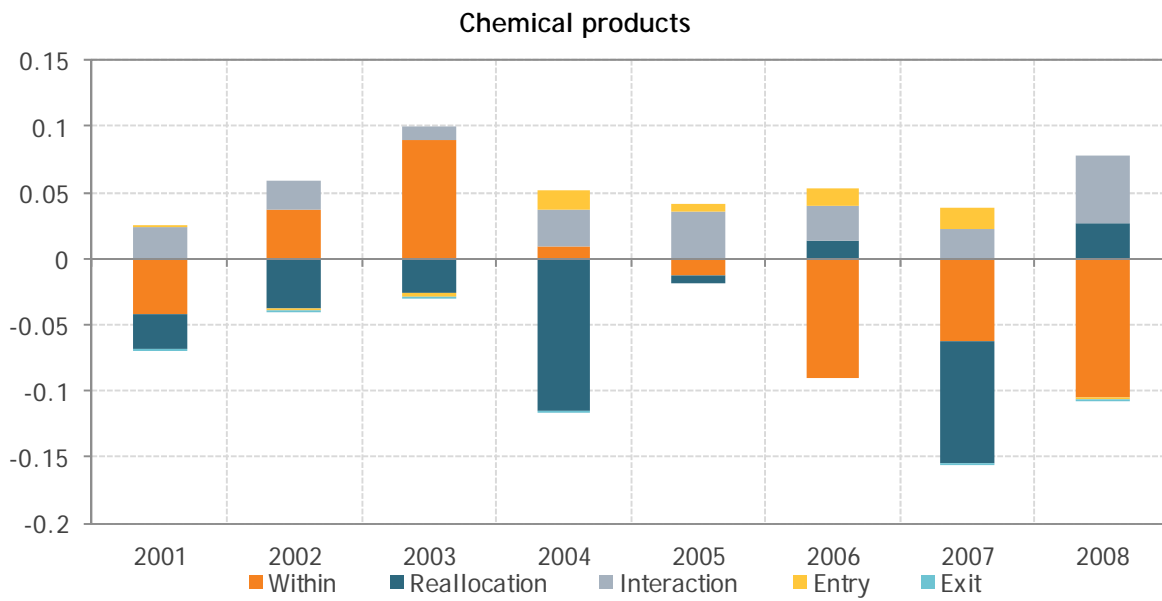
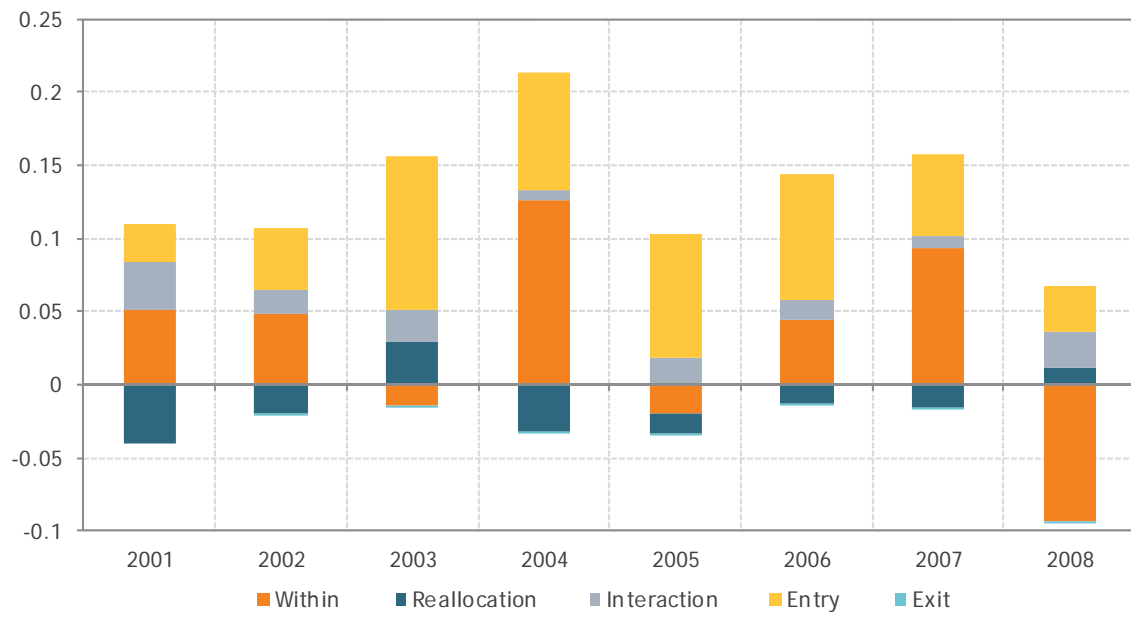


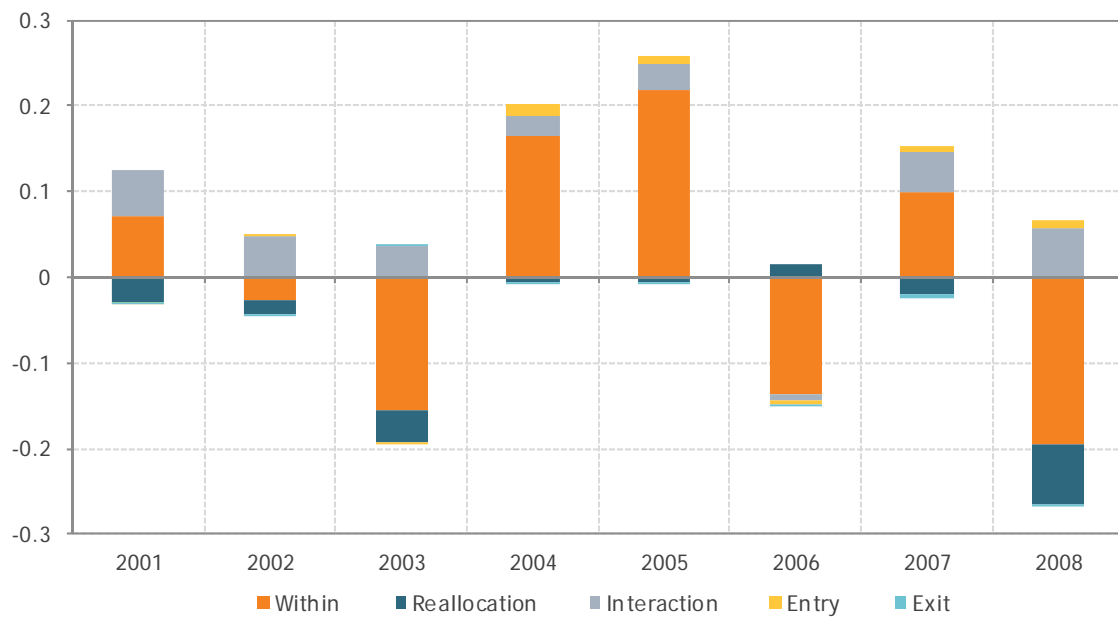


Figure 8 Continued

### Electrical and optical equipment



### Transport equipment



Note: The figure provides a graphical illustration of the components resulting from a decomposition of industry-level TFP (index) growth, as reported in table 5; for a selection of four industries.

The correlation between the entry component and industry-level TFP growth was very strong in the decomposition analysis based on the TFP index and the only correlation to be statistically significant. Figure 9 shows the link between the within and the entry component respectively and industry-level growth. Both links are positive but only the link of the entry component was statistically significant.<sup>6</sup> The productivity of entrants relative to the industry mean, as denoted by the entry component, appears to be more important to industry-level TFP growth than the relative number of entrants (i.e. number of entrants relative to number of incumbent firms). There was actually a negative correlation between the ratio of entrants to incumbents and industry-level TFP growth, both for computed and estimated TFP whereas the correlation between the numbers of firms that left a given industry and TFP growth was positive, although none of the correlations were statistically significant. The industry with the highest entry component (relative to TFP growth), i.e. industry 26-27 (electrical and optical equipment), also witnessed the highest TFP growth but was only ranked fourth in terms of the entrants to incumbents ratio whereas the industry with the second highest (relative) entry component, i.e. 13-15 (textiles, leather and footwear), witnessed the third highest TFP growth over the period 2000-2008 but had the lowest number of entrants to incumbents of all industries. In industry 26-27, as shown in table 3, 30.51% of entrants were found in the highest quartile of the TFP distribution, two years after entry.

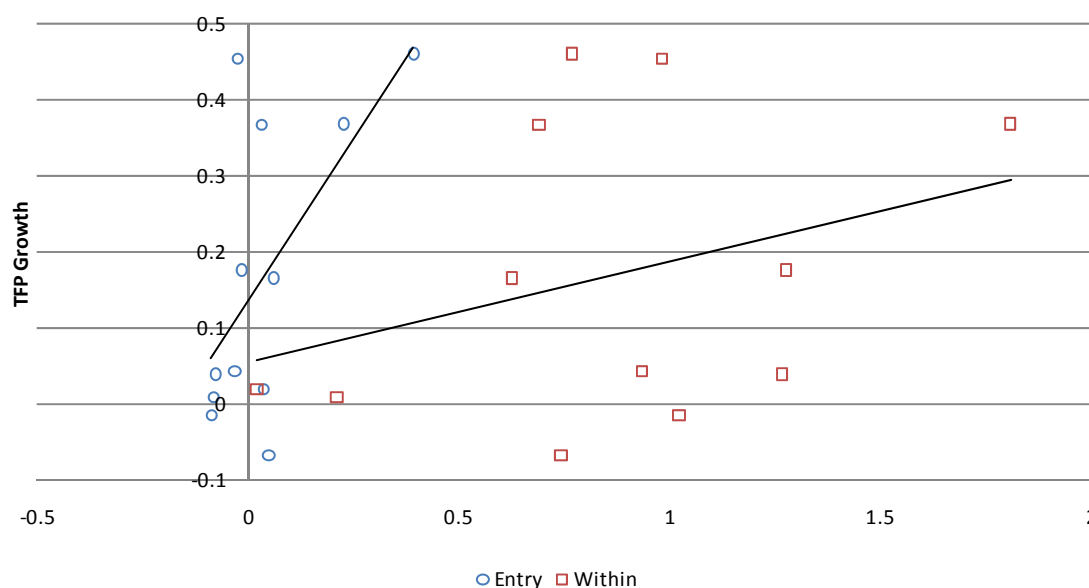
Table 6 Correlation between components (relative to TFP growth) and TFP growth for computed TFP (Index) and estimated TFP (OLS)

	Index	OLS
Within	0.33	0.13
Reallocation	-0.19	0.19
Interaction	-0.34	-0.23
Entry	0.62*	0.12
Exit	0.30	-0.34

Note: The table shows the correlation of the five components resulting from the decomposition and industry-level TFP growth (index and OLS). The five components have been divided by industry-level TFP growth as the components in absolute terms will be higher the higher TFP growth is. \* denotes statistical significance at 5%.

Figure 9 Link between respectively relative firm-level TFP growth (within component) and the relative firm entry component and industry-level TFP growth

2000-2008



Note: The figure shows the link between the within component and the entry component resulting from decomposition (both on the x-axis) and relative industry-level TFP growth (Index) over the period 2000-2008.

## 5. Conclusions

Previous empirical studies have shown that productivity differences between firms within the same industry are often considerable and rather persistent. In this paper data on firms that are established in Belgium were used to analyse the growth in total factor productivity (TFP) between 2000 and 2008, for 12 manufacturing industries. In most industries incumbent firms were - on average - technologically more efficient than entrants and the latter were - on average - more efficient than firms that stopped their activities (e.g. due to bankruptcy). In two industries, i.e. *textiles, leather and footwear* and *electrical and optical equipment*, a relatively large share of entrants was found at the higher end of the industry TFP distribution whereas in most other industries the largest share of entrants was found at the lower end of the distribution.

Given the substantial firm heterogeneity, industry-level productivity growth may be explained by differences in firm-level productivity growth as well as by changes in the market shares of firms. The Belgian firm-level data were used to decompose industry-level TFP growth into five underlying components. A first component shows the extent to which industry-level TFP growth results from changes in firm-level TFP growth for given market shares. This component provides an indication of overall changes in technological efficiency. A second component shows to what extent reallocation (i.e. changes in market shares) between firms explain industry-level TFP growth. The third component captures the interaction between changes in firm-level TFP and changes in market shares. The final two components indicate the effects of respectively firms that entered the industry and firms that left the industry.

There is a clear cyclical pattern in the first (within) component of the TFP growth decomposition, i.e. often positive in years with high demand (economic growth) and negative in years with slowing economic growth (especially in 2008). Taken at face value this suggests a decrease in technological efficiency at the firm level which seems rather improbable except for periods of transition to new technologies. A more likely explanation is that the within component captures the business cycle effect in TFP growth that results from changes in capacity utilization and labour hoarding (firms retain workers in years of falling demand) which are not accounted for. The interaction component is important and positive in many industries, suggesting that firms with positive (negative) TFP growth - on average - appear to have gained (lost) market shares. The reallocation component on the other hand was negative in many industries and years, i.e. firms with above (below) average TFP levels lost (gained) market shares. The negative reallocation component and the positive interaction component seem to indicate convergence in TFP, i.e. high-productivity incumbents witnessed slow growth in TFP and market shares and low-productivity incumbents witnessed high growth in TFP and market shares. The contribution of entrants to industry-level TFP growth was positive in most industries but only substantial in some industries, most notably in *electrical and optical equipment*. The productivity of entrants relative to the industry average appears to be more important to industry-level TFP growth than the relative number of entrants (i.e. number of entrants relative to number of incumbent firms). The impact of firm exit on industry-level TFP growth was negligible in all industries.

The analysis presented in this paper does not consider the determinants of TFP growth. Such an exercise would be worthwhile but requires the firm-level data used in our analysis to be linked to other firm-level data, e.g. on R&D expenditures, innovation and exports. It would, for instance, be interesting to see whether it is possible to assess the difference between process innovation, likely to be captured by changes in firm-level TFP growth, and product innovation which will also be reflected in changes in market shares. Biatour et al. (2011) recently assessed the impact of the determinants of industry-level TFP using a panel of 21 Belgian industries over the period 1988-2007.

Altomonte (2010) pointed out that there could be some conflict between a policy that aims to increase industry-level productivity, focusing on increasing firm-level productivity (e.g. through support for R&D activities of individual firms) or reallocation towards the more efficient firms within an industry (e.g. through competition policy) and policies supporting employment growth, which would actually benefit from reallocation towards less efficient firms, i.e. firms that require more inputs (e.g. labour) than their competitors to produce a given output. Our analysis lends some support to this view as firms that witnessed high productivity growth appear to have created value added in terms of higher average wages and profits but also decreased their relative demand for workers and capital.

## 6. References

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