Productivity Dynamics and Exports in the French Forest Product Industry[*][†]

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June 2022

Abstract

This paper investigates aggregate productivity dynamics of the French forest product industry based on firm-level data from 1994 to 2016. The main objectives of the paper are to investigate aggregate productivity growth in the industry, while taking market entry and exit into account. Further, aggregate productivity growth is investigated with respect to firms' export status and with respect to their domestic and export economic activity. Decomposing the productivity growth into the contribution of incumbent, entering, and exiting firms, the results show a considerable slowdown during the economic crisis from 2007 on, which is mainly induced by decreasing productivity improvements and inefficient resource allocation among incumbent firms. Moreover, the study shows that exporters contribute more to aggregate productivity growth than non-exporters. However, investigating the contribution of firms' domestic and export economic activities on aggregate productivity growth, I find that the aggregate productivity growth is mainly related to firms' domestic economic activity.

Keywords: production function estimation, aggregate productivity, productivity decomposition, technological change, international trade, market entry and exit.

JEL Classification: C13; C14; D24; D30; O47

[*]I would like to thank especially Bertrand Koebel and Anne-Laure Levet for precious discussions and suggestions from the beginning of the writing process. Also, I would like to thank Phu Nguyen-Van and Gérard Deroubaix, Haroun Ba, Hanitra Rakotoarison, Benoit Genere as well as the participants of seminars and conferences in Champs-sur-Marne (FCBA), Paris (Colloque ECOFOR, 2018), London (European Workshop on Efficiency and Productivity Analysis, 2019) and Nancy (Seminar BETA, 2019) for their helpful comments.

[†]The project was financially supported by FCBA (French Institute of Technology for Forest-based and Furniture Sectors) and ONF (National Forests Office, France) which I would also like to thank for providing expertise concerning the forest product industry. The paper circulated in an earlier version with the title "*Productivity Dynamics in French Woodworking Industries*".

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1 Introduction

Among all manufacturing industries, the forest product industry is probably the oldest and most traditional one, existing for centuries. At the same time it has become a key industry in coping with current and future challenges linked to climate change and the energy transition, i.e., the reduction of CO2 emissions as well as the reinforced demand for renewable resources (Lundmark, 2010). Notably, in 2013 the French government declared the domestic forest product industry, among others, part of the public action plan *"La Nouvelle France Industrielle"*, aiming to effectively tackle these challenges on a larger scale.[1]

As a result, great importance is also assigned to the French forest product industry, which requires to deepen the understanding of its economic performance and sustainability. This paper seeks to investigate the economic performance and sustainability of the French forest product industry by analysing aggregate productivity dynamics in the face of firm entry and exit by the application of the Dynamic-Olley Pakes Productivity Decomposition (DOPD, henceforth) (Melitz and Polanec, 2015). In doing so, the effect of reallocation of sales shares among firms on productivity growth is investigated, providing information about the allocative efficiency in the industry. As a second element, the paper analyses the relationship between aggregate productivity growth and export dynamics. For this purpose, I investigate differences in aggregate productivity growth dynamics w.r.t. firms' export status (i.e. exporting and non-exporting) as well as the volumes of their domestic and export activity. This breakdown is achieved by using appropriate productivity decomposition methods.

Aggregate productivity is derived from firm-level total factor productivity (TFP), which, in turn, is estimated through a Cobb-Douglas value added production function (Ackerberg et al., 2015). To estimate TFP, I use fiscal firm-level data for firms active in the French forest product industry, over the period 1994-2016. Since it is likely that the structural parameters of the production function change over such a long period, a test for structural stability is applied on the sub-periods 1994-2007 and 2008-2016. My results point to structural instability between both periods.

Beside the fact that the forest product industry is an important pillar for coping with environmental challenges, it is also important because of its economic weight withing the overall French manufacturing. More precisely, the three big manufacturing sub-sectors of the forest product industry, the manufacture of wood and wood products, the manufacture of pulp, paper, and paperboard, and the manufacture of furniture, account on average for about 5% of total turnover, 3% of total exports, and 7% of total labour demand of the overall French manufacturing industry. However, during the period from 1994 to 2016, the French forest product industry has struggled: The shares in turnover and exports relative to the overall French manufacturing industry have decreased over time. Further, compared to 1994, by 2016 the number of active firms and total labour demand has dramatically decreased, by about 30% and 40%, respectively. At the same time, value added production has only slightly increased.[2] These developments raise the serious question of whether the French forest product industry is sufficiently prepared for and oriented towards future challenges. One important element in answering this question is to shed light on productivity dynamics. To understand why this matters, consider growth in aggregate value added production, which might be induced by either growth in capital (through an aggregate increase in firm investment), labour accumulation, and/or by higher aggregate productivity. The latter component, is widely believed to be the most important driver of long-run growth and economic prosperity (Calligaris et al., 2016; Caselli, 2005). For this reason, a detailed investigation of the aggregate productivity trajectory helps to better understand the overall development of an industry.

Generally, for a given industry, aggregate productivity is most frequently measured as a weighted average of all firms' productivity, weighted by their sales shares. Aggregate productivity itself might therefore change for three reasons: (i) firms improve their own productivity, (ii) sales shares shift from less to more productive firms, and (iii) new firms enter the market, crowding out less productive firms. In the literature, (i) is referred to as *within-change* in productivity improvement and/or learning effects, occurring when firms learn to more efficiently transform inputs into output. (ii) is referred to as *between-change*, occurring when sales shares shift between firms through reallocation. From a public welfare point of view, Haltiwanger (2011) describes that an industry is well-working if it shows *allocative efficiency*, distinguishing between static efficiency, i.e. firms with higher productivity produce more, as well as dynamic allocative efficiency, i.e. over time, sales shift from less to higher productive firms. Economists, therefore, generally consider resource

[1] Official web page of the public action plan *"La Nouvelle France Industrielle"* available at https://www.gouvernement.fr/action/la-nouvelle-france-industrielle, (May, 2021).

[2] Source: own calculations. See Section 5 as well as Appendix B for further descriptive statistics.

allocation a crucial indicator for the healthiness of an industry.

Beside the analysis of aggregate productivity w.r.t. reallocation effects and entry and exit dynamics, the paper also aims to investigate the relation between aggregate productivity and international trade. This is motivated by the fact that the trade balance of the French forest product industry reveals a negative trend over the past decades accounting for about 10% of France's total trade deficit (Levet et al., 2014). The degree of forest endowment of a country is an important factor of its comparative advantage in the international trade of wooden products (Levet et al., 2015; Lundmark, 2010). Even though France is one of the best endowed countries in Europe in terms of forest area, the affiliated industry is not able to take advantage of that property. Instead, comparing the world's most important producer countries of wood products based on country-level data, Koebel et al. (2016) illustrate that the export sales share of the French forest product industry has decreased between 2000 and 2011. Importantly, in their study they also find a positive relation between an industry's aggregate productivity and its trade balance.

This study distinguishes from the above mentioned papers as it provides a detailed analysis of productivity dynamics in the light of international trade based on firm-level data, which is, to the best of my knowledge, not yet conducted for the French forest product industry. The paper aims to fill this gap using a long panel over more than two decades. This is a further key contribution to the literature as it allows to follow firms over a long time horizon, which is important for identifying technological change.

From a policy point of view, the paper aims to contribute to the discussion of how France may react to recent developments such as an increasing degree of competition on the international market of forest products, where the country lost export market shares, resulting in a considerable negative trade balance. In order to properly respond to these dynamics, profound knowledge w.r.t. firms' productivity development and export behavior is instrumental if not indispensable for the country. The literature provides many stylized facts in terms of the link between firms productivity and export behavior. For instance, numerous studies show that exporting firms are more productive already before entering in exporting but also take substantial productivity improvements once they are active in export markets (Bellone et al., 2008; Bernard and Jensen, 1999; De Loecker, 2013; Girma et al., 2004; Pavcnik, 2002). The international trade literature therefore recommends policies enabling a higher degree of international orientation of a given industry, allowing to increase its aggregate productivity and, thus, its competitiveness.

The investigation of aggregate productivity growth w.r.t. firms' export status shows that the aggregate productivity of the group of exporters grows more consistently during different periods compared to non-exporters and that exporting firms reveal a 7% to 9% higher median productivity level. However, when investigating the contribution of firms' domestic and export economic activity to aggregate productivity growth I find that domestic activity contributes considerably more compared to export activity as the French forest product industry generates most sales in the domestic market. My results therefore confirm that, all else equal, a more international orientation of the industry, both in terms of the number of exporters and in terms of export intensity, is promising for a higher and more sustainable productivity growth, which in turn would increase the country's competitiveness on the international market.

Considering all firms irrespective their export status, I find that the aggregate productivity of the French forest product industry grew considerably during the periods 1994-2000 and 2001-2007. Afterwards, during the period of economic distress, 2008-2012, the industry's aggregate productivity growth experienced a significant slowdown, which recovers over the period 2012-2016. the most important driver for these dynamics is the contribution of the group of incumbent firms.

The paper is organized as follows. Section 2 reviews the related literature, Section 3 presents the empirical framework, Section 4 describes the data, Section 5 provides descriptive statistics, Section 6 presents empirical results of the test for structural stability and the distribution of firm-level productivity, Section 7 discusses results of aggregate productivity dynamics, and Section 8 concludes.

2 Literature Review

2.1 Productivity and resource allocation

Aggregate productivity increases not only if single firms increase their productivity but also if more productive firms produce more. Moreover, new entering firms replace older and probably unproductive ones, scrapping together with surviving firms the left market shares - also known as the process of creative destruction (Schumpeter, 1942). In the literature effects of firm dynamics, in terms of market entry and exit, on aggregate productivity growth are extensively investigated by the application of various productivity decomposition methods. Baily et al. (1992) develop in their seminal work a productivity growth decomposition that allows to measure the contribution to productivity growth of the group of surviving firms - composed of the contribution through surviving firms' productivity improvement and through reallocation in output shares - as well as the contribution of the group of entering and exiting firms. Investigating the U.S. manufacturing industry for 1972-1982, they find that reallocation of market shares to more productive firms contributes considerably to aggregate productivity growth and that the effect of firm entry and exit is relatively is low. Further, Griliches and Regev (1995) and Foster et al. (2001) develop a very similar decomposition approach in the sens that they trace back firms w.r.t. changes in market shares and productivity. Griliches and Regev (1995) investigate the Israeli manufacturing for 1979-1988 and find that most of the aggregate productivity improvement comes from individual firms' productivity improvements (learning effects), where the net entry contribution to productivity growth is here also measured to be small. Foster et al. (2001) show that the results w.r.t. reallocation and entry/exit effects are sensitive to the methodology in use. Their study shows that reallocation is a very dynamic process varying cyclically with substantial differences across industries, also they show that entering firms have higher productivity compared to exiting firms, sustaining the hypothesis of creative destruction. Foster et al. (2006) analysing the U.S. retail sector in the 90's and show that the largest part of the productivity growth is due to new entering firms, replacing older low productivity firms. Foster et al. (2008) highlight the importance of distinguishing between productivity measured based on physical or revenue output when analyzing the effect of entry on aggregate productivity growth. This is because revenue productivity is likely to be positively correlated with firms' prices, i.e. a firm might be considered productive not only because it is cost-efficient but also because of setting high prices. They, therefore, argue that as young entering firms ask lower prices the effect of firm entry to aggregate productivity growth is likely to be underestimated when revenue productivity is used. Baldwin and Gu (2006) apply both the productivity decomposition described by Griliches and Regev (1995) and Foster et al. (2001) on the Canadian manufacturing industry. Both decomposition approaches reveal that most of the aggregate productivity growth is contributed by surviving firms' within productivity improvements. More recently, Melitz and Polanec (2015) present, to my knowledge, the most current productivity growth decomposition incorporating the contribution of surviving firms, reallocation effects, as well as the contribution of firm entry and exits effects. They compare their method with the ones presented by Griliches and Regev (1995) and Foster et al. (2001), and show that their method does more accurately measure the effect of surviving, entering, and exiting firms. Analysing the Slovenian manufacturing from 1995 - 2000, they find that surviving firms contribute considerably more to aggregate productivity growth compared to entrants and exitors. The study also reveals that entrants and exitors contribute negatively and positively, respectively, to aggregate productivity growth. According to their method, this implies that on the aggregate level both the group of entrants and exitors are relatively less productive compared to the group of surviving firms.[3]

Note that beside the reallocation of market shares, i.e. the allocation of firms' output within a given industry, productivity is also affected by the allocation of inputs, such as capital and labor. That is, similar to the case of the allocation of output shares, where the highest level of efficiency of a given industry would be attained if the output is produced by the most productive firms, inputs should be allocated to those firms with the highest marginal products w.r.t. to a given input factor. In this sense, Hsieh and Klenow (2009) investigate allocative efficiency of China and India and compare them as a benchmark to the United States. They find if resource allocation in China and India was as efficient as in the United States, both countries would gain in aggregate productivity between 30% - 50%, and 40% - 60%, respectively. Also See Restuccia and Rogerson (2013) reviewing the literature on missalocation and productivity as well as further studies in this stream for Italy (Calligaris et al., 2016) and Latin America (Busso et al., 2013).

2.2 Productivity and international trade

Productivity is frequently analyzed in the context of international trade in order to investigate the effect of trade policy on the aggregate productivity of a given industry. Generally, there is a consensus in the literature that exporting firms reveal higher productivity compared to firms that are only active on the domestic market. Bernard and Jensen (1999), for instance, find for the U.S. manufacturing a positive correlation between exporting firms and the level of productiv-

[3] This issue is discussed more in detail in Section 3.2.1.

ity, however, no causal evidence that exporting leads to higher productivity. Bernard and Jensen (2004) show that firms' past business success plays an important role for firms' decision to start export activity, indicating that exporting firms are already more productive, prior to engage in exporting.[4] Melitz (2003) presents a dynamic industry model with heterogeneous firms and draws the theoretic link between aggregate productivity improvements and international trade. In this model, firms that are more efficient compared to their competitors self-select to export, whereas less efficient firms remain in the domestic market, shrink and finally exit. Hansson and Lundin (2004) studying Swedish manufacturing firms in the 1990s confirm both a considerable advantage in productivity for exporting firms and a higher productivity level prior to start export activity. Pavcnik (2002) shows for the Chilean manufacturing industry that firms active in industries where goods are internationally traded improve more in terms of productivity compared to firms active in industries with no international trade. Melitz and Ottaviano (2008) develop a monopolistic model of trade with heterogeneous firms and find that aggregate productivity (average markups) are positively (negatively) related to the size of the market and to the extend the market is integrated to international trade.[5] Harris and Li (2008) investigate firms in the UK active both in the manufacturing and service sector. They apply the aggregate productivity decomposition proposed by Foster et al. (2001) and show that exporting firms contribute more to overall UK productivity growth compared to non-exporting firms. De Loecker (2013) provides further empirical evidence using Slovenian micro data and shows that firms take a substantial advantage in terms of productivity improvement when entering to export. Also see Girma et al. (2004) drawing a similar conclusion investigating UK manufacturing firms.

2.3 Studies with focus on France and/or the forest product industry

There are several studies particularly related to France in terms of productivity as well as to the forest product industry. Bellone et al. (2008) investigates productivity patterns of firms active in the French manufacturing after entry to export. Using firm-level data covering the period 1990-2002, they find that firms first tend to suffer from a decrease in productivity whereupon productivity increases, arguing that the positive effects from the entry to foreign market is not immediate but lags back. Bellone et al. (2014) investigate productivity differences w.r.t. firms' export status, both for the French and Japanese manufacturing. They show, among other results, that firms' export status matters when it comes to differences to differences in productivity between both countries. Cette et al. (2017) report a detailed analysis of the evolution of the productivity of firms active in the French economy. They find an ongoing productivity slowdown from 2000 on and point to inefficient reallocation mechanisms in the economy.[6] Ben Hassine (2019) investigates the French manufacturing and service industry in terms of aggregate productivity growth before and after the economic and financial crisis in 2007. Applying various decomposition methods he shows that there was only low aggregate productivity growth before the crisis and a decline after. Using different productivity decomposition methods he finds that aggregate productivity growth is mainly driven by individual firms' productivity improvement (learning effect or within contribution). After the crisis the within contribution is even negative, which is interpreted by the author as firms' difficulties to adapt to the changing economic environment.[7] Similarly, De Monte (2021) estimates aggregate productivity growth for French manufacturing firms over the period 1994-2016. He also finds a slowed aggregate productivity growth from 2000 on, which is mainly induced by incumbent firms' slowed reallocation process of output shares, and that net entry contributes considerably less to aggregate productivity growth compared to the contribution of incumbent firms.

Turning to more specific studies on the forest product industry, Lundmark (2010) illustrates the fast growth of international trade for forest products in Europe, where he highlights that the growth is not only due to economic growth in general but is also induced by the ongoing process of European integration, an improved transport infrastructure as well as the new demand for biofuel with regard to the energy transition. Lundmark (2010) also investigates the effect of forest endowment on the trade balance of a country, suggesting that forest endowment is a crucial factor for explaining differences in net trade between countries. That is, for a given country, a higher level of forest endowment should lead to an increase the trade balance (export - imports). Levet et al.

[4]See Bernard et al. (2003) embedding firm characteristics w.r.t. productivity and export status in a macro model to investigate the effect of globalization and other factors on productivity, firm entry and exit. Bernard et al. (2007) discuss further theoretical and empirical aspects w.r.t. firms and international trade.

[5]A firm's markup is defined as the gap between its output price and its marginal costs.

[6]Also see Bellone (2017) for a detailed discussion on the findings presented in Cette et al. (2017).

[7]Note that the French forest product industry is not included in that study.

(2014) show that the trade balance of the French forest product industry is negative, accounting for about 10% of France's total deficit. Since France is one of the best endowed countries in Europe in terms of forest surface, they speak about the French paradox: a highly negative trade balance in spite of a high degree of forest endowment. Obviously, the competitiveness of an industry is also an important determinant for success in the international market. Levet et al. (2015) present a first study on this issue, specific to the French forest product industry. They identify various aspects impacting the industry's competitiveness: (i) *resource endowment*, i.e. a higher level of resource endowment for a given country should translate into more exports, (ii) *domestic demand*, i.e. a higher domestic demand is expected to be negatively related with the industry's export intensity, and (iii) *aggregate productivity*, i.e. the higher an industry's total factor productivity, the higher its exports. Koebel et al. (2016) compare the most important European countries for trading wood products, covering the period 1995 to 2007, and also find that resource endowment as well as aggregate productivity plays a significant role in explaining the differences in net trade between countries.

3 Empirical framework

In this section I present the analytical framework of the paper. More precisely, I first present the specification and estimation procedure of the Cobb-Douglas value added production function, to finally obtain firm-level productivity estimates. Second, I illustrate the methodology to measure aggregate productivity growth linked to firm entry and exit, i.e., presenting the Dynamic Olley-Pakes Productivity Decomposition. In this section I also introduce how the relation between aggregate productivity growth and firms' exporting behavior is investigated.

3.1 Production function estimation

Consider a given manufacturing sector with N firms, indexed by n at time t. I suppose that firms transform inputs into value added output according to a Cobb-Douglas value added production function, given by

$$q_{nt} = \beta_L l_{nt} + \beta_K k_{nt} + \omega_{nt} + \epsilon_{nt}, \tag{1}$$

where q_{nt}, l_{nt}, and k_{nt} denote the log of value added production, labor, and capital input, respectively. Further, ω_{nt} denotes (unobserved) total factor productivity (TFP) and ϵ_{nt} is an error term. To consistently estimate the technology parameters, β_L and β_K, one needs to deal with the well-known endogeneity issues linked to the estimation of firm-level production functions. That is, since firms' productivity ω_{nt} is supposed to be known by firms (but unknown to the econometrician), firms' input choices are potentially correlated with ω_{nt}.[8] To overcome this problem I follow Ackerberg et al. (2015) (ACF, henceforth), using a proxy variable approach which consists in modeling material input as a function of a firm's capital input and productivity, i.e. $m_{nt} = h(k_{nt}, \omega_{nt}, \mathbf{c}_{nt})$. Thus, material input is called a proxy variable for unobserved productivity.[9] Note that $\mathbf{c}_{nt}$ is a vector of control variables affecting the optimal choice of material input. As I aim to capture differences in productivity related to market entry and exit and firms' export status, the according dummy variables as well as time dummy variables are used as controls.[10] By supposing that m_{nt} is strictly monotonic in ω_{nt}, we can take the inverse and write $\omega_{nt} = h^{-1}(k_{nt}, m_{nt}, \mathbf{c}_{nt})$. A further key assumption is that productivity follows a first-order Markov process, i.e.,

$$\omega_{nt} = g(\omega_{n,t-1}, x_{nt}, exp_{nt}) + \xi_{nt}, \tag{2}$$

where $g(\cdot)$ denotes the productivity process that depends on a firm's lagged productivity, its exit decision as well as its export status. In particular, $x_{nt} = 1$ if the firms exits in the subsequent

[8]Correlation between ω_{nt} and, for instance, labour demand l_{nt} might come through firms' anticipation of the realized productivity and the accordingly adjusted (flexible) labor demand. That is, firms' take their productivity, ω_{nt}, into account when optimally choosing their input quantities. Therefore, if we aggregated the two error components into a single, i.e. $u_{nt} = \omega_{nt} + \epsilon_{nt}$, u_{nt}, would likely be correlated with the input factors through ω_{nt}, leading to biased estimates when OLS is used.

[9]Also see Olley and Pakes (1996) (OP) who propose to use firms' investment as proxy variable for unobserved firm productivity. Instead Levinsohn and Petrin (2003) (LP) propose to rather use material inputs arguing that firms' investment might often be zero in the data, especially for small firms. While both OP and LP propose a semiparametric two step estimation approach (which is also the case for the ACF method, used in this paper) Wooldridge (2009) develops a one step parametric estimation approach. Blanchard and Mathieu (2016) compare the methods OP, LP, and ACF, using a Cobb-Douglas production function, and find that the estimated coefficients are robust w.r.t. the method in use.

[10]See De Loecker and Warzynski (2012) for a detailed discussion on the use of control variables in the context of production function estimation.

period and zero else, $exp_{nt} = 1$ if a firm exports and zero else. The exit dummy is included to control for self-selected exit (Olley and Pakes, 1996). The inclusion of the export dummy allows that exporting might impact firms' productivity and thus also controls for potential self-selection biases w.r.t. firms' export decision (De Loecker, 2013). Further, ξ_{nt} is called the innovation to productivity. By this setting, the estimation of the parameters of interest, β_L and β_K, is done in a two-step semiparametric procedure: First, replacing the productivity term in equation (1) by its proxy variable yields

$$\begin{aligned} q_{nt} &= \beta^L l_{nt} + \beta_K k_{nt} + h^{-1}(k_{nt}, m_{nt}, \mathbf{c}_{nt}) + \epsilon_{nt}, \\ &= \Phi(l_{nt}, k_{nt}, m_{nt}, \mathbf{c}_{nt}) + \epsilon_{nt}. \end{aligned} \tag{3}$$

where $\Phi(l_{nt}, k_{nt}, m_{nt}, \mathbf{c}_{nt}) \equiv \beta^L l_{nt} + \beta_K k_{nt} + h^{-1}(k_{nt}, m_{nt}, \mathbf{c}_{nt})$. Estimating in this first step $\Phi(\cdot)$ by means of nonparametric kernel regression allows to define unobserved productivity as a function of the parameters of interest as

$$\omega_{nt}(\beta_L, \beta_K) = \widehat{\Phi}(l_{nt}, k_{nt}, m_{nt}, \mathbf{c}_{nt}) - \beta_L l_{nt} - \beta_K k_{nt}. \tag{4}$$

Obtaining the innovations in productivity, ξ_{nt} by regressing $\omega_{nt}(\beta_L, \beta_K)$ on $(\omega_{n,t-1}(\beta_L, \beta_K), x_{nt}, exp_{nt})$, the parameters can be estimated in a second step using GMM, imposing the following moment conditions

$$E\left(\xi_{nt}(\beta_L, \beta_k)\begin{pmatrix} l_{n,t-1} \\ (l_{n,t-1})^2 \\ k_{it} \end{pmatrix}\right). \tag{5}$$

Note that the instruments, $l_{n,t-1}$, $(l_{n,t-1})^2$ and k_{it}, are chosen by the the so called timing assumptions: Capital and labor input are assumed to be fixed and flexible, respectively, where the latter is potentially correlated with the innovation. For this reason, lagged values are used as instruments. I use these three instruments to test for overidentification restriction, however, there are many other candidate instruments, such as material inputs, interacted variables and higher polynomials (Donald et al., 2009; Hansen, 1982).[11]

Firm-level productivity can then be recovered from the parameter estimates, given by

$$\widehat{\omega}_{nt} = q_{nt} - \widehat{\beta}_L l_{nt} - \widehat{\beta}_K k_{nt} - \widehat{\epsilon}_{nt}, \tag{6}$$

where $\widehat{\epsilon}_{nt}$ is obtained from the first step estimation, shown in equation (3).[12]

Discussion

Clearly, the specification and estimation of the production function in use matters for the estimation of firm-level productivity. In the literature, the most frequently employed production function specifications are, as in this paper, Cobb-Douglas type production functions. See for instance, De Loecker et al. (2020), Ben Hassine (2019), Cette et al. (2017), Bellone et al. (2016), Pavcnik (2002), and Olley and Pakes (1996). Certainly, the Cobb-Douglas production function is restrictive compared to more flexible specifications such as a Translog production function as it implies constant output elasticities w.r.t. inputs over all firms (see De Monte (2021) and De Loecker and Warzynski (2012) for a discussion and comparison of Cobb-Douglas type and Translog production functions). However, using a Cobb-Douglas production function also reveals some advantages as the small number of parameters to be estimated is numerically less burdensome (concerning the nonlinear second-stage GMM regression), and requires fewer instruments for identification, while the parameters are easily interpretable and comparable with other studies.

The main motivation, in this paper, for the use of a value added instead of a gross output Cobb-Douglas production function is that, as ACF show, using a gross output production function bears serious identification problems. This is because, a gross output specification comprises, beside the flexible input labor, l_{nt}, the equally flexible material input, m_{nt}. In this case, however, it can be shown that l_{nt} is "functionally dependent" on k_{nt} and m_{nt}. In other words, l_{nt} is determined by k_{nt} and m_{nt}, thus in l_{nt} there is no variation left to identify β_l. See also Gandhi et al. (2020) for a discussion on that issue. To circumvent this problem, ACF propose to use data on firms' optimization error in l_{nt}, i.e. when firms are not able to optimally chose labor input. This is the case, for example, when workers calling in sick. As they show, this introduces sufficient variation in l_{nt}, conditional on k_{nt} and m_{nt}, allowing to identify β_l. Unfortunately, the data I use does not include information on workers' sick days (nor other sources allowing to conjecture on firms' optimizing error in l_{nt}), which is why I use the value added production function specification.

[11] See Appendix C.2, Table C1, presenting the results of the production function estimation. The table also contains information of the J-Test/Hansen test for overidentification restrictions/validity of the the instruments.

[12] That is, $\widehat{\epsilon}_{nt} = q_{nt} - \widehat{\Phi}(l_{nt}, k_{nt}, m_{nt}, \mathbf{c}_{nt})$. See Appendix C.3 for information on the distribution of $\widehat{\epsilon}_{nt}$.

Testing for structural stability

The production function specified in (1) is estimated for each 4-digit sector separately. Furthermore, since it is likely that the technological parameters change over time I estimate the production function parameters for two periods, 1994-2007 and 2008-2016, and test for differences in the parameters, which is also referred to test for structural stability. For a given 4-digit sector, let $\widehat{\beta}_j = (\widehat{\beta}_{L,j}, \widehat{\beta}_{K,j})'$ with $j = \{1, 2\}$ be the estimated production function parameters associated with the two sub-periods. To test for structural stability I apply a Wald-type test with the test statistic given by

$$W_T = \left(\widehat{\beta}_1 - \widehat{\beta}_2\right)' (\widehat{V}_1 + \widehat{V}_2)^{-1} \left(\widehat{\beta}_1 - \widehat{\beta}_2\right), \tag{7}$$

where $\widehat{V}_1$ and $\widehat{V}_2$ are the bootstrapped (2×2) variance-covariance matrices belonging to $\widehat{\beta}_1$ and $\widehat{\beta}_2$, respectively. The test statistic W_T follows a $\chi^2(r)$ distribution, with $r = 2$ a degree of freedom equal to the number of parameter restrictions (Andrews and Fair, 1988).

3.2 Aggregate productivity growth, firm entry and exit, and export status

The paper's motivation and contribution is its detailed analysis of aggregate productivity dynamics and its decomposition w.r.t. different groups of firms. In particular, I aim to show to which extend the group of survivors, entrants, and exitors, contribute to aggregate productivity growth. Moreover, I aim to relate aggregate productivity growth to firms' export behavior. In the following I present the decomposition methods to achieve these objectives. Note that for notational convenience, I drop the hat over $\widehat{\omega}_{nt}$, denoting the estimate of firms' productivity level, described in (6).

3.2.1 Aggregate productivity decomposition w.r.t. market entry and exit

Olley and Pakes (1996) present a static approach to measure aggregate productivity for a given industry and year, by

$$\begin{aligned} \Omega_t &= \sum_{n}^{N_t} s_{nt}\omega_{nt} = \bar{\omega}_t + \sum_{n}^{N_t} (s_{nt} - \bar{s}_t)(\omega_{nt} - \bar{\omega}_t) \\ &= \bar{\omega}_t + N_t cov(s_{nt}, \omega_{nt}), \end{aligned} \tag{8}$$

where the first equality is the weighted average productivity, weighted by firms' sales shares, s_{nt}. The second and third equality separates the weighted average into and unweighted productivity average, $\bar{\omega}_t = N_t^{-1} \sum_{n=1}^{N_t} \omega_{nt}$, and the covariance between firms' productivity and their sales share. Note that N_t denotes the number of active firms for a given industry at t and $\bar{s}_t = 1/N_t$ the average sales share. Considering the aggregate productivity growth between two periods, i.e. $\Delta\Omega = \Omega_t - \Omega_{t-1}$, it can be shown that the growth is transmitted by individual firms' productivity improvement, i.e. by a change in the unweighted average productivity $\Delta\bar{\omega}$, and by sales share reallocation among firms, i.e, by a change in the covariance of sales shares and firm level productivity $\Delta cov(s_{nt}, \omega_{nt})$. Aggregate productivity growth induced by individual firms' productivity improvements and sales share reallocation is referred to "within-change" and "between-change", respectively. In a dynamic setting, where firm entry and exit is taken into account, $\Delta\Omega$ can be expressed by the sum of changes in aggregate productivity w.r.t. the groups of surviving, entering and exiting firms. To measure the contribution of each group I adopt the Dynamic Olley-Pakes Decomposition (DOPD, henceforth) (Melitz and Polanec, 2015).[13] As already pointed out by Griliches and Regev (1995), entering and exiting firms can have a positive or negative contribution to aggregate productivity depending on the considered reference level of productivity. For instance, if the reference level is given by the aggregate productivity of surviving firms, entering firms reduce the overall aggregate productivity if that group's aggregate productivity is lower than the aggregate productivity of the group of surviving firms. Similarly, the disappearance of a group of exiting firms will reduce the overall aggregate productivity if that group's aggregate productivity is higher compared the aggregate productivity of the reference group of surviving firms. In that spirit, the DOPD approach models aggregate productivity with entry and exit in the following way: Let $S_{Gt} = \sum_{n \in G} s_{nt}$ denote the aggregate sales share of a group G, where $G = (E, S, X)$ indexes the group of entrants, survivors,

[13] See De Monte (2021) for an application of the DOPD approach on various French 2-digit manufacturing industries.

and exitors. A group's aggregate productivity is then defined by $\Omega_{Gt} = \sum_{n\in G}(s_{nt}/S_{Gt})\,\omega_{nt}$. Considering the aggregate productivity of two periods, where the aggregate productivity at $t = 1$ and at $t = 2$, Ω_1 and Ω_2, is given by

$$\Omega_1 = S_{S1}\Omega_{S1} + S_{X1}\Omega_{X1} = \Omega_{S1} + S_{X1}(\Omega_{X1} - \Omega_{S1}) \tag{9}$$
$$\Omega_2 = S_{S2}\Omega_{S2} + S_{E2}\Omega_{E2} = \Omega_{S2} + S_{E2}(\Omega_{E2} - \Omega_{S2}). \tag{10}$$

That is, Ω_1 is composed of the weighted sum of aggregate productivity of the groups of firms surviving and exiting until $t = 2$. Instead, Ω_2 is composed of the weighted aggregate productivity of the firms having survived and the new firms that have entered the market at $t = 2$. Taking the difference between (9) and (10) we obtain the growth in aggregate productivity between two arbitrary time points, given by

$$\begin{aligned}\Delta\Omega &= \underbrace{(\Omega_{S2} - \Omega_{S1})}_{\text{Survivors}} + \underbrace{S_{E2}(\Omega_{E2} - \Omega_{S2})}_{\text{Entrants}} + \underbrace{S_{X1}(\Omega_{S1} - \Omega_{X1})}_{\text{Exitors}} \\ &= \Delta\bar{\omega}_S + \Delta N_S cov_S + S_{E2}(\Omega_{E2} - \Omega_{S2}) + S_{X1}(\Omega_{S1} - \Omega_{X1}). \end{aligned} \tag{11}$$

Here, the contribution of surviving firms is further decomposed into the within- and between-change, derived by Olley and Pakes (1996). As can be seen, entrants only contribute positively to aggregate productivity change if their aggregate productivity at $t = 2$ is higher compared to the aggregate productivity of survivors at $t = 2$ $(\Omega_{E2} - \Omega_{S2})$. The group of exitors only contribute positively to aggregate productivity change if their aggregate productivity at $t = 1$ is lower compared to the aggregate productivity of surviving firms at $t = 1$ $(\Omega_{S1} - \Omega_{X1})$.

3.2.2 Aggregate productivity decomposition w.r.t. firms' export status and firms' export activity

As a first step, to relate aggregate productivity growth to firms' export status, I apply equation (11) separately to the group of non-exporters and exporters. In this way it can be investigated how aggregate productivity growth within each of the two firm types, and to which extend firm survival, entry, and exit affects or contributes to the aggregate growth. This approach is very much in line with Harris and Li (2008), who only use a slightly different productivity decomposition.

However, most exporting firms realize the highest share output sales in the domestic market. To disentangle the contribution of domestic and export activity to aggregate productivity growth I adapt the Olley-Pakes productivity decomposition. As presented in equation (8) the aggregate productivity, of a given industry, is measured by a weighted average, where firms' sales shares, s_{nt}, serve as weights. Here, a firm's sales share is measured by its gross output over total output - where deflated sales are used as proxy for gross output. Generally, a firm's total amount of output is distributed through domestic and export activity, say Y^d_{nt} and Y^{exp}_{nt}, respectively. Therefore, a firm's sales share is composed of the share related to domestic and export activity, too. Formally,

$$s_{nt} = \frac{Y^d_{nt}}{Y_t} + \frac{Y^{exp}_{nt}}{Y_t} = s^d_{nt} + s^{exp}_{nt}, \tag{12}$$

where $Y_t = \sum_n^{N_t}(Y^d_{nt} + Y^{exp}_{nt})$ denotes total sales of a given industry at t. Firms that are only active in the domestic market are characterized by $s^d_{nt} > 0$ and $s^{exp}_{nt} = 0$. Plugging (12) into (8), we obtain

$$\begin{aligned}\Omega_t &= \sum_n^{N_t}(s^d_{nt} + s^{exp}_{nt})\omega_{nt} \\ &= \sum_n^{N_t} s^d_{nt}\omega_{nt} + \sum_n^{N_t} s^{exp}_{nt}\omega_{nt} \\ &= \underbrace{N_t\bar{s}^d_t\bar{\omega}_t + \sum_n^{N_t}\left(s^d_{nt} - \bar{s}^d_t\right)(\omega_{nt} - \bar{\omega}_t)}_{\Omega^d_t} + \underbrace{N_t\bar{s}^{exp}_t\bar{\omega}_t + \sum_n^{N_t}\left(s^{exp}_{nt} - \bar{s}^{exp}_t\right)(\omega_{nt} - \bar{\omega}_t)}_{\Omega^{exp}_t}\end{aligned} \tag{13}$$

where Ω^d_t and Ω^{exp}_t denote the parts of an industry's aggregate productivity generated from firm's domestic and export activity. Each of these two components is further decomposed into a simple average productivity term, weighted by the respective groups sales share, given by $(N_t\bar{s}^i_t$ with

$i = \{d, exp\}$), and the covariance term. Note that while it is possible to disentangle a firm's sales share into the part related to domestic and export activity, its productivity cannot be separated into these two components since it is measured based on its overall output (value-added).

Aggregate productivity growth based on the decomposition shown in the third equality of equation (13) is determined by taking the difference between two arbitrary points in time, $t = 2$ and $t = 1$, which yields

$$\begin{aligned}\Delta\Omega &= \Omega_2 - \Omega_1 \\ &= \underbrace{\Delta N \bar{s}^d \bar{\omega}}_{W^d} + \underbrace{\Delta \sum_{n=1}^{N} \left(s_n^d - \bar{s}^d\right)(\omega_n - \bar{\omega})}_{B^d} + \underbrace{\Delta N \bar{s}^{exp} \bar{\omega}}_{W^{exp}} + \underbrace{\Delta \sum_{n=1}^{N} \left(s_n^{exp} - \bar{s}^{exp}\right)(\omega_n - \bar{\omega})}_{B^{exp}},\end{aligned} \tag{14}$$

where W^i and B^i with $i = \{d, exp\}$ denote the within and between contribution to aggregate productivity, related to firms' domestic and export activity. If between two periods, the aggregate sales shares of domestic and export activity remains constant, an increase in the unweighted average productivity, i.e. $\Delta\bar{\omega} > 0$, yields positive within contribution of both domestic and export activity. However, if, for instance, the aggregate sales shares sufficiently decreases, an increase in the average productivity might be absorbed by that change in aggregate sales share.[14]

An important remark is that when applying this decomposition, I only consider firms that have survived in the market between $t = 1$ and $t = 2$. In this way, growth contribution and reallocation effects among firms active in the domestic and export market are not affected by the appearance of new entering firms.

4 Data and variables

I use French fiscal firm-level data of firms active in the forest product industry, covering the period 1994 - 2016. Table 1 below lists the considered 4-digit sectors. The choice of the 4-digit sectors is made in order to cover a representative part of both the first level of wood transformation - given by the manufacture of wood, and products of wood and cork - and the second level of wood transformation - i.e. the manufacture of pulp, paper, and paperboard as well as the manufacture of furniture. The data contains information based on firms' balance sheet and income statement, where each firm is identified by a specific identification number (code siren). Moreover, the data is composed of the two fiscal datasets FICUS (1994 - 2007) and FARE (2008 - 2016). It is important to mention that in 2008 the French Institute of Statistics (INSEE) made significant modifications w.r.t. the 4-digit sector nomenclature firms belong to. That is, the sector a firm belongs to is differently classified in FICUS (according to NAF, révision 1) and FARE (according to NAF, révision 2, 2008).[15] To maintain the current nomenclature used in FARE throughout the whole period, i.e. from 1994 to 2016, I adopt the following method: I first calculate transition probabilities of those firms observed both in FICUS and FARE. That is, I calculate the probability of firms transiting from a specific sector of the former nomenclature (until 2007) to the current nomenclature (from 2008 on). The obtained transition probabilities are then used to assign to those firms that are only observed in FICUS (in case of firm exit before 2008) by probability the current sector classification. In this manner I obtain a sample consistent in the current 4-digit sector classification through out the whole sample period, allowing to trace back an sector's evolution until 1994.[16] Note that I only consider firms that report at least 5 employees in order to prevent estimates to be distorted by the very large number of small firms, likely to contain measurement errors. In addition, I only keep firms reporting positive values in value added, capital, and materials, which is motivated by the fact that these variables are required to be positive to estimate the logarithmized Cobb-Douglas

[14] Consider the following simple example. The log average productivity, common for both domestic and export activity, is given by $\bar{\omega}_{t-1} = 1$ and $\bar{\omega}_t = 1.1$, representing a 10% increase. The constant aggregate sales share for domestic and export activity are given by $N_t\bar{s}^d_{t-1} = N_t\bar{s}^d_t = 0.7$ and $N_t\bar{s}^{exp}_{t-1} = N_t\bar{s}^{exp}_t = 0.3$, respectively. Hence, $W^d = 0.7 \cdot 1.1 - 0.7 \cdot 1.0 = 0.07$ and $W^{exp} = 0.3 \cdot 1.1 - 0.3 \cdot 1.0 = 0.03$, where $W^d + W^{exp} = 0.1$. If, however, aggregate sales shares also change, for example, the aggregate export share drops from 0.3 at $t-1$ to 0.2 at t, then we obtain $W^d = 0.8 \cdot 1.1 - 0.7 \cdot 1.0 = 0.18$ and $W^{exp} = 0.2 \cdot 1.1 - 0.3 \cdot 1.0 = -0.08$. That is, the drop in export activity absorbs the productivity improvement, leading to a negative within contribution related to export activity.

[15] Note that FICUS and FARE refer to "fichier de comptabilité unifié dans SUSE" and "fichier approché des résultats d'Esane", respectively. That is, FICUS was part of the French firm-level database SUSE. In 2008, FICUS was replaced by FARE, which, in turn, belongs to the database Esane. The French industry classification NAF refers to "nomenclature d'activités françaises".

[16] See Appendix A.1 for a more detailed description of the combination of the data sets FICUS and FARE, where also an exemplary transition matrix is presented.

value added production function. In doing so, for the period 1994-2016, the treated sample contains 13,509 firms summing up to 112,159 observations (see Table 1). This represents about 85% of total value added production and about 95% of total turnover w.r.t. the total forest product industry.[17]

Table 1: Description of 4-digit forest product sectors

Sector^{a,b}	Description	# Firms	# Obs.
16	**Manufacture of wood and products of wood and cork**		
1610	Sawmilling and planing of wood	2,463	21,778
1621	Manufacture of veneer sheets and wood-based panels	197	1,923
1622	Manufacture of assembled parquet floors	48	360
1623	Manufacture of other builders' carpentry and joinery	1,825	14,396
1624	Manufacture of wooden containers	1,276	11,846
1629	Manufacture of other products of wood	722	5,670
17	**Manufacture of pulp, paper, and other products of paper**		
1711	Manufacture of pulp	14	128
1712	Manufacture of paper and paperboard	270	2,532
1721	Manufacture of corrugated cardboard/cardboard/paper packaging	1,021	10,549
1722	Manufacture of paper products of domestic/health usage	90	718
1723	Manufacture of paper stationery	216	1,993
1724	Manufacture of wallpaper	16	132
1729	Manufacture of other products paper/cardboard	511	5,146
31	**Manufacture of furniture**		
3101	Manufacture of office and shop furniture	1,186	10,044
3102	Manufacture of kitchen furniture	625	5,004
3109	Manufacture of other furniture	3,029	19,940
Total		13,509	112,159

a) Statistical classification of economic activities in the European Community, Rev. 2 (2008)

b) Because of a low number of observations the following sectors are aggregated: 1621 and 1622 (1621/22), 1711 and 1712 (1711/12), 1721 and 1722 (1721/22), as well as 1723, 1724, and 1729 (1723/24/29).

4.1 Production function and export variables

Since I am mainly interested in the estimation of a value added Cobb-Douglas production function to recover firm-level productivity estimates, I describe in the following the variables necessary for this purpose. Beginning with the production input factors. Firms' log capital stock, labor, and intermediary products (materials), denoted by k_{nt}, l_{nt}, and m_{nt}, consists in firms' log amount of tangible assets, number of workers, and intermediary products consumption. The latter is given by the sum of firms' expenditures for both raw materials and intermediary products. Firms' (deflated) value added production is denoted by $Q_{nt} = Y_{nt} - M_{nt}$, where Y_{nt} and M_{nt} represent firms' (deflated) gross output (firms' reports on annual sales) and materials. Note that q_{nt} denotes the log value of firms' value added output. Y^d_{nt} and Y^{exp}_{nt} denote a firm's sales on the domestic and export market. A firm is called and exporter only if $Y^{exp}_{nt} > 0$.[18] For the year 2008 firms' export values are not available from the data. This year will therefore be excluded for the analysis related to aggregate productivity growth and firms' export behavior.

4.2 Definition of firm entry and exit

4.2.1 Definition of entry and exit year by year

The number of firms in the data varies for three reasons: first, firm entry and exit, second temporal inactivity and third, nonresponse. The latter reason is not frequently observed since firms' participation in the survey is mandatory. Instead, temporal inactivity, i.e cases in which firms are not observed for given interval, whereupon they reactivate their activity, is more frequently observed. However, the data also shows that this is more often the case for shorter intervals. In order to allow consistent analysis on firm entry and exit I adopt the following approach:[19] Let $a_{nt} \in \{0, 1\}$ be a binary variable, taking the value 0 in case of inactivity, and 1, if the firm is active. A firm is

[17] See Appendix A.2 for details on the raw data, illustrating the loss of observations when only keeping firms reporting at least 5 employees.

[18] Note that to obtain real values I deflate all monetary variables by a corresponding 2-digit industry price index. For each firm and industry, I know the imbrication $n \in \mathcal{N}_4 \subseteq \mathcal{N}_2$, where $\mathcal{N}_2$ and $\mathcal{N}_4$ denote the set of firms within the 2- and 4-digit sectors respectively. The sectoral price data are available at https://www.insee.fr/fr/statistiques/2832666?sommaire=2832834, (May, 2021).

[19] See Blanchard et al. (2014) for a similar approach.

said to be active at t, if it reports nonmissing or nonzero data for one of the following variables: total production, sold production, turnover, net profit. In all other cases the firm is supposed to be inactive. Further, survival is denotes by $s_{nt} \in \{0,1\}$ with $s_{nt} = 1$ if $a_{n,t-1} = a_{nt} = a_{n,t+1} = 1$. Entry is denoted by $e_{nt} \in \{0,1\}$ with $e_{nt} = 1$ if $a_{n,t-1} = 0$ and $a_{nt} = a_{n,t+1} = 1$. Exit is denoted by $x_{nt} \in \{0,1\}$ with $x_{nt} = 1$ if $a_{n,t-1} = a_{nt} = 1$ and $a_{n,t+1} = 0$. The status of firms that are active between two periods of inactivity is not identified since the firm could both entrant and exitor. For this case I define $u_{nt} \in \{0,1\}$ and takes the value 1 if $a_{n,t-1} = 0$, $a_{nt} = 1$ and $a_{n,t+1} = 0$.[20]

4.2.2 Definition of entry and exit between time-spans longer than one year

The above method to define entry and exit is based on a yearly basis, which is a very useful measure for presenting entry and exit patterns from year to year, as we will see in the following section. However, since it would take two much space to present all results as, for instance, aggregate productivity growths rate on a yearly basis over the whole sample period, I will also provide results spanning over periods longer than one year. For this purpose I need to slightly extend the above definition of entry and exit to the case of entry and exit over time spans longer than one year: Let t_1 and t_2 be two periods in time with $t_1 < t_2$. A firm is defined as a survivor from t_1 to t_2 if the firm is active both at t_1 and at t_2. Furthermore, a firm is defined as an exitor if the firm has exited the market, i.e. $x_{nt} = 1$, for some t with $t_1 \leq t < t_2$ and if the firm was active at t_1 but inactive at t_2. Moreover, a firm is defined as an entrant if the firm has entered the market, i.e. $e_{nt} = 1$, for some t with $t_1 < t \leq t_2$ and if the firm was inactive at t_1 but active at t_2.

Remark 1

It is important to notice that the year by year definition for firm entry and exit, presented in Section 4.2.1, does not identify any surviving, entering or exiting firm for the very first and last year of the sample period, i.e., 1994 and 2016. Instead, the definition for firm entry and exit between longer time periods, presented in Section 4.2.2, allows to identify those firms that survive and exit from the the initial year until the last year of a given period as well as to identify those firm that enter between the initial and the last year. This is important in particular for the analysis of the DOPD described in Section 3.2.1.

Remark 2

Firms that fall below or pass over the threshold of five employees are not counted as entrants or exitors. That is, firms' activity status of either survivor, entrant, or exitor is determined before dropping any observation, guaranteeing not to count abundant firm entry and exit.

5 Descriptive statistics

This section provides some descriptive statistics to present the treated data, highlighting the most important variables for the purposes of the paper.

Table 2 presents averages over all years (1994-2016) w.r.t. firm size groups. The table shows that the share of firms in the sample is decreasing in firm size. The largest share of firms is represented by the group reporting between 5 and 9 employees, given by about 37%. Instead, the group of large firms, reporting 500 employees and more, represents less than 1% of all firms in the sample. The firm size group between 20 and 49 employees detain the largest share of workers in the sample, given by about 19%, followed by the group with 500 and more employees, representing about 18%. Also, it can be seen that this latter group detains the largest share of turnover, given by about 24%. The table also shows that average entry and exit rates are decreasing in firm size. Instead, the rate of exporters, i.e. the percentage of exporting firms, increases in firm size.

[20] Note that $u_{nt} = 1$ if and only if $s_{nt} = e_{nt} = x_{nt} = 0$, that is, the firm is not identified as survivor, entrant or exitor.

Table 2: Summary statistics w.r.t. firm size: averages from 1994-2016[a,b]

Size group[c]	# of firms	Share of firms	Share of empl.	Share of turnover	Entry rate	Exit rate	Share of exporters	Age
5-9	1746	37.40	6.77	4.14	5.11	5.02	27.40	16.02
10-19	1201	25.73	9.46	6.66	4.04	4.54	45.20	19.26
20-49	1081	23.16	19.43	15.47	2.56	3.02	63.70	22.65
50-99	315	6.75	12.54	10.96	2.55	3.22	79.90	26.26
100-199	177	3.79	14.21	14.74	2.22	3.22	89.80	27.78
200-499	113	2.42	19.34	23.92	2.07	2.87	92.30	26.80
500+	35	0.75	18.26	24.11	1.79	1.92	99.40	27.64
TOTAL	4668	100.00	100.00	100.00	3.86	4.17	48.41	19.87

[a] All figures represent averages over the whole period 1994-2016.
[b] Shares and rates are given in %.
[c] Size group is given in terms of number of employees.

Table 3 reports the same average statistics, here, however, w.r.t. the different 4-digit forest product sectors. The biggest sector in terms of number of firms is given by the sector sawmilling and planing of woods (1610), which contains about 19% of all firms, whereas the smallest sector is given by the manufacture of veneer sheets/wood-based panels/parquet floors (1621/22) and the manufacture of pulp and paper (1711/12), containing both only about 2% of all firms. In terms of turnover, the biggest sector is given by the the manufacture of cardboard/packaging/etc. (1721/22), producing by about 25% of total turnover, whereas the smallest sector is represented by the manufacture for wooden containers (1629), given by somewhat less than 2% of total turnover. Table 3 also exhibits that entry and exit rates vary across sectors, ranging between 3.1% and 5.6%. The share of exporting firms varies considerably across sectors: For instance, the manufacture of pulp and paper (1711/12) reveals the highest share of exporting firms, given by about 83%. In contrast, the sector of other builders' carpentry and joinery (1623) shows a much lower share of exporters, given by only about 23%. Moreover, Figure 1 presents the evolution of important

Table 3: Summary statistics w.r.t. 4-digit sectors: averages from 1994-2016[a,b]

Sector[c]	# of firms	Share of firms	Share of empl.	Share of turnover	Entry rate	Exit rate	Share of exporters	Age
1610	907	19.43	9.35	8.06	3.78	3.64	50.56	20.86
1621/22	95	2.04	4.12	5.15	3.21	3.49	68.76	22.06
1623	599	12.83	9.54	7.47	5.06	4.63	23.14	17.58
1624	493	10.56	6.97	5.65	3.48	3.46	50.91	20.10
1629	236	5.06	2.72	1.94	3.19	4.45	56.19	20.95
1711/12	110	2.36	11.12	20.14	3.64	3.76	83.14	21.59
1721/22	469	10.05	21.86	25.19	2.72	3.67	66.61	24.05
1723/24/29	302	6.47	7.51	7.67	2.84	3.14	68.58	22.34
3101	418	8.96	8.43	6.36	4.46	4.27	43.72	18.17
3102	208	4.46	4.65	3.60	3.90	3.64	29.02	17.18
3109	830	17.78	13.73	8.75	4.33	5.62	43.22	17.94
Total	4667	100.00	100.00	100.00	3.86	4.17	48.40	19.90

[a] All figures represent averages over the whole period 1994-2016.
[b] Shares and rates are given in %.
[c] 1610 - sawmilling/wood planning, 1621/22 - veneer sheets/wood-based panels/parquet floors, 1623 - other builders' carpentry/joinery, 1624 - wooden containers, 1629 - other products of wood, 1711/12 - pulp, paper, and paperboard, 1721/22 - cardboard/packaging/paper for domestic and health usage, 1723/24/29 - other products of paper, 3101 - office/shop furniture, 3102 kitchen furniture, 3109 - other furniture.

aggregated variables, i.e. value added, labor and capital, as well as exports. The time series for each variable represent sums over all firms in the sample, normalized to 100 for the initial year 1994. The graph shows that the demand for capital, represented by the dashed line, has increased throughout the whole period, where the aggregate level in 2016 exceeds the level in 1994 by 45.7. Aggregate exports of the forest product industry, given by the solid line, have increased until 2007, whereupon a sharp decrease took place - obviously related to the economic and financial crisis hitting the world economy at that time. From about 2009 on exports increase again, reaching a level of 133.4 w.r.t. 1994. Aggregate value added production, represented by the dotted line, has also increased until 2007 whereupon total value added consistently decreases. In 2016, the industry's total value added only accounts for 111.0 w.r.t. 1994. Lastly, aggregate labor (the number of workers over all firms), represented by the bottom line, shows the strongest negative trend, where in 2016 total labor only accounts for about 60.4 relative to the initial level in 1994.[21]

[21] See Appendix B, Figure B2 for the evolution of aggregate value added, export, and inputs separately for each of the considered 4-digit sectors.

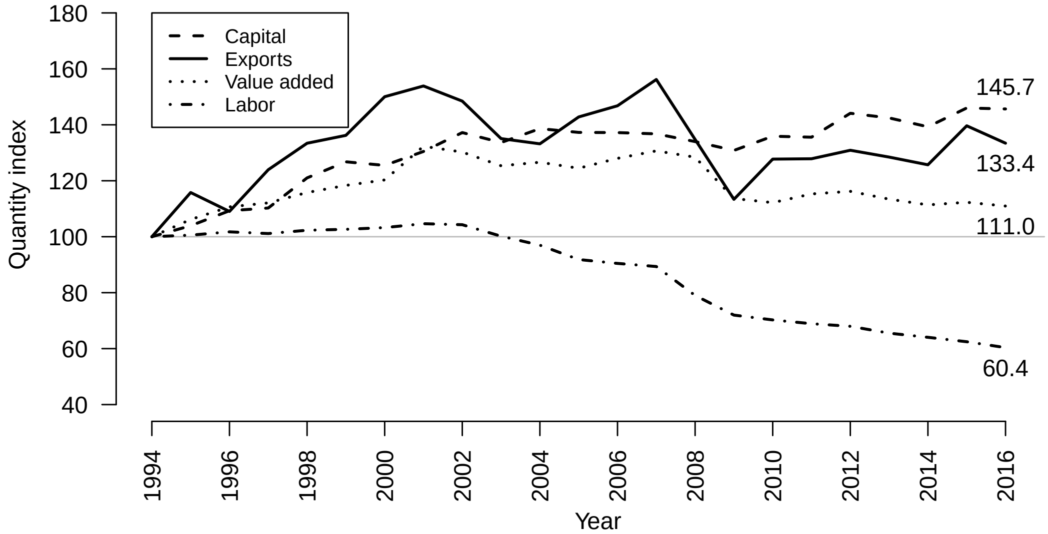

Figure 1: Aggregate production, exports, and inputs over time

Since firm entry and exit is a crucial aspect in this paper, Figure 2 illustrates the evolution of the number of active firms and the corresponding entry and exit rate. The number of firms (with at least five employees), represented by the dashed line (with the corresponding values on the left y-axis), remains relatively stable until 2007/2008, whereupon a significant negative trend has taken place. In fact, in 2016 the number of active firms only accounts for about 70% w.r.t. 1994, which translates into a (negative) average annual growth rate of about -1.5%.[22] This trend is also reflected in the entry and exit patterns, represented by the solid and dotted lines (with the corresponding y-axis on the right), respectively. Until 2007/08 both the entry and exit rate oscillate at a similar level, whereas from 2008 on the exit rate lies consistently above the entry rate.

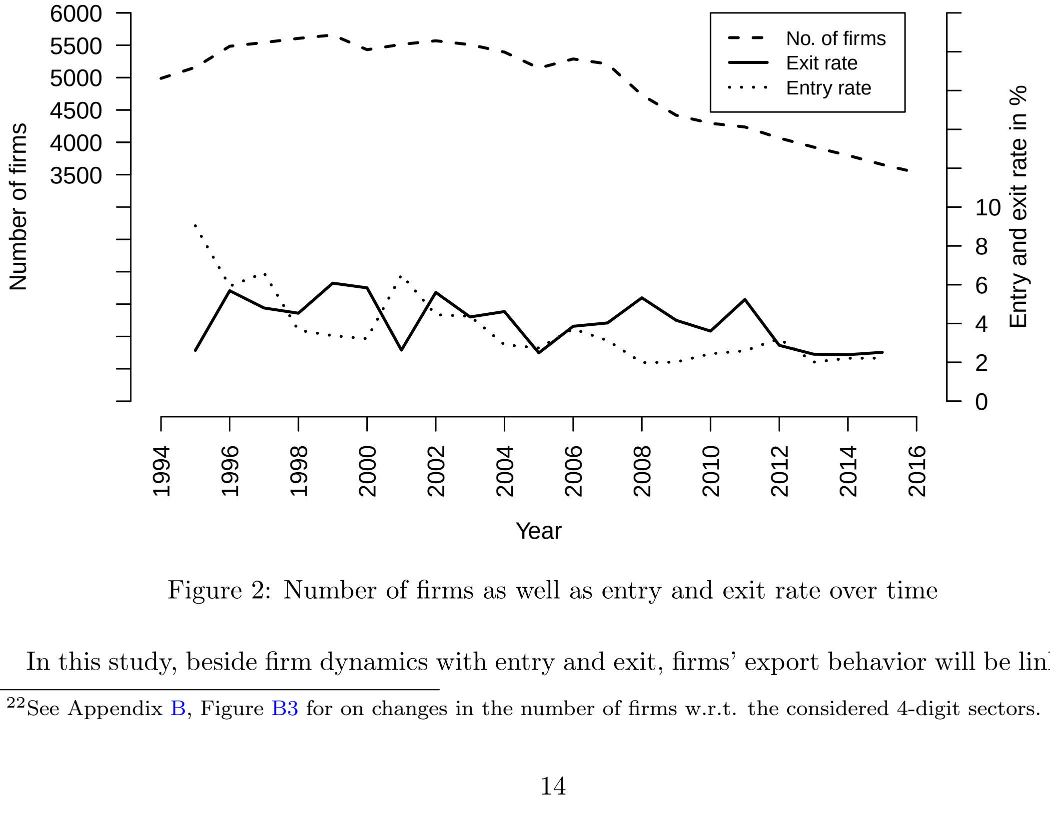

Figure 2: Number of firms as well as entry and exit rate over time

In this study, beside firm dynamics with entry and exit, firms' export behavior will be linked to

[22]See Appendix B, Figure B3 for on changes in the number of firms w.r.t. the considered 4-digit sectors.

aggregate productivity growth. To provide some basic information on the export behavior of firms active in the French forest product industry Table 4 reports, for different periods, the share of exporters (columns 2) as well as the distribution of firms' share of exported production w.r.t. their total production (column 3-5). More precisely, the average share of exporters generally slightly increases from 48.1% for the period 1994-2000 to 50.8% for the period 2013-2016. Moreover, the share of firms' export sales w.r.t. their total sales also slightly increases over time. That is, while for the period 1994-2007 75% (99%) of all firms export 5.5% (77.5%) or less w.r.t. their total production, for the period 2013-2016 75% (99%) of all firms export 6.9% (84.8%) or less. This means that most of the firms in my sample produce mainly for the domestic market.

Table 4: Firms' export characteristics

		Distribution of firms' exports w.r.t. their total production				
Period	Share of exporters	50%	75%	90%	95%	99%
1994-2000	48.14	0.00	5.52	25.97	44.54	77.54
2001-2007	47.54	0.00	6.00	29.26	51.11	80.68
2009-2012	49.01	0.00	5.99	28.66	51.68	82.44
2013-2016	50.84	0.04	6.88	31.87	56.89	84.84

6 Empirical results of structural stability and productivity distribution

As earlier outlined in the paper, I conduct the Wald-type test for structural stability for the two sub-periods, 1994-2007 and 2008-2016. Table 5 presents the empirical test results for structural, showing that for most of the 4-digit sectors the null hypothesis of structural stability is strongly rejected. More precisely, the only sector for which the null cannot be rejected is given by the manufacture of other builders' carpentry and joinery (1623), the manufacture of pulp and paper (1711/12) as well as the manufacture of kitchen furniture (3102). Generally, the test results give empirical support for structural instability between the two sub-periods and I therefore rely on the period specific parameter estimates in this paper. That is, firm-level productivity is recovered based on the production function coefficients estimated from the two sub-periods. See Appendix C.2 for the results of the estimates of the production function coefficients.

Table 5: Test for structural stability

	Sector*										
	1610	1621/22	1623	1624	1629	1711	1721/22	1723/24/29	3101	3102	3109
Statistic	254.277	8.496	3.576	9.009	6.296	3.474	33.162	34.181	198.003	3.067	213.741
P-value	0.000	0.014	0.167	0.011	0.043	0.176	0.000	0.000	0.000	0.216	0.000

* 1610 - sawmilling/wood planning, 1621/22 - veneer sheets/wood-based panels/parquet floors, 1623 - other builders' carpentry/joinery, 1624 - wooden containers, 1629 - other products of wood, 1711/12 - pulp, paper, and paperboard, 1721/22 - cardboard/packaging/paper for domestic and health usage, 1723/24/29 - other products of paper, 3101 - office/shop furniture, 3102 kitchen furniture, 3109 - other furniture.

Log TFP is computed based on the production function estimates. Figure 3 shows kernel density estimates of log firm-level productivity for the periods 1994-2007 and 2008-2016. The productivity distribution shifts to the right from the period 1994-2007 to 2008-2016, indicating a higher level of productivity for the latter period.This might be induces both due to the fact that I use for each sub-period different parameter estimates of the production function to recover firm-level productivity and by firms productivity improvements. The latter aspect will be examined in detail in the subsequent sections.

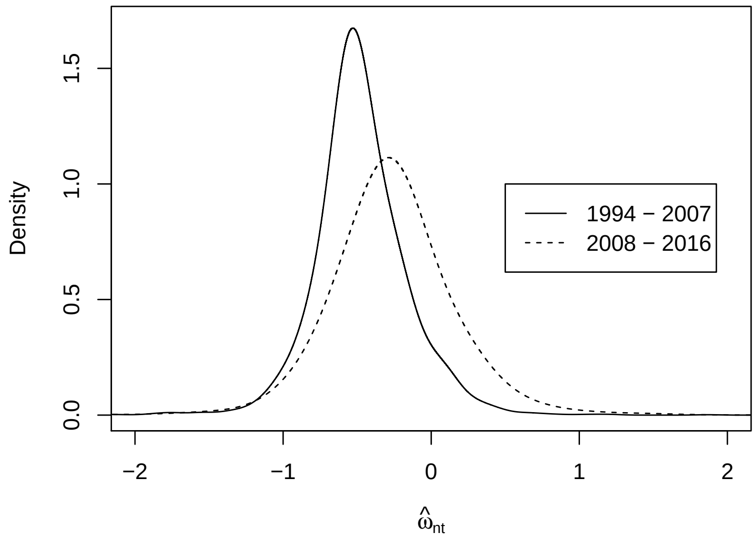

Figure 3: Kernel density estimates of log firm-level productivity

Table 6 shows some percentile ratios, corresponding to the two productivity distributions. The table suggest that productivity dispersion among firm has increased, as all ratios increase. I measure the most considerably change for the 99/1 percentile ratio, which is given for 1994-2007 and 2008-2016 by 5.56 and 9.40, respectively. That is, while over the period 1994-2007 the top 1% most productive firm was about five times more productive compared to the bottom 1% less productive firm, over the period 2008-2016, the most productive firms are about nine times more productive compared to the less productive firms.

Cette et al. (2017) also finds an increase in the dispersion of productivity, considering firms active in the whole French economy. They highlight that an increase in productivity dispersion can be related to increasing inefficiency in the allocation of production factors, such as capital and labor.[23]

Table 6: Percentile ratios of the productivity distribution

Percentile ratio	1994-2007	2008-2016
90/10	2.04	2.45
95/5	2.71	3.38
99/1	5.46	9.40

7 Empirical results of aggregate productivity dynamics

This section presents the empirical results of aggregate productivity dynamics and its decomposition. In particular, Section 7.1 presents the results of the aggregate productivity decomposition with market entry and exit over all firms, Section 7.2 discusses differences of aggregate productivity dynamics w.r.t. firms' export status (e.g. exporter and non-exporter), and Section 7.3 illustrates the results of aggregate productivity dynamics related to firms' domestic and export economic activity.

7.1 Aggregate productivity with market entry and exit

Figure 4 shows the aggregate productivity level for the three firm groups, survivors, entrants and exitors, over all firms active in the French forest product industry. The aggregate productivity of survivors, represented by the dashed line, increases especially until around 2008, whereupon it is difficult to graphically conclude for a significant change until 2015. The aggregate productivity level of the group of entrants and exitors, indicated by the solid and dotted line, respectively, is shown to be much more volatile and fluctuates around the level of aggregate productivity of the group of survivors. The figure suggests, though, that the aggregate productivity of both the groups

[23] Also see Hsieh and Klenow (2009) and Restuccia and Rogerson (2013) for detailed discussion on that aspect.

of entrants and exitors follow the same trend compared to the aggregate productivity of the group of survivors, i.e. towards a higher level of productivity.[24]

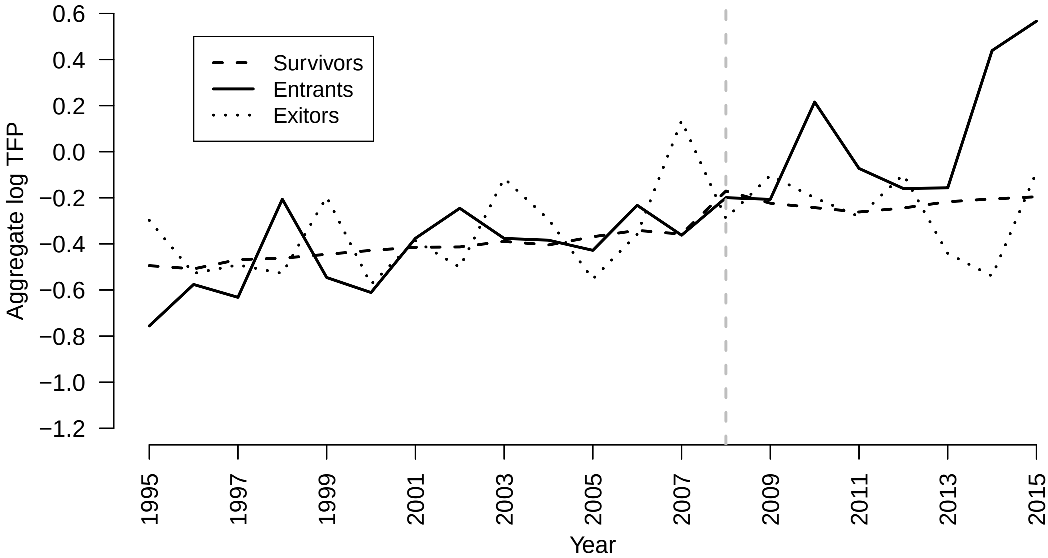

Figure 4: Aggregate productivity level of the groups survivors, entrants, and exitors (over all firms)

Figure 5 illustrates the corresponding total annual growth rates of aggregate productivity, as well as the contributions related to the three firm groups, survivors, entrants, and exitors. The contributions of the different groups to aggregate productivity growth are calculated according to the DOPD decomposition presented in Section 3.2.1.[25] The graph shows that total growth, represented by the solid line, is, except for few years, mostly positive and closely followed by the contribution of the group of survivors. This is not surprising since each group's contribution to aggregate productivity growth is weighted by its aggregate sales share, where surviving firms detain by fare the largest sales share.[26] It follows that, the contribution of the group of entrants and exitors to the aggregate productivity growth, represented by the dotted and dashed-dotted lines, respectively, are much lower compared to the contribution of survivors and are, hence, always very close to the zero line. The large productivity growth rate in 2008 (given by the peak of total growth and the contribution of survivors) is related to the structural instability between the two period 1994-2007 and 2008-2016. More specifically, by the change in the production function parameters, I measure for 2008, the year of structural break (indicated by the vertical dashed line), a high growth rate in aggregate productivity, induced by a higher productivity level of the group of surviving firms.[27]

[24]Note that according to the definition of firms' status of either survivor, entrant or exitor, described in Section 4.2.1, 1995 and 2015 are the first and the last years at which the status can be identified. Also see Appendix E.1, Table E1 providing more details on yearly aggregate productivity and sales shares w.r.t. the different firm groups.

[25]Since 1995 is the first year at which survivors, entrants, and exitors can be identified, the first year of aggregate productivity growth (and its contributors) can be measured only at 1996. The last year at which growth rates can be measured is given by 2015.

[26]See Appendix E.1, Table E1.

[27]This can also be seen in Figure 4, where the productivity level of the group of surviving firms increases considerably from 2007 to 2008.

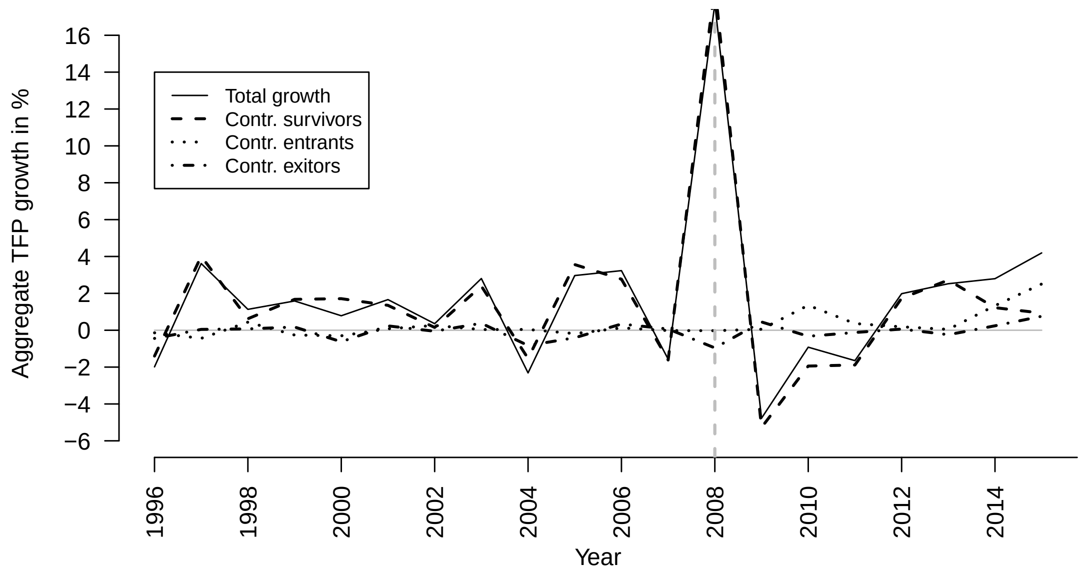

Figure 5: Aggregate productivity growth (DOPD, over all firms)

In order to more accurately investigate aggregate productivity growth, Table 7 presents the decomposition results for the sub-periods 1994-2000, 2001-2007, 2008-2012, and 2012-2013. The latter two sub-periods are chosen to investigate aggregate productivity growth during and after the economic crisis, which started towards the end of 2007. The table reports total aggregate productivity growth rates over all firms, annual average productivity growth rates (given in parenthesis) as well as the respective contributions of the groups of survivors, entrants, and exitors.[28] Also, the contribution of survivors is further decomposed into the within and between growth contribution.

Consider first the total (annual average) growth, given in the second column. Aggregate productivity growth is higher during the first two periods 1994-2000 and 2001-2007, given by 7.97% with an annual average of 1.29% and 6.69% (1.09%), compared to the last two periods, 2008-2012 and 2012-2016. During the financial and economic crisis, 2008-2012, I measure a considerable negative productivity growth, here given by only -5.87% (-1.44%). Over the last period, instead, aggregate productivity growth recovers, with a total (annual average) growth rate, given by 3.73% (1.23%). A productivity slowdown from 2000 on is also found by Cette et al. (2017), investigating the whole French economy, and by De Monte (2021), studying the French manufacturing industry. This suggests that the here presented findings are not only a characteristic specific to the forest product industry but also reflect general patterns of the French economy.

Splitting up the total growth into its different contributors it can be seen that the group of surviving firms is an important driver for aggregate productivity growth. Here, especially during the first two periods, the group of surviving firms contributes considerably through the within productivity growth contribution (learning effect), given for 1994-2001 and 2001-2007 by 7.95% (1.28%) and 5.99% (0.97%), respectively. Surviving firms' contribution to aggregate productivity growth through sales shares reallocation (between contribution) is found to be less. Remarkably, for the crisis period, 2008-2012, I measure a stark negative within and between growth rate, given by -3.26% (-0.80%) and -2.68 (-0.66)%. Finally, over the last period, 2013-2016, surviving firms' within contribution remains negative, while their between contribution, induced by the reallocation process of sales shares, becomes positive again.

Haltiwanger (2011) describes that both positive within and between contribution points to a "well working" economy from a welfare perspective, since the economy is able to produce a given output at less costs. That is, positive within growth rates reflects firms' ability to improve their productivity through learning while positive between contribution indicates a higher level of allocative efficiency as sales shares shift from less to more productive firms.

The general picture indicates that surviving firms manage to improve their productivity until 2007 whereupon they encounter considerable difficulties in continuing that trajectory. Further,

[28]Note that here firms' status of either survivor, entrant or exitor determined according to the definition of entry and exit over longer time spans, see Section 4.2.2.

by mostly positive between contributions, the forest product industry exhibits improvements in allocative efficiency.

Turning to the contribution of aggregate productivity growth of the firm groups of entrants and exitors. Generally, I find that the contribution of both firm groups is less compared to the one of survivors, with changing sign for their contribution. This finding goes largely in line with other similar studies (Baily et al., 1992; Ben Hassine, 2019; De Monte, 2021; Foster et al., 2001; Melitz and Polanec, 2015). According to the DOPD approach, if entering (exiting) firms' contribution is positive, their aggregates productivity is larger (smaller) compared to the group of surviving firms. Here, especially the group of exiting firms shows for the most periods a negative contribution, which indicates that the industry has lost relatively productive firms.

Table 7: Aggregate productivity growth (DOPD) over all firms[a]

Period	Total Growth[b]	Contribution Survivors Within	Between	Contribution Entrants	Contribution Exitors
1994 - 2000	7.97 (1.29)	7.95 (1.28)	2.11 (0.35)	-1.36 (-0.23)	-0.73 (-0.12)
2001 - 2007	6.69 (1.09)	5.99 (0.97)	0.55 (0.09)	0.43 (0.07)	-0.28 (-0.05)
2008 - 2012	-5.87 (-1.44)	-3.26 (-0.80)	-2.68 (-0.66)	0.59 (0.15)	-0.52 (-0.13)
2013 - 2016	3.73 (1.23)	-2.68 (-0.88)	5.36 (1.76)	-0.25 (-0.08)	1.29 (0.43)

[a] All figures represent growth rates in % relative to the initial year of the given period. Average annual growth rates are given in parenthesis.
[b] The total growth in aggregate productivity is the sum of the contributions of survivors, entrants and exitors.

The DOPD presented in Table 8, splits aggregate productivity and sales shares measures w.r.t. the three firm groups. More precisely, the table is separated into two panels: Panel A reporting measures in the initial year of the period (Year 1), i.e. aggregate productivity and sales shares of those firms that survive and exit until/before the last year of the period; And Panel B, reporting the measures at the last year of the period (Year 2), i.e., aggregate productivity/output shares of those firms that have survived/entered until the last year.[29] Table 8 also provides some insights into the allocation of sales shares between the groups of survivors and exitors, given in Panel A (measured at Year 1 of a given period) as well as the allocation of sales shares for the groups of survivors and entrants, given in Panel B (measured at Year 2 of a given period). It can be seen that group of survivors always detains by far the largest aggregate sales share, given by at least 80%. This is important to notice since according to the employed aggregate productivity decomposition each groups aggregate productivity is weighted by its aggregate sales share and thus highlights why surviving firms contribute considerably more compared to entering and exiting firms.

Table 8: Aggregate productivity and sales shares[a]

Panel A: Measures at Year 1							
Year 1	Year 2	$\Omega_{S,1}$	$S_{S,1}$	$\Omega_{X,1}$	$S_{X,1}$	No. Surv.	No. Exitors
1994	2000	-0.532	85.70	-0.481	14.30	3265	726
2001	2007	-0.421	80.12	-0.407	19.88	3526	978
2008	2012	-0.173	87.03	-0.133	12.97	3033	654
2013	2016	-0.188	94.33	-0.416	5.67	2934	248
Panel B: Measures at Year 2							
Year 1	Year 2	$\Omega_{S,2}$	$S_{S,2}$	$\Omega_{E,2}$	$S_{E,2}$	No. Surv.	No. Entrants
1994	2000	-0.432	83.71	-0.515	16.29	3265	1096
2001	2007	-0.356	87.47	-0.321	12.53	3526	811
2008	2012	-0.233	90.20	-0.173	9.80	3033	325
2013	2016	-0.161	94.02	-0.203	5.98	2934	128

[a] The columns $\Omega_{G,j}$ and $S_{G,j}$ with $G = \{S, X, E\}$ and $j = \{1, 2\}$, denote the aggregate productivity and the aggregate sales share of the firm groups survivors, exitors, and entrants - measured for the initial year (Year 1) and the last year of the period (Year 2). All sales shares $S_{G,j}$ are given in %.

[29] Note that Table 7 corresponds to equation (11), whereas Panel A and Panel B in Table 8 correspond to equation (9) and (10), respectively.

7.2 Aggregate productivity and export status

To relate aggregate productivity growth with firms' export status, I apply the DOPD approach separately on the group of non-exporter and exporter. Table 9 presents the results. The figures represent growth rates (average annual growth rates in parenthesis) within the two group of firms, taking market entry and exit into account. The column "total growth" shows that non-exporting firms reveal a relatively higher growth rate for the two initial periods compared to the group of exporting firms. More specifically, for 1994-2000 and 2001-2007, non-exporting (exporting) firms increase their productivity by 9.41% (8.12%) and 11.16% (6.13%). Instead, for the last two periods non-exporting firms encounter more difficulties to keep improving their productivity compared to exporting firms. That is, for 2009-2012 and 2013-2016, total aggregate productivity growth of non-exporting (exporting) firms is given by -8.28% (1.25%) and 1.20% (3.79%).

As the table also shows, exporting firms were able to increase their aggregate productivity by a sustainable positive within contribution over the last two periods. Instead, the negative within contribution of the group of non-exporters has considerably reduced their aggregate productivity growth.[30,31]

The figures suggest, hence, that aggregate productivity growth of the group of exporting firms is more consistent and more resilient during times of economic distress compared to the aggregate productivity growth of non-exporters. This is intuitive for two reasons: First, beside the export activities, exporting firms tend to detain higher sales shares in the domestic market; Second, since exporting firms may be able to compensate losses in terms of sales and sales shares on the domestic market by their export activity. The results confirm Harris and Li (2008) who provide evidence that exporting firms in the UK economy (1994-2004) contribute more to aggregate productivity growth compared to non-exporting firms.

Table 9: Aggregate productivity growth (DOPD) by firms' export status[a]

Export status	Period	Total growth[b]	Contribution survivors Within	Contribution survivors Between	Contribution entrants	Contribution exitors
Non-exporter	1994 - 2000	9.41 (1.51)	8.53 (1.37)	0.95 (0.16)	0.03 (0.01)	-0.11 (-0.02)
	2001 - 2007	11.16 (1.78)	5.46 (0.89)	5.92 (0.96)	0.04 (0.01)	-0.25 (-0.04)
	2009 - 2012	-8.28 (-2.69)	-2.95 (-0.97)	-5.59 (-1.83)	0.17 (0.06)	0.08 (0.03)
	2013 - 2016	1.20 (0.40)	-6.92 (-2.25)	7.98 (2.59)	0.14 (0.05)	0.00 (0.00)
Exporter	1994 - 2000	8.12 (1.31)	7.00 (1.13)	3.10 (0.51)	-1.36 (-0.23)	-0.62 (-0.10)
	2001 - 2007	6.13 (1.00)	6.31 (1.03)	-0.49 (-0.08)	0.33 (0.05)	-0.03 (0.00)
	2009 - 2012	1.25 (0.41)	1.77 (0.59)	-0.53 (-0.18)	0.39 (0.13)	-0.37 (-0.12)
	2013 - 2016	3.79 (1.25)	0.58 (0.19)	2.36 (0.78)	-0.44 (-0.15)	1.29 (0.43)

[a] All figures represent growth rates in % relative to the initial year of the given period. Average annual growth rates are given in parenthesis.
[b] The total growth in aggregate productivity is the sum of the contributions of survivors, entrants and exitors.

In order to compare the individual productivity levels of the two groups of non-exporting and exporting firms, I apply the concept of first-order stochastic dominance. This is done by graphically comparing the empirical cumulative distribution function (ECDF) as well as by the conduction of the Kolmogorov-Smirnov (KS) test (Kolmogorov, 1933; Smirnov, 1939) to assess statistical significance in the difference between both distributions.[32] The intuition is that if, for instance, the productivity ECDF belonging to the group of exporting firms is consistently located to the right w.r.t. the ECDF of non-exporting firms, then exporters have a higher productivity level at any percentile of the productivity distribution. Figure 6 illustrates for the investigated sup-periods the comparison of the ECDFs belonging to the two groups of firms. It can be seen that for all periods, the productivity ECDF of exporting firms is located to the right compared to the ECDF of non-exporting firms, implying higher productivity levels of exporters over to whole range of the productivity distribution.

[30] Similarly to the case where the DOPD approach was applied to all firms, irrespective to their export status, here firm entry and exit plays a minor role to aggregate productivity change, too.

[31] Also see Appendix E.2.1, Table E5, for detailed information on both aggregate sales shares and aggregate productivity of the different firm groups.

[32] See Appendix E.2.1 for a detailed description of the approach.

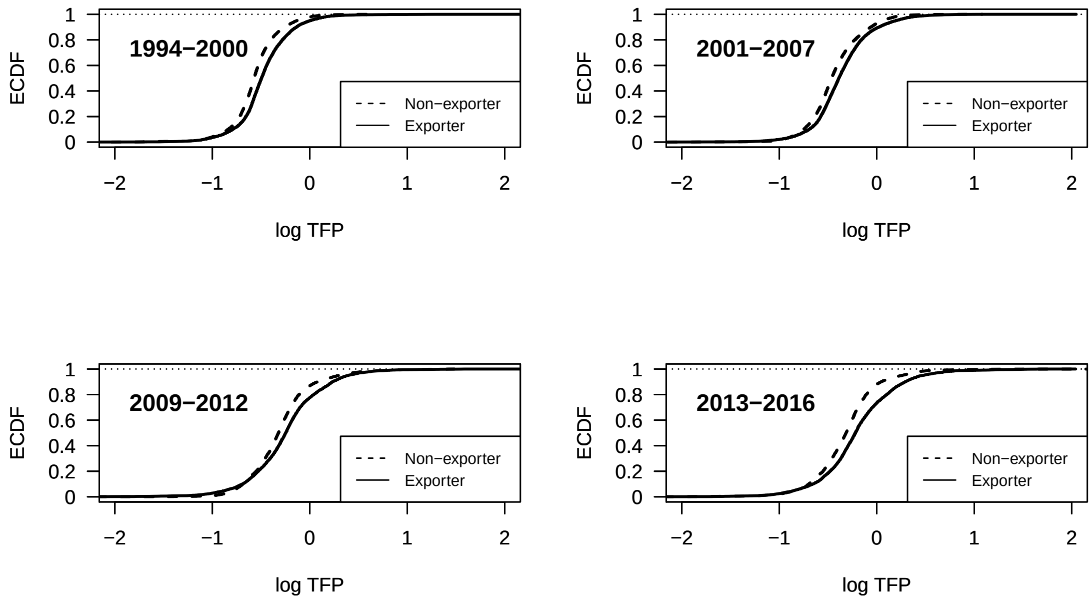

Figure 6: Comparing the productivity distribution of domestic and exporting firms.

Complementary, Table 10 presents the KS-test results. The table shows that the two sided test, testing for equality of both distributions, is highly rejected for all periods, meaning that the productivity distribution of exporters and non-exporters firms do not follow the same distribution. Further, the one-sided test, testing the null hypothesis of a difference in productivity favorable to exporters, is, except for 2009-2012, highly rejected. This suggest that exporters are significantly more productive compared to firms only active on the domestic market. Also, the last column of Table 10 illustrates that the median TFP level of exporters exceeds the median TFP level of non-exporters between 7.49% (1994-2000) and 9.54% (2013-2016). The finding of higher productivity of exporters goes in line with literature that mostly documents productivity advantages for exporting firms (Bellone et al., 2014; Bernard and Jensen, 1999; De Loecker, 2013; Harris and Li, 2008).

Table 10: KS-test for first-order stochastic dominance between exporting and non-exporting firms

	Observations		Two-sided test H_0: Equality of distributions		One-sided test H_0: Difference favorable to exporters		
Period	# of exporter	# of non-exporter	Statistic	p-value	Statistic	p-value	Median TFP difference
1994-2000	9890	6924	0.169	0.000	0.002	0.977	7.49%
2001-2007	10436	8823	0.132	0.000	0.008	0.564	7.54%
2009-2012	5567	4921	0.128	0.000	0.025	0.040	7.46%
2013-2016	5167	4348	0.164	0.000	0.007	0.816	9.54%

7.3 Aggregate productivity and domestic and export activity

An important feature of the French forest product industry is that about 75% of total production is distributed on the domestic market, i.e., most firms only export very little w.r.t. their total sales.[33] For this reasons it seems important to relate aggregate productivity growth not only to firms' export status, but also their volumes of sales in the domestic and export market. Section 3.2.2 presented the aggregate productivity decomposition for this purpose. Remember that I here simply split firms' sales shares into its domestic and export component, respectively. I then apply the static Olley-Pakes productivity decomposition to continuing firms, i.e., without taking market entry and exit effects into account that are studied in the previous sections. In this manner I am able to investigate, to which extend productivity growth dynamics are related to the domestic and export economic activity.

Table 11 presents the corresponding the results. The table shows that especially during the first two periods, 1994-2000 and 2001-2007, total growth is mainly driven by firms' domestic activity.

[33]See Section 5, Table 4, and Appendix E.2.2, Table E6.

For instance, considering the period 1994-2000, the contribution to aggregate productivity growth of firms' domestic activity is given by 7.2% (sum of within and between contribution) whereas aggregate productivity growth from firms export activity is only given by 2.16%. Here, in particular, firms' within growth related to domestic activity contributes considerably to the aggregate productivity growth. A similar pattern is measured for the period 2001-2007.

For the period of economic distress, 2009-2012, as well as for 2013-2016, the within contribution related to both domestic and export activity is measured to be negative. Here, compared to the first two periods, especially the within contribution related to domestic activity reduces dramatically, given by -0.22% and -1.86%, respectively. Over the last period, I measure a considerable positive between contribution related to both firms domestic and export activity, indicating that after the crisis, domestic and export sales shares were considerably from less to more productive firms.

Table 11: Olley-Pakes productivity decomposition w.r.t. firms' domestic and export activity

Period	Total growth	Domestic activity Within	Domestic activity Between	Export activity Within	Export activity Between
1994 - 2000	9.36 (1.50)	6.82 (1.11)	0.38 (0.06)	1.13 (0.19)	1.03 (0.17)
2001 - 2007	7.56 (1.22)	4.09 (0.67)	0.42 (0.07)	1.89 (0.31)	1.15 (0.19)
2009 - 2012	-0.56 (-0.19)	-0.22 (-0.07)	0.16 (0.05)	-0.35 (-0.12)	-0.16 (-0.05)
2013 - 2016	3.37 (1.11)	-1.86 (-0.62)	3.74 (1.23)	-0.81 (-0.27)	2.31 (0.76)

[a] All figures represent growth rates in % relative to the initial year of the given period. Average annual growth rates are given in parenthesis.

[b] The total growth in aggregate productivity is the sum of the contributions of survivors, entrants and exitors.

The key message from this section is that firms domestic activity is a crucial driver for aggregate productivity growth, which is induced by the high share of sales distributed in the domestic market. That is, while exporting firms exhibit higher productivity levels and a more sustainable aggregate productivity growth, domestic economic activity states the most important pillar for the industry's productivity growth. Generally, my results suggest that a higher degree of internationalization of the French forest product industry could have two positive effects. Fist, more firms would benefit from export-learning increasing their individual productivity (Bellone et al., 2008). Second, by higher export sales shares aggregate productivity would be less vulnerable to domestic economic distress, thus, allowing for a more sustainable aggregate productivity and economic growth.

8 Conclusion

This paper investigates productivity dynamics in the French forest product industry between 1994 and 2016. More specifically, it analyses the effect of market entry and exit on aggregate productivity growth as well as the relation between firms' export status (i.e. exporting or non-exporting) and export volumes and aggregate productivity growth in the industry.

For this purpose I use French firm-level data covering the period from 1994-2016 and estimate firm-level productivity based on a value added Cobb-Douglas production function, following Ackerberg et al. (2015). Compared to more recent periods, I find that the industry's total aggregate productivity growth is considerably higher for the periods 1994-2000 and 2001-2007. During the period of worldwide economic distress, 2008-2012, a remarkable slowdown in productivity growth took place, with some improvement during the period after the economic crisis, 2012-2016, which goes in line with other studies considering productivity of the French economy (Ben Hassine, 2019; Cette et al., 2017; De Monte, 2021). The analysis further shows that an important driver for these dynamics is the contribution of the group of incumbent firms, where market entry and exit reveals a much lower contribution. Moreover, investigating aggregate productivity growth separately w.r.t. firms export status, i.e. non-exporting and exporting firms, I find that the group of exporting firms feature higher aggregate productivity growth rates compared to the group of non-exporting firms. This result is similar to the findings by Harris and Li (2008), who investigate UK firms. Further, applying the concept of first order stochastic dominance, exporter show higher productivity levels on the whole range of the productivity distribution, where I measure exporters' median productivity as 7% and 9% higher compared to non-exporters. However, when decomposing aggregate productivity into the part contributed by firms' domestic and export activity, the results suggest, that domestic activity contributes considerably more to aggregate productivity growth for the periods 1994-2000 and 2001-2007, compared to the contribution of export activity. This is due to the fact that by far the largest part of firms' production is for the domestic market. That is, the slowed aggregate productivity growth is mainly transmitted by firms' domestic activity. Therefore, given firms learn and improve through exporting (Bellone et al., 2008; De Loecker, 2013; Girma et al., 2004), my results suggest that a more international orientation of the French forest product industry promotes a higher and more sustainable aggregate productivity growth, which would, in turn, also be more resilient to domestic economic distress. Moreover, as the French forest product industry exhibits a considerable trade deficit (Levet et al., 2014), losing sales share on the global market (Koebel et al., 2016), further research should be done to better understand the barriers preventing firms from engaging in export activity and to evaluate what policy measures would be best suited to facilitate firms' entry to export as well as to support their competitiveness in the global market.

The analysis performed in the paper leaves room for improvement in several ways. First, the use of a value added Cobb-Douglas production function, implying constant output elasticities across firms, is restrictive. More general models, such as a Translog production technology (De Loecker and Warzynski, 2012; De Monte, 2021) and/or nonparametric estimation approaches of production functions (Demirer, 2020; Doraszelski and Jaumandreu, 2018; Gandhi et al., 2020), would allow for more flexibility. Second, firm productivity is estimated from revenue data and as such it conflates price-setting effects with physical productivity. In other words, a firm might be considered productive as it is cost-effective or because it has significant market power. Using firm-level price indicators (Morlacco, 2017) or physical output/input data would be possible ways to avoid this issue. Third, the measure of market entry and exit is only based on firm observations in the data but not on the legal activity status of a firm, which might bias the effect of firm entry and exit on aggregate productivity. A possible solution for that concern would be to merge the used data from FICUS and FARE with data on firms' exact status of activity and define entry and exit based on that information. For instance, for France data on all registered firm IDs is publicly available, containing information on the creation and cessation of any firm activity.[34]

[34] Publicly available data of firms' legal status in France: https://www.sirene.fr/sirene/public/static/acces-donnees, (May, 2021).

Appendix

A Data

A.1 Merging of the data sets FICUS and FARE

For my analysis I merge the two fiscal firm-level data sets FICUS and FARE, covering the periods from 1994 to 2007, and 2008 to 2016, respectively. Both in FICUS and FARE firms are classified by a 4-digit sector nomenclature "NAF" (nomenclature d'activité française). However, from FICUS to FARE this sector nomenclature has significantly changed. In FICUS, the nomenclature was organized according to "NAF 1", while in FARE the nomenclature is organized according to "NAF 2". In this study I treat one single data set, 1994 - 2016, by establishing consistency in the sector nomenclature NAF 2 throughout the whole period. That is, I assign the current 4-digit sector nomenclature NAF 2 retrospectively for all firm observations from FICUS. For firms that are observed both in FICUS and FARE or only in FARE the 4-digit sector according to NAF 2 they belong to is known. However, for firms that have exited the market before 2008 I do not know to which NAF 2 4-digit sector they would have belonged to if they had continued their activity. To also classify these firms by the NAF 2 4-digit nomenclature I use the following methodology. I first only look at firms that are observed in both data sets FICUS and FARE. From these observations I build a transition matrix where each row represents a 4-digit sector according to NAF 1 and each column represents a 4-digit sector according to NAF 2. Each cell of the transition matrix contains the number of firms transiting from a specific 4-digit sector in FICUS (NAF 1) to the new 4-digit sector in FARE (NAF 2). Table A1 shows an exemplifying transition matrix, where I chose the NAF 1 4-digit sectors 201A - 205C, i.e. the manufacture of wood and products of wood. For instance it can be seen that there are 2060 firms observed that were classified in FICUS in 201A (first row) and in FARE in the sector 1610 (third columns), while there are only 46 observations that were classified in 201A and in FICUS in 0220 (first column). From these observed transition frequencies I then calculate the transition probabilities by simply dividing each element of the matrix by the sum of its corresponding row. That is, the NAF 1 - NAF 2 transition probabilities are calculated by

$$p_{IJ} = \frac{\sum_{n \in I,J}^{N_J} \mathbf{1}_{[n \in I \text{ and } n \in J]}}{\sum_{n \in I}^{N_I} \mathbf{1}_{[n \in I]}}, \tag{15}$$

where n is a firm observed in both FICUS and FARE, I and J are specific 4-digit sectors according to NAF 1 and NAF 2, respectively. $\mathbf{1}$ is an index variable equal to 1 if the condition in parenthesis is fulfilled. Table A2 contains the transition probabilities according to the observed transitions Table A1. It can be seen that those 4-digit transitions between FICUS and FARE that were more frequently observed obtain accordingly higher probabilities. In a second step, firms only observed in FICUS belonging to a specific NAF 1 4-digit sector, are assigned to a NAF 2 4-digit, by drawing from a discrete probability distribution which corresponds to the row in the probability transition matrix, i.e. the NAF 1 4-digit sector a firm belongs to and its potential transition possibilities.

Table A1: FICUS - FARE: Observed transition frequencies

	NAF 2																		
NAF 1	0220	1392	1610	1621	1622	1623	1624	1629	2223	2512	3101	3109	3319	4329	4332	4391	4399	5610	9524	Total
201A	46	0	2060	5	6	22	35	12	0	0	0	7	0	0	25	24	9	5	0	2256
201B	0	0	498	0	0	0	0	0	0	0	0	0	0	17	4	36	24	0	0	579
202Z	0	0	0	108	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	112
203Z	0	7	33	0	15	1880	8	8	41	26	0	41	0	6	1005	386	34	0	0	3490
204Z	0	0	17	0	0	4	857	6	0	0	0	0	35	0	6	0	0	0	0	925
205A	4	16	10	4	0	21	5	1215	0	0	12	317	0	0	87	0	4	10	156	1861
205C	0	0	0	0	0	0	0	86	0	0	0	0	0	0	0	0	0	0	0	86

Table A2: FICUS - FARE: Transitions probabilities

	NAF 2																		
NAF 1	0220	1392	1610	1621	1622	1623	1624	1629	2223	2512	3101	3109	3319	4329	4332	4391	4399	5610	9524	Total
201A	0.02	0.00	0.91	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	1.00
201B	0.00	0.00	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.06	0.04	0.00	0.00	1.00
202Z	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	1.00
203Z	0.00	0.00	0.01	0.00	0.00	0.54	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.29	0.11	0.01	0.00	0.00	1.00
204Z	0.00	0.00	0.02	0.00	0.00	0.00	0.93	0.01	0.00	0.00	0.00	0.00	0.04	0.00	0.01	0.00	0.00	0.00	0.00	1.00
205A	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.65	0.00	0.00	0.01	0.17	0.00	0.00	0.05	0.00	0.00	0.01	0.08	1.00
205C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00

A.2 Data cleaning

Table A3 provides information about the raw data, i.e., without any data cleaning. The motivation of the table is to show observations irrespective of number of workers, and/or missing, zero, and negative values for value-added, capital and materials. The table shows that in the raw data, the share of firms with less than five employees accounts for about 56%. These firms, however, only account for about 4.8% of total turnover. That is, firms with five and more employees represent approximately about 95% of total turnover.

Table A3: Summary statistics w.r.t. firm size, all observations[a,b]

Size group[c]	# of firms	Share of firms	Share of empl.	Share of turnover	Entry rate	Exit rate	Share of exporter	Age
0	6370	29.44	0.06	1.32	11.09	10.83	3.44	12.05
1	2606	12.05	1.33	0.92	7.76	8.15	6.96	13.13
2-4	3127	14.45	4.34	2.52	6.75	7.02	13.47	13.91
5-9	2115	9.78	7.14	4.46	5.48	5.66	27.73	16.01
10-19	1362	6.30	9.35	6.63	4.35	5.13	45.17	19.22
20-49	1192	5.51	18.68	14.88	2.82	3.61	63.33	22.51
50-99	335	1.55	11.64	10.23	2.72	3.90	79.75	26.24
100-199	187	0.86	13.06	13.54	2.52	3.93	89.18	27.77
200-499	120	0.55	17.86	22.17	2.33	3.54	91.71	27.16
500+	37	0.17	16.56	22.57	2.08	2.20	98.84	27.41
NA	4183	19.34	0.00	0.75	15.09	11.90	9.03	12.99
Total	21634	100.00	100.00	100.00	9.14	8.68	17.27	14.51

[a] All figures represent averages over the whole period 1994-2016.
[b] Shares and rates are given in %.
[c] Size group is given in terms of number of employees. NA denotes the group of firms for which the number of employees is not available.

B Descriptive statistics

B.1 Share of the French forest product industry w.r.t. the overall manufacturing industry

Table B1 provides some quantitative information mentioned in the introduction, concerning the importance of the forest product industry w.r.t. to the over all French manufacturing industry. The table is based on the sample without any restriction on observations in terms of firm size or other variables and figures are calculated for the whole period 1994-2016. The table shows that the share of firms active in the forest product industry accounts for about 10%, w.r.t. all firms active in the French manufacturing. Further, the forest product industry's share of turnover and exports is given by 4.6% and 3.2%, respectively.

As also mentioned in the main text, these shares are however decreasing over time, as can be seen in Figure B1, illustrating the share of the French forest product industry in terms of the number of firms, workers, turnover, and exports w.r.t. the overall manufacturing industry. All shares show a decreasing tendency over time, indicating a lower economic importance of the forest product industry.

Table B1: Share of the French forest product industry w.r.t. overall manufacturing industry[a]

Manufacturing	No. of firms	Share of firms	Share of employees	Share of turnover	Share of exports
Forest product[b]	5351	10.05	7.02	4.62	3.19
other[c]	47889	89.95	92.98	95.38	96.81

[a] Shares are given in %.
[b] Contains firms with at least than 5 employees belonging to those 4-digit forest product sectors considered in this paper.
[c] Contains firms with at least than 5 belonging to all other manufacturing industries (2-digit nomenclature 10-33, NAF, révision 2, 2008).

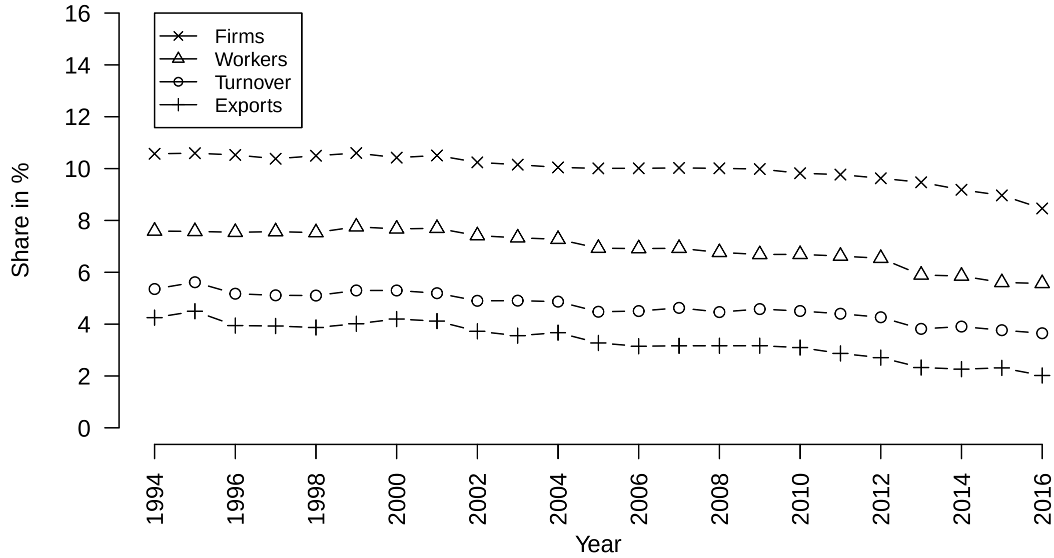

Figure B1: Shares over time of the French forest product industry w.r.t. the overall French manufacturing.

B.2 Evolution of value added, inputs, and exports by 4-digit sectors

Complementary to Figure 1 in the main text, Figure B2 shows production variables and exports over time for the different forest product 4-digit sectors. The illustrated variables are aggregates over all firms active in the specific industry and year. The y-axis shows the values of a quantity index, where the initial year 1994 represents 100% for each of the evolving variables, capital, exports, value added and labor demand.

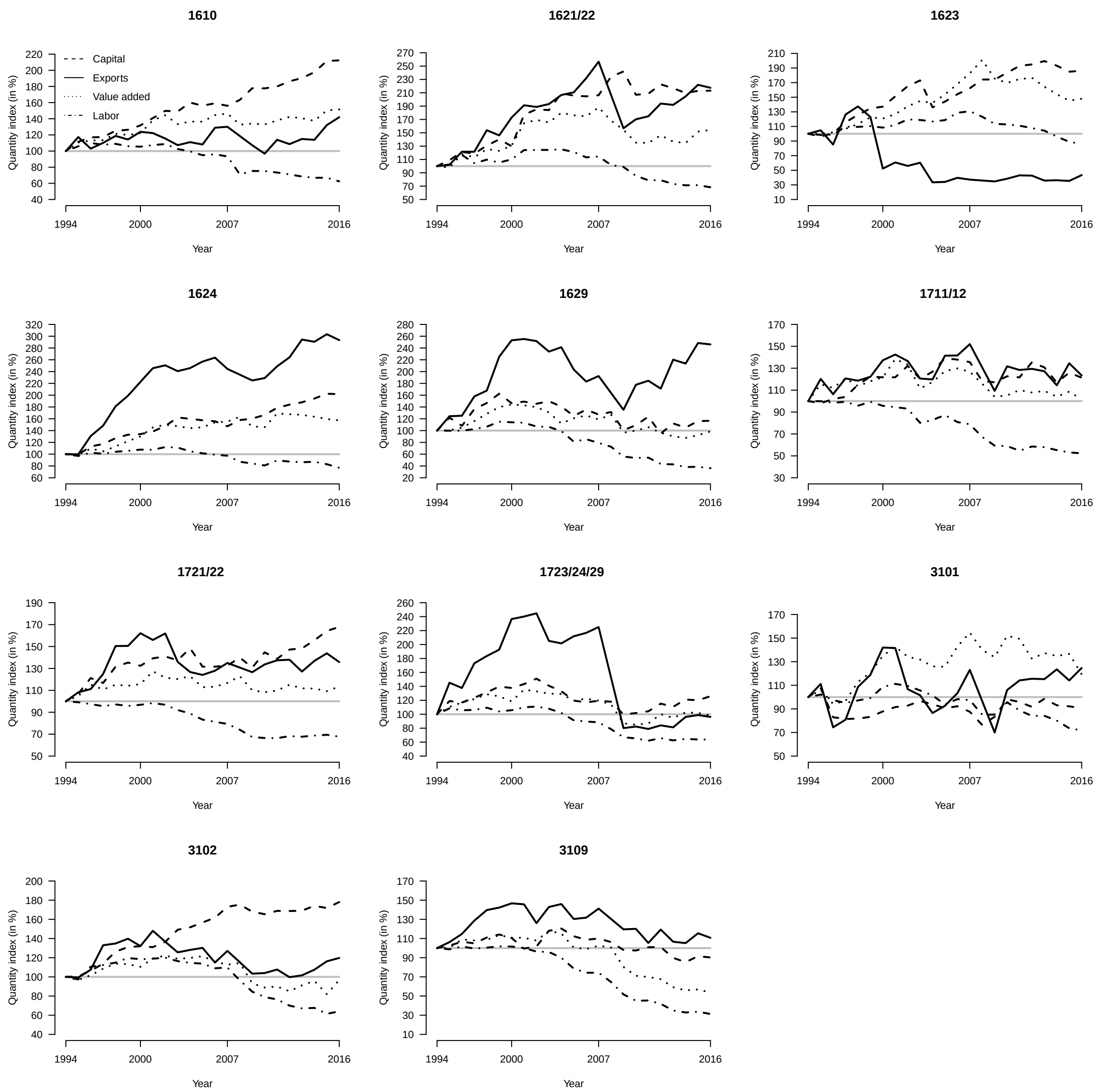

Figure B2: The evolution of aggregate value added, exports, and inputs for all included 4-digit forest product sectors.
1610 - sawmilling/wood planning, 1621/22 - veneer sheets/wood-based panels/parquet floors, 1623 - other builders' carpentry/joinery, 1624 - wooden containers, 1629 - other products of wood, 1711/12 - pulp, paper, and paperboard, 1721/22 - cardboard/packaging/paper for domestic and health usage, 1723/24/29 - other products of paper, 3101 - office/shop furniture, 3102 kitchen furniture, 3109 - other furniture.

Complementary to Figure 2 in the main text, Figure B3 shows the evolution of the number of firms, expressed in percent, for all included 4-digit forest product sectors. Here, the initial year of the sample, 1994, represents the base year, given by 100%. The figure shows that all sectors, at least from 2007/2008 on, show a negative trend in the number of active firms.

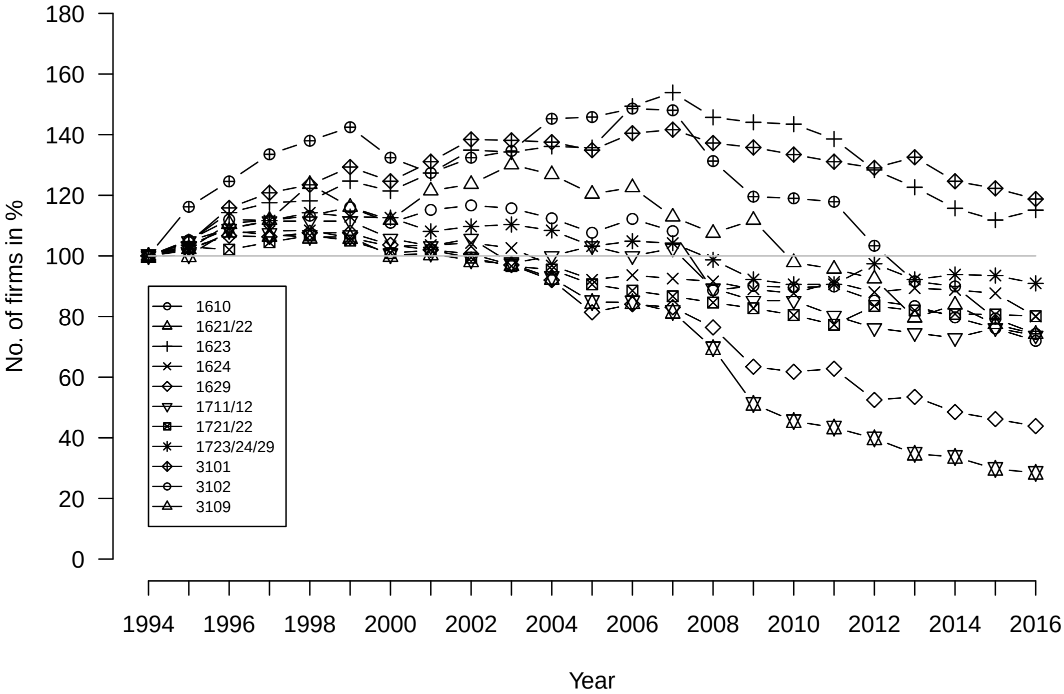

Figure B3: Evolution of number of active firms in %.
1610 - sawmilling/wood planning, 1621/22 - veneer sheets/wood-based panels/parquet floors, 1623 - other builders' carpentry/joinery, 1624 - wooden containers, (1629) other products of wood, 1711/12 - pulp, paper, and paperboard, 1721/22 - cardboard/packaging/paper for domestic and health usage, 1723/24/29 - other products of paper, 3101 - office/shop furniture, 3102 kitchen furniture, (3109) other furniture.

C Production function estimation

This section presents more details on the estimation and the results of the Cobb-Douglas value added production function. In particular, Section C.1 provides a chunk code of the estimation procedure using the statistical software R, Section C.2 presents the estimation results of the production function parameters, and Section C.3 illustrates the distribution of the production function residual from the first stage estimation.

C.1 Chunk code

Recall, I estimate the production function by making use of the proxy variable approach, presented by Olley and Pakes (1996) and closely follow Ackerberg et al. (2015). The production function to be estimated is given by

$$q_{nt} = \beta_L l_{nt} + \beta_K k_{nt} + \omega_{nt} + \epsilon_{nt},$$

where I keep the same notation as in the main text. The first stage of the estimator consists in a non parametric estimation of the term $\Phi(l_{nt}, k_{nt}, m_{nt}, \mathbf{c}_{nt})$, derived from

$$\begin{aligned} q_{nt} &= \beta_L l_{nt} + \beta_K k_{nt} + \tilde{h}_t^{-1}(k_{nt}, l_{nt}, m_{nt}, \mathbf{c}_{nt}) + \epsilon_{nt} \\ &= \Phi(l_{nt}, k_{nt}, m_{nt}, \mathbf{c}_{nt}) + \epsilon_{nt}. \end{aligned}$$

I use the statistical software R and estimate $\Phi(\cdot)$ nonparmaterically, by making use of kernel regression techniques, implemented in the **np** package (Hayfield and Racine, 2015). Optimal bandwidths are obtained by using the expected Kullback-Leibler cross-validation method. In the second step I regress $\widehat{\omega_{nt}}(\beta_L, \beta_K)$ on a higher order polynomial of $\widehat{\omega_{n,t-1}}(\beta_L, \beta_K)$ along with the exit and export dummy. The residuals of this regression, denoted by $\widehat{\xi}_{nt}$, called the innovation to productivity, are then used to for the GMM estimation, by imposing the moment conditions given by

$$E\left[\widehat{\xi}_{nt}(\beta_L, \beta_K)\begin{pmatrix} k_{nt} \\ l_{n,t-1} \\ l^2_{n,t-1}\end{pmatrix}\right] = 0.$$

For the GMM regression I use the R-package **gmm** (Chaussé, 2010). The the R command **gmm()** requires first to define a function that returns a matrix where each column contains a moment conditions. I call this function "Moment_f". In the formals of the function I define "theta", the set of parameters to be estimated, and "data", a data.table object containing all necessary variables. The following chunk code illustrates the implementation of the estimation routine.

```
library(np)
library(gmm)
library(data.table)

# Moments function
Moment_f <- function(theta, data){

  # Specify the production function parameters
  betaL = theta[1]; betaK = theta[2]

  # Data
  # First step nonparametric estimate and its lagged values
  phi_hat <- data[,"phi_hat"] ;  phi_hat_l1 <- data[,"phi_hat_l1"]

  # Explanatory variables its lagged values
  # Capital
  k <- data[, "k"] ; k_l1 <- data[, "k_l1"]
  # Labor
  l <- data[, "l"] ; l_l1 <- data[, "l_l1"]
  # Exit/export dummy
  X <- data,[,"X"] ; EXP <- data[,"EXP"]

  # Instruments
  z1 <- k; z2 <- l_l1; z3 <- l_l1^2

  # Moment matrix (to be returned by the function)
  Mom <- matrix(NA, nrow = nrow(data), ncol = 3)

  # Generate omega (firm productivity) and its lagged values
  omega  <- phi_hat -  betaL*l- betaK*k
  omega_lag <- phi_hat_l1 - betaL*l_l1- betaK*k_l1
  omega_lag_pol <- cbind(1, omega_lag, omega_lag^2, omega_lag^3)

  # Regress omega on its lagged values (using a 3rd order polynomial)
  # and in exit/export dummy and recover residuals

  # Right-hand-side variables
  reg_vars = cbind(omega_lag_pol, X, EXP)

  # Residuals (innovation to productivity)
  resid <- resid(lm(omega ~ reg_vars - 1))

  # Specify moments
  # (supposed to be in expectation orthogonal to the innovations)
  Mom[,1] <- z1*resid; Mom[,2] <- z2*resid; Mom[,3] <- z3*resid

  return(Mom)
```

```
}

# First stage non-parametric estimation
# Note: The dummy variables X and EXP identify firms activity and export status
#       X = 1, if firms is about to exit and 0 else
#       EXP = 1, if firm exports and 0 else
data$phi_hat = fitted(npreg(q ~ l + k + m + factor(X) + factor(EXP),
                            bwmethod = "cv.aic", data = data))

# Creation of lagged variables
data[, phi_hat_l1 := lag(phi_hat,1), by = "id" ]
data[, l_l1 := shift(l,1), by = "id" ]
data[, k_l1 := shift(k,1), by = "id" ]

# Second stage GMM estimation
# Note: a) Take OLS estimates as initial values
#       b) Use "optimal" weighting matrix
#       c) use "optim" as numeric optimizer (default Nelder-Mead algo.)
t0 = coefficients(lm(y ~ l + k, data = data))[2:3]

res.gmm <- gmm(g = Moment_f, x = as.matrix(na.omit(data))),
               t0 = t0, wmatrix = "optimal", optfct = "optim")
```

C.2 Production function estimates

Table C1 presents the production function estimates according to Ackerberg et al. (2015). The estimation routine is based on non-linear optimisation within the parameter space of the production function parameters β_L and β_K, by imposing the moment conditions, given in equation (5). The initial values for the non-linear optimization are chosen by the corresponding parameter estimates from the OLS regression, given in Table C2 below. For each 4-digit sector, the parameters are estimated for the sub-periods, 1994-2007 and 2008-2016. The J-Test or test for overidentification, given in the bottom of each output table, does not reject the H_0, indicating for all sectors and periods valid instruments, implying consistent estimation of the parameters. Note that based on these estimates the Wald-test for structural stability between both periods is applied.

Table C1: Production function estimates (Ackerberg et al., 2015)[a,b,c]

	Sawmilling/ wood planning 1610		Veneer sheets/wood-based panels/parquet floors 1621/22		Other builders' carpentry/joinery 1623	
	1994-2007	2008-2016	1994-2007	2008-2016	1994-2007	2008-2016
$\widehat{\beta}_L$	0.836***	1.019***	0.747***	0.641***	0.858***	0.662***
	(0.008)	(0.011)	(0.077)	(0.240)	(0.020)	(0.139)
$\widehat{\beta}_K$	0.181***	0.080***	0.327***	0.191	0.162***	0.495**
	(0.004)	(0.005)	(0.044)	(0.165)	(0.011)	(0.238)
OID-Test	0.962	0.764	0.863	0.620	0.855	0.868
# Firms	1720	1111	165	132	1094	938
# Obs.	12,192	5,445	1,296	590	7,033	4,299
	Wooden containers 1624		Other wood products 1629		Pulp, paper paperboard 1711/12	
	1994-2007	2008-2016	1994-2007	2008-2016	1994-2007	2008-2016
$\widehat{\beta}_L$	0.937***	0.890***	0.907***	0.988***	0.976***	1.183***
	(0.008)	(0.014)	(0.035)	(0.037)	(0.146)	(0.115)
$\widehat{\beta}_K$	0.101***	0.125***	0.185***	0.138***	0.177**	0.036***
	(0.005)	(0.008)	(0.011)	(0.016)	(0.075)	(0.014)
OID-Test	0.835	0.999	0.945	0.918	0.898	0.913
# Firms	891	626	503	249	198	131
# Obs.	6,317	3,404	3,367	1,159	1,532	678
	Cardboard/packaging domestic/health usage 1721/22		Other products of paper 1723/24/29		Office/shop furniture 3101	
	1994-2007	2008-2016	1994-2007	2008-2016	1994-2007	2008-2016
$\widehat{\beta}_L$	0.884***	0.903***	0.852***	0.816***	0.788***	1.029***
	(0.018)	(0.012)	(0.025)	(0.021)	(0.012)	(0.013)
$\widehat{\beta}_K$	0.167***	0.130***	0.139***	0.104***	0.150***	0.012
	(0.009)	(0.008)	(0.015)	(0.014)	(0.007)	(0.010)
OID-Test	0.784	0.671	0.838	0.937	0.95	0.953
# Firms	811	579	528	395	745	617
# Obs	6,293	3,166	3,948	2,072	4,986	3,106
	Office/shop furniture 3102		Kitchen furniture 3109			
	1994-2007	2008-2016	1994-2007	2008-2016		
$\widehat{\beta}_L$	0.970***	1.016***	0.789***	0.845***		
	(0.033)	(0.132)	(0.009)	(0.027)		
$\widehat{\beta}_K$	0.062***	0.018	0.208***	0.091***		
	(0.018)	(0.030)	(0.005)	(0.010)		
OID-Test	0.757	0.823	0.298	0.802		
# Firms	407	282	2095	738		
# Obs	2,733	1,232	12,304	2,984		

[a] Standard errors are bootstrapped using 400 replications and given in parenthesis.
[b] *p<0.1; **p<0.05; ***p<0.01.
[c] The OID-Test reports p-values of the overidentification test for validity of the instruments. A p-value > 0.05 indicates validity of the instruments.

Table C2: Production function OLS estimates[a,b]

	Sawmilling/ wood planning 1610		Veneer sheets/wood-based panels/parquet floors 1621/22		Other builders' carpentry/joinery 1623	
	1994-2007	2008-2016	1994-2007	2008-2016	1994-2007	2008-2016
$\widehat{\beta}_L$	0.867***	0.987***	0.774***	0.862***	0.849***	0.929***
	(0.008)	(0.013)	(0.029)	(0.051)	(0.011)	(0.013)
$\widehat{\beta}_K$	0.170***	0.077***	0.277***	0.212***	0.194***	0.093***
	(0.004)	(0.006)	(0.018)	(0.031)	(0.007)	(0.008)
Constant	−0.490***	−0.289***	−0.471***	−0.510***	−0.458***	−0.276***
	(0.018)	(0.027)	(0.064)	(0.112)	(0.025)	(0.027)
# Obs	12,192	5,445	1,296	590	7,033	4,299
R^2	0.726	0.686	0.854	0.762	0.789	0.790
	Wooden containers 1624		Other wood products 1629		Pulp, paper paperboard 1711/12	
	1994-2007	2008-2016	1994-2007	2008-2016	1994-2007	2008-2016
$\widehat{\beta}_L$	0.908***	0.896***	0.843***	0.908***	0.788***	1.039***
	(0.012)	(0.015)	(0.017)	(0.028)	(0.023)	(0.036)
$\widehat{\beta}_K$	0.139***	0.119***	0.171***	0.117***	0.284***	0.122***
	(0.008)	(0.009)	(0.011)	(0.017)	(0.014)	(0.021)
Constant	−0.571***	−0.191***	−0.572***	−0.349***	−0.400***	−0.439***
	(0.028)	(0.033)	(0.039)	(0.061)	(0.054)	(0.085)
# Obs	6,317	3,404	3,367	1,159	1,532	678
R^2	0.737	0.734	0.703	0.662	0.908	0.883
	Cardboard/packaging domestic/health usage 1721/22		Other products of paper 1723/24/29		Office/shop furniture 3101	
	1994-2007	2008-2016	1994-2007	2008-2016	1994-2007	2008-2016
$\widehat{\beta}_L$	0.884***	0.837***	0.805***	0.779***	0.866***	0.974***
	(0.011)	(0.015)	(0.016)	(0.021)	(0.012)	(0.014)
$\widehat{\beta}_K$	0.164***	0.171***	0.168***	0.123***	0.141***	0.050***
	(0.007)	(0.010)	(0.011)	(0.014)	(0.008)	(0.009)
Constant	−0.486***	−0.092***	−0.154***	0.222***	−0.205***	−0.179***
	(0.025)	(0.033)	(0.035)	(0.045)	(0.029)	(0.029)
# Obs	6,293	3,166	3,948	2,072	4,986	3,106
R^2	0.866	0.840	0.777	0.714	0.808	0.824
	Office/shop furniture 3102		Kitchen furniture 3109			
	1994-2007	2008-2016	1994-2007	2008-2016		
$\widehat{\beta}_L$	0.961***	0.989***	0.958***	0.938***		
	(0.017)	(0.027)	(0.009)	(0.017)		
$\widehat{\beta}_K$	0.136***	0.068***	0.132***	0.063***		
	(0.012)	(0.019)	(0.006)	(0.011)		
Constant	−0.839***	−0.673***	−0.812***	−0.397***		
	(0.037)	(0.051)	(0.020)	(0.037)		
# Obs	2,733	1,232	12,304	2,984		
R^2	0.857	0.821	0.780	0.742		

[a] Standard errors are given in parenthesis.
[b] *p<0.1; **p<0.05; ***p<0.01.

C.3 Distribution of the production function residual $\widehat{\epsilon}_{nt}$

The production function estimation presumes zero mean of the error term ϵ_{nt} (see the regression equation (1)). After the nonparametric first step regression the corresponding residuals, $\widehat{\epsilon}_{nt}$, can be obtained according to equation (3). The residuals are then in further use when estimating firm-level productivity, $\widehat{\omega}_{nt}$, shown in equation (6). To provide some information on $\widehat{\epsilon}_{nt}$, Figure C1 shows the distribution for both sub-periods, with a strong symmetric concentration around zero.

Figure C2 provides the corresponding *qq*-plot to investigate the distributions on normality. The solid line indicate the theoretical values of the standard normal distribution, i.e., when the obtained residual follow this line normality can be concluded. A large share of the residuals of both distribution follow the solid line, however, extreme values, i.e. tales of the distribution, are farer from the theoretical quantiles of the normal. That is, the distributions of the residuals w.r.t. both sub-periods do not follow the standard normal in the tales.

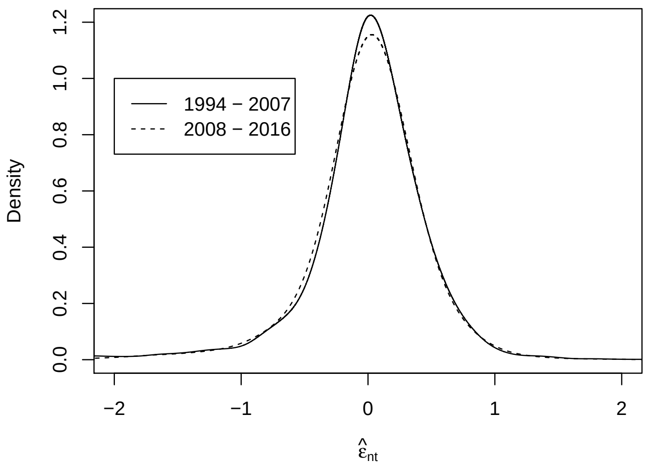

Figure C1: Distribution of the production function residual $\widehat{\epsilon}_{nt}$.

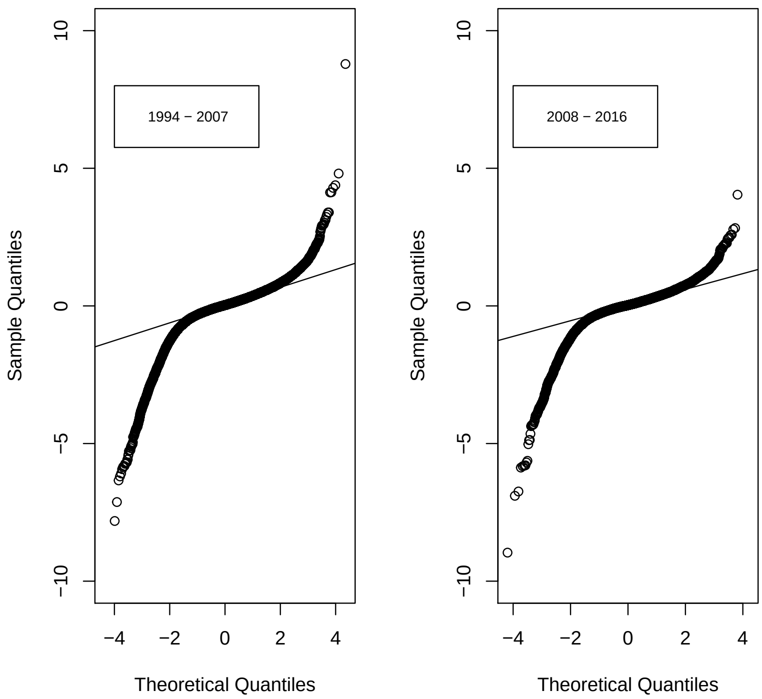

Figure C2: qq-plot of the production function residual $\widehat{\epsilon}_{nt}$.

D Productivity distribution and dispersion by 4-digit sector

This sections provides some further results concerning changes in the the productivity dispersion by sector. Table D1 illustrates the percentile ratios of the productivity distribution w.r.t. the period 1994-2007 and 2007-2016, given in Panel A and B, respectively (over all firms and w.r.t. each sector separately). The table shows that the productivity dispersion has increased within almost all sectors, as the percentile rations increase between the two periods. For the sectors 1621/22 and 1623 I measure a massive increase especially in the 99/1 percentile ratio, indicating that in these sectors the most productive firms (at the $99th$ percentile of the productivity distribution) have substantially more increased their productivity compared to the less productive firms (at the $1th$ percentile of the productivity distribution).

Table D1: Percentile-ratios of the productivity distribution by 4-digit sector

Panel A: 1994-2007

		Sector*										
	All	1610	1621/22	1623	1624	1629	1711/12	1721/22	1723/24/29	3101	3102	3109
90/10	2.04	1.62	2.23	1.77	1.47	1.69	2.44	1.47	1.66	1.85	1.93	1.72
95/5	2.71	2.00	3.82	2.17	1.81	2.14	3.33	1.79	2.22	2.30	2.39	2.06
99/1	5.46	4.23	25.18	4.00	3.66	5.38	11.07	3.53	6.94	4.35	5.07	3.34

Panel B: 2008-2016

		Sector*										
	All	1610	1621/22	1623	1624	1629	1711/12	1721/22	1723/24/29	3101	3102	3109
90/10	2.45	1.71	3.12	3.11	1.77	2.06	2.84	1.79	1.88	1.64	1.60	1.70
95/5	3.38	2.13	5.24	4.76	2.34	2.79	4.41	2.40	2.85	2.03	1.96	2.13
99/1	9.40	5.33	44.40	18.36	4.16	6.21	31.30	5.49	9.75	4.27	3.52	5.07

* 1610 - sawmilling/wood planning, 1621/22 - veneer sheets/wood-based panels/parquet floors, 1623 - other builders' carpentry/joinery, 1624 - wooden containers, (1629) other products of wood, 1711/12 - pulp, paper, and paperboard, 1721/22 - cardboard/packaging/paper for domestic and health usage, 1723/24/29 - other products of paper, 3101 - office/shop furniture, 3102 kitchen furniture, (3109) other furniture.

E Productivity decomposition

This section provides more empirical results w.r.t. the various applied aggregate productivity decompositions in this paper. Section E.1 provides further material concerning the yearly aggregate productivity decomposition with entry and exit. Section E.2 applies the DOPD approach for each 4-digit industry separately. Section E.2.1 provides further empirical results concerning the productivity decomposition w.r.t. firms export status and Section E.2.2 does the same concerning the productivity decomposition w.r.t. firms' domestic and export sales activity.

E.1 Annual aggregate productivity with entry and exit

Table E1 provides figures w.r.t. aggregate productivity and sales shares of the firm groups survivors, entrants, and exitors. Note that Figure 4 in the main text can directly be reproduced using the aggregate productivity measures for the three firm groups ($\Omega_{S,t}, \Omega_{E,t}, \Omega_{X,t}$). Figure 5, showing the contribution to aggregate productivity growth by the three firm groups, can be deduced from Table E1, by applying the DOPD decomposition, given in equation (11).

Table E1: Aggregate productivity and sales shares over all firms*

Year	$S_{S,t}$	# Surv.	$S_{E,t}$	# Entr.	$S_{X,t}$	# Exit.	Ω_t	$\Omega_{S,t}$	$\Omega_{E,t}$	$\Omega_{X,t}$
1995	92.66	4539	5.04	466	2.26	135	-0.503	-0.494	-0.756	-0.298
1996	95.16	4780	2.08	325	2.36	312	-0.513	-0.508	-0.576	-0.528
1997	93.98	4895	2.70	366	3.13	266	-0.475	-0.468	-0.632	-0.491
1998	95.53	5133	1.71	205	2.62	254	-0.459	-0.462	-0.206	-0.528
1999	94.62	5088	2.60	191	2.51	344	-0.440	-0.445	-0.546	-0.196
2000	96.33	4879	1.65	175	1.59	317	-0.434	-0.428	-0.611	-0.575
2001	96.06	4997	2.01	359	1.90	145	-0.413	-0.415	-0.376	-0.386
2002	93.98	4976	1.54	248	4.29	312	-0.414	-0.413	-0.245	-0.501
2003	94.25	5015	2.68	241	3.03	239	-0.381	-0.389	-0.376	-0.116
2004	93.74	4940	1.99	157	3.69	249	-0.400	-0.405	-0.384	-0.294
2005	94.94	4865	3.15	141	1.83	128	-0.374	-0.369	-0.428	-0.552
2006	94.62	4831	1.17	197	4.07	204	-0.341	-0.341	-0.232	-0.358
2007	94.37	4824	3.58	163	1.95	210	-0.348	-0.357	-0.362	0.135
2008	95.16	4358	0.88	94	3.77	252	-0.175	-0.171	-0.199	-0.289
2009	93.91	4127	3.16	89	2.73	184	-0.219	-0.223	-0.207	-0.103
2010	93.69	4024	2.95	105	2.89	155	-0.226	-0.243	0.216	-0.200
2011	94.65	3888	1.91	110	3.23	222	-0.258	-0.262	-0.072	-0.281
2012	95.90	3800	2.18	131	1.68	117	-0.239	-0.244	-0.160	-0.099
2013	98.06	3747	0.77	79	1.07	95	-0.219	-0.217	-0.157	-0.441
2014	95.41	3603	2.07	84	2.26	91	-0.198	-0.205	0.439	-0.540
2015	95.51	3474	3.29	81	1.14	92	-0.169	-0.196	0.567	-0.089

* The columns $S_{G,t}$ and $\Omega_{G,t}$ with $G = \{S, E, X\}$ denote the aggregate sales share and the aggregate productivity of the firm groups survivors, exitors, and entrants, measured at the respective year. All sales shares $S_{G,t}$ are given in %.

E.2 Aggregate productivity and entry and exit w.r.t. 4-digit sectors

This section present the results of the DOPD for each 4-digit sector separately, given in Table E2. Further bellow, Table E3 and E4 provide measures of aggregate productivity and sales shares of the firm groups survivors, exitors, and entrants (likewise for each 4-digit sector separately), from which the growth rates reported in Table E2 can be derived. Note that Table E3 illustrate the empirical results associated with equation (9), the measures related to the initial year of a given period, i.e., measuring at Year 1 the aggregates for those firms that survive and exit until Year 2. Whereas Table E4 is associated with equation (10), i.e., measuring at Year 2 the aggregates for those firms that survive and enter until Year 2.

Generally, Table E2 shows that aggregate productivity growth evolution varies substantially among the different 4-digit sectors. However, there are some patters in common. First, many sectors reveal a considerable productivity growth for the initial period, 1994-2000, whereupon a decline in the growth rate is observed. Second, for most sectors the period of crisis 2008-2012, is marked with relatively low or negative growth in aggregate productivity. Third, for most cases, the group of surviving firms contributes most to aggregate productivity growth. Fourth, firms' entry and exit contribution is less important for the overall aggregate productivity growth.

There are some interesting information, though, regarding to some specific sectors: For instance, considering the sector for wood-based panels/parquet floors (1621/22), the within contribution, i.e. firms average productivity improvement through learning is negative throughout the whole periods. Instead, the positive between contribution, i.e. reallocation effects of sales shares moving from less to more productive firms fully compensates the negative within contribution. Furthermore, for most years and periods the three manufacturing sectors for products of furniture (3101, 3102, and 3103) experience negative between-contribution of surviving firms, indicating inefficient allocation of sales shares. Furthermore, for some sectors, the contribution of entering and exiting firms is substantial: For example, the industry for wood-based panels reveals a quite consistent negative (positive) contribution of the group of entrants (exitors). According to the DOPD approach, this implies that entrants and exitors are relatively less productive compared to the group of surviving firms. A similar pattern can be seen for the sector 1721/21.

Table E2: Aggregate productivity growth (DOPD) w.r.t. 4-digit sectors[a]

Sector	Period	Total Growth[b]	Contribution Survivors Within	Contribution Survivors Between	Contribution Entrants	Contribution Exitors
11610	1994 - 2000	3.25 (0.53)	7.33 (1.19)	-5.98 (-0.97)	0.87 (0.14)	1.03 (0.17)
Sawmilling/	2001 - 2007	18.89 (2.93)	9.73 (1.56)	7.14 (1.16)	-0.61 (-0.10)	2.63 (0.43)
wood planning	2008 - 2012	-8.48 (-2.06)	1.46 (0.36)	-6.73 (-1.64)	-1.09 (-0.27)	-2.11 (-0.52)
	2013 - 2016	16.89 (5.34)	4.90 (1.61)	7.99 (2.60)	0.23 (0.08)	3.77 (1.24)
1621/22	1994 - 2000	4.65 (0.76)	-6.31 (-1.03)	4.82 (0.79)	3.21 (0.53)	2.93 (0.48)
wood-based	2001 - 2007	7.23 (1.17)	-6.50 (-1.06)	12.13 (1.93)	-0.18 (-0.03)	1.77 (0.29)
panels/parquet floors	2008 - 2012	1.62 (0.40)	-7.65 (-1.86)	7.99 (1.94)	-3.50 (-0.86)	4.79 (1.18)
	2013 - 2016	3.09 (1.02)	-4.31 (-1.42)	7.77 (2.53)	-1.67 (-0.56)	1.30 (0.43)
1623	1994 - 2000	4.88 (0.80)	8.06 (1.30)	-4.73 (-0.77)	1.50 (0.25)	0.05 (0.01)
Other builders'	2001 - 2007	6.14 (1.00)	10.78 (1.72)	0.28 (0.05)	-2.13 (-0.35)	-2.78 (-0.46)
carpentry/joinery	2008 - 2012	-15.76 (-3.73)	-14.63 (-3.47)	-2.86 (-0.71)	2.72 (0.67)	-0.99 (-0.25)
	2013 - 2016	-4.58 (-1.50)	-22.97 (-7.13)	14.68 (4.67)	5.69 (1.86)	-1.98 (-0.66)
1624	1994 - 2000	20.45 (3.15)	8.56 (1.38)	14.21 (2.24)	-2.46 (-0.41)	0.14 (0.02)
Wooden containers	2001 - 2007	7.03 (1.14)	6.99 (1.13)	0.71 (0.12)	-0.43 (-0.07)	-0.24 (-0.04)
	2008 - 2012	-6.81 (-1.66)	-3.65 (-0.90)	-2.58 (-0.64)	-1.93 (-0.48)	1.35 (0.34)
	2013 - 2016	-2.70 (-0.89)	-1.77 (-0.59)	-0.97 (-0.32)	-0.16 (-0.05)	0.20 (0.07)
1629	1994 - 2000	13.03 (2.06)	0.31 (0.05)	15.18 (2.38)	-2.24 (-0.37)	-0.21 (-0.04)
Other wood	2001 - 2007	-11.47 (-1.83)	1.96 (0.32)	3.36 (0.55)	-0.46 (-0.08)	-16.34 (-2.55)
products	2008 - 2012	19.92 (4.65)	2.01 (0.50)	11.52 (2.76)	-0.65 (-0.16)	7.03 (1.71)
	2013 - 2016	14.97 (4.76)	-0.07 (-0.02)	0.88 (0.29)	14.20 (4.52)	-0.03 (-0.01)
1711/12	1994 - 2000	7.11 (1.15)	5.01 (0.82)	4.35 (0.71)	-1.37 (-0.23)	-0.88 (-0.15)
Pulp and	2001 - 2007	13.68 (2.16)	8.93 (1.44)	2.17 (0.36)	2.74 (0.45)	-0.16 (-0.03)
paper	2008 - 2012	6.65 (1.62)	2.26 (0.56)	3.07 (0.76)	-0.95 (-0.24)	2.27 (0.56)
	2013 - 2016	8.72 (2.83)	2.20 (0.73)	7.11 (2.32)	-0.82 (-0.27)	0.23 (0.08)
1721/22	1994 - 2000	10.41 (1.66)	3.12 (0.51)	6.74 (1.09)	-0.37 (-0.06)	0.93 (0.15)
Cardboard/packaging/	2001 - 2007	4.63 (0.76)	2.28 (0.38)	1.20 (0.20)	-0.30 (-0.05)	1.45 (0.24)
domestic/health usage	2008 - 2012	-0.01 (0.00)	1.15 (0.29)	-3.39 (-0.84)	1.20 (0.30)	1.03 (0.26)
	2013 - 2016	-2.16 (-0.71)	-0.68 (-0.22)	-1.96 (-0.65)	-0.02 (-0.01)	0.50 (0.17)
1723/24/29	1994 - 2000	-5.13 (-0.84)	1.13 (0.19)	-7.67 (-1.24)	5.99 (0.97)	-4.58 (-0.75)
Other products	2001 - 2007	1.68 (0.28)	1.18 (0.20)	7.77 (1.25)	-0.96 (-0.16)	-6.31 (-1.02)
of paper	2008 - 2012	6.42 (1.57)	3.46 (0.85)	6.47 (1.58)	2.46 (0.61)	-5.96 (-1.46)
	2013 - 2016	-5.53 (-1.81)	-3.94 (-1.30)	-1.65 (-0.55)	0.61 (0.20)	-0.55 (-0.18)
3101	1994 - 2000	33.39 (4.92)	26.64 (4.01)	13.78 (2.17)	-3.87 (-0.64)	-3.15 (-0.52)
Office/shop	2001 - 2007	6.08 (0.99)	11.51 (1.83)	-7.20 (-1.17)	-1.53 (-0.25)	3.30 (0.54)
furniture	2008 - 2012	-6.68 (-1.63)	-3.12 (-0.77)	-10.47 (-2.52)	6.05 (1.48)	0.86 (0.21)
	2013 - 2016	8.77 (2.84)	1.11 (0.37)	7.00 (2.28)	0.29 (0.10)	0.37 (0.12)
3102	1994 - 2000	-3.55 (-0.58)	13.17 (2.08)	-17.29 (-2.69)	0.44 (0.07)	0.12 (0.02)
Kitchen	2001 - 2007	-4.82 (-0.79)	9.77 (1.57)	-13.22 (-2.09)	-0.86 (-0.14)	-0.51 (-0.08)
furniture	2008 - 2012	-5.89 (-1.44)	-1.41 (-0.35)	-1.68 (-0.42)	0.83 (0.21)	-3.63 (-0.90)
	2013 - 2016	20.15 (6.31)	4.52 (1.48)	16.57 (5.24)	-0.77 (-0.26)	-0.17 (-0.06)
3109	1994 - 2000	-0.40 (-0.07)	10.12 (1.62)	-11.45 (-1.82)	1.54 (0.25)	-0.60 (-0.10)
Other	2001 - 2007	3.08 (0.51)	-0.23 (-0.04)	-1.51 (-0.25)	1.27 (0.21)	3.55 (0.58)
furniture	2008 - 2012	-6.77 (-1.65)	-3.62 (-0.89)	-5.20 (-1.27)	-0.72 (-0.18)	2.76 (0.68)
	2013 - 2016	-12.64 (-4.05)	-1.45 (-0.48)	-10.31 (-3.32)	-1.22 (-0.41)	0.35 (0.12)

[a] All figures represent growth rates in % relative to the initial year of the given period. Average annual growth rates are given in parenthesis.

[b] The total growth in aggregate productivity is the sum of the contributions of survivors, entrants and exitors.

Table E3: Aggregate productivity and sales shares by 4-digit sectors (Year 1)*

Sector	Year 1	Year 2	Measures in Year 1					
			$\Omega_{S,1}$	$S_{S,1}$	$\Omega_{X,1}$	$S_{X,1}$	No. Surv.	No. Exitors
1610	1994	2000	-0.53	87.85	-0.61	12.15	664	102
Sawmilling/	2001	2007	-0.42	77.93	-0.54	22.07	710	176
wood planning	2008	2012	-0.26	86.94	-0.10	13.06	541	100
	2013	2016	-0.31	95.98	-1.25	4.02	555	38
1621/22	1994	2000	-0.52	87.57	-0.75	12.43	70	9
Wood-based	2001	2007	-0.48	86.81	-0.62	13.19	81	15
panels/parquet floors	2008	2012	1.07	80.54	0.83	19.46	60	16
	2013	2016	1.04	98.53	0.15	1.47	55	3
1623	1994	2000	-0.45	86.11	-0.46	13.89	318	84
Other builders'	2001	2007	-0.40	74.68	-0.29	25.32	452	96
carpentry/joinery	2008	2012	-0.49	87.07	-0.42	12.93	422	109
	2013	2016	-0.67	94.08	-0.34	5.92	413	50
1624	1994	2000	-0.64	85.72	-0.65	14.28	350	75
Wooden containers	2001	2007	-0.43	84.83	-0.42	15.17	363	94
	2008	2012	-0.01	89.41	-0.14	10.59	348	46
	2013	2016	-0.05	97.50	-0.13	2.50	375	21
1629	1994	2000	-0.81	86.41	-0.79	13.59	195	33
Other wood	2001	2007	-0.72	69.44	-0.18	30.56	170	53
products	2008	2012	-0.56	72.87	-0.82	27.13	125	43
	2013	2016	-0.45	90.27	-0.45	9.73	104	12
1711/12	1994	2000	-0.89	84.63	-0.84	15.37	81	18
Pulp and	2001	2007	-0.78	83.85	-0.77	16.15	91	21
paper	2008	2012	-0.68	91.62	-0.95	8.38	71	15
	2013	2016	-0.69	88.91	-0.71	11.09	70	8
1721/22	1994	2000	-0.46	90.11	-0.55	9.89	382	73
cardboard/packaging/	2001	2007	-0.37	74.28	-0.43	25.72	354	119
domestic/health usage	2008	2012	-0.13	88.70	-0.22	11.30	329	55
	2013	2016	-0.09	96.68	-0.24	3.32	378	22
1723/24/29	1994	2000	-0.21	80.16	0.02	19.84	226	43
Other products	2001	2007	-0.13	82.51	0.23	17.49	229	52
of paper	2008	2012	0.14	80.88	0.45	19.12	205	26
	2013	2016	0.30	93.28	0.38	6.72	243	11
3101	1994	2000	-0.08	72.59	0.04	27.41	229	55
Office/shop	2001	2007	0.34	80.83	0.17	19.17	320	79
furniture	2008	2012	-0.15	86.77	-0.22	13.23	323	61
	2013	2016	-0.16	92.66	-0.21	7.34	308	35
3102	1994	2000	-0.59	90.81	-0.60	9.19	120	32
Kitchen	2001	2007	-0.59	92.05	-0.53	7.95	159	27
furniture	2008	2012	-0.57	86.71	-0.29	13.29	123	30
	2013	2016	-0.54	96.38	-0.50	3.62	102	13
3109	1994	2000	-0.38	83.59	-0.34	16.41	630	202
Other	2001	2007	-0.37	80.56	-0.56	19.44	597	246
furniture	2008	2012	0.15	84.05	-0.02	15.95	318	141
	2013	2016	0.23	93.72	0.17	6.28	225	34

* The columns $\Omega_{G,1}$ and $S_{G,1}$ with $G = \{S, X\}$ denote the aggregate productivity and the aggregate sales share of the firm groups survivors, exitors, and entrants - measured for the initial year (Year 1) of the period. All sales shares $S_{G,1}$ are given in %.

Table E4: Aggregate productivity and sales shares by sector (Year 2)*

Sector	Year 1	Year 2	$\Omega_{S,2}$	$S_{S,2}$	$\Omega_{E,2}$	$S_{E,2}$	No. Surv.	No. Entrants
		Measures in Year 2						
1610	1994	2000	-0.52	85.99	-0.45	14.01	664	192
Sawmilling/	2001	2007	-0.25	86.15	-0.30	13.85	710	172
wood planning	2008	2012	-0.32	91.60	-0.45	8.40	541	62
	2013	2016	-0.18	97.22	-0.10	2.78	555	21
1621_22	1994	2000	-0.53	82.45	-0.35	17.55	70	16
Wood-based	2001	2007	-0.43	77.86	-0.44	22.14	81	15
panels	2008	2012	1.08	97.82	-0.53	2.18	60	4
	2013	2016	1.07	93.96	0.79	6.04	55	4
1623	1994	2000	-0.42	86.94	-0.30	13.06	318	163
Other builders'	2001	2007	-0.28	81.78	-0.40	18.22	452	151
carpentry/joinery	2008	2012	-0.67	86.33	-0.47	13.67	422	59
	2013	2016	-0.76	94.99	0.38	5.01	413	24
1624	1994	2000	-0.42	82.27	-0.55	17.73	350	111
Wooden containers	2001	2007	-0.36	91.60	-0.41	8.40	363	63
	2008	2012	-0.07	86.14	-0.21	13.86	348	47
	2013	2016	-0.08	99.10	-0.26	0.90	375	11
1629	1994	2000	-0.65	84.62	-0.80	15.38	195	49
Other wood	2001	2007	-0.67	88.45	-0.71	11.55	170	31
products	2008	2012	-0.42	95.17	-0.56	4.83	125	7
	2013	2016	-0.45	74.06	0.10	25.94	104	4
1711/12	1994	2000	-0.80	69.98	-0.85	30.02	81	31
Pulp and	2001	2007	-0.67	91.46	-0.35	8.54	91	19
paper	2008	2012	-0.63	94.55	-0.80	5.45	71	8
	2013	2016	-0.60	85.75	-0.66	14.25	70	8
1721/22	1994	2000	-0.36	93.00	-0.41	7.00	382	88
cardboard/packaging/	2001	2007	-0.34	84.28	-0.36	15.72	354	58
domestic/health usage	2008	2012	-0.15	91.66	-0.01	8.34	329	33
	2013	2016	-0.12	97.98	-0.13	2.02	378	8
1723/24/29	1994	2000	-0.28	83.38	0.08	16.62	226	47
Other products	2001	2007	-0.04	92.23	-0.16	7.77	229	39
of paper	2008	2012	0.24	80.12	0.37	19.88	205	25
	2013	2016	0.24	92.47	0.33	7.53	243	7
3101	1994	2000	0.33	81.93	0.11	18.07	229	120
Office/shop	2001	2007	0.39	87.20	0.27	12.80	320	86
furniture	2008	2012	-0.29	84.35	0.10	15.65	323	20
	2013	2016	-0.08	97.73	0.05	2.27	308	10
3102	1994	2000	-0.63	81.01	-0.61	18.99	120	63
Kitchen	2001	2007	-0.63	92.94	-0.75	7.06	159	43
furniture	2008	2012	-0.60	92.44	-0.49	7.56	123	12
	2013	2016	-0.33	94.10	-0.46	5.90	102	6
3109	1994	2000	-0.39	89.22	-0.25	10.78	630	216
Other	2001	2007	-0.39	90.90	-0.25	9.10	597	134
furniture	2008	2012	0.06	87.22	0.01	12.78	318	32
	2013	2016	0.11	95.94	-0.19	4.06	225	18

* The columns $\Omega_{G,2}$ and $S_{G,2}$ with $G = \{S, E\}$, denote the aggregate productivity and the aggregate sales share of the firm groups survivors, exitors, and entrants - measured for the last year of the period (Year 2). All sales shares $S_{G,2}$ are given in %.

E.2.1 Aggregate productivity and firms' export status

Aggregate productivity decomposition w.r.t. export status

Table E5 provides measures of aggregate productivity and sales shares of the firm groups survivors, exitors, and entrants, separately for the firm categories non-exporter and exporter. Note that Panel A illustrates the empirical results associated with equation (9), the measures related to the initial year of a given period, i.e., measuring at Year 1 aggregate productivity/sales shares for those firms that survive and exit until Year 2. Whereas Panel B is associated with equation (10), i.e., measuring at Year 2 the aggregate productivity/sales shares for those firms that survive and enter until Year 2. Note that, here the sales shares of both the group of non-exporter and exporter sum up to 100% for a given year. For instance, consider Panel A, period 1994 (Year1) - 2000 (Year 2), the aggregate sales shares of group of surviving (exiting) firms belonging the group of non-exporter is given in 1994 by 11.21% (2.01%). For the same period, the sales shares of the surviving (exiting) firms belonging to the group of exporter is given in 1994 (Panel A) by 74.49% (12.29%), which in total yields 100%. Similarly, to obtain the total number of surviving firms, one needs to sum up surviving firms belonging to the group of non-exporter and exporter, given by 1484 and 1781, yielding a total surviving firms of 3265. Note that this number of survivors was also reported in Table 8 when considering all firms irrespective of their export status.

Table E5: Aggregate productivity and sales shares: domestic and export firms[a]

	Panel A: Measures in Year 1							
	Year 1	Year 2	$\Omega_{S,1}$	$S_{S,1}$	$\Omega_{X,1}$	$S_{X,1}$	No. Surv.	No. Exitors
Non-exporter	1994	2000	-0.555	11.21	-0.502	2.01	1484	400
	2001	2007	-0.429	10.94	-0.339	2.85	1676	510
	2009	2012	-0.242	13.43	-0.282	2.06	1506	260
	2013	2016	-0.299	14.66	-0.296	0.88	1395	140
Exporter	1994	2000	-0.529	74.49	-0.478	12.29	1781	326
	2001	2007	-0.420	69.18	-0.418	17.03	1850	468
	2009	2012	-0.217	78.05	-0.159	6.45	1713	219
	2013	2016	-0.167	79.67	-0.438	4.79	1539	108
	Panel B: Measures in Year 2							
	Year 1	Year 2	$\Omega_{S,2}$	$S_{S,2}$	$\Omega_{E,2}$	$S_{E,2}$	No. Surv.	No. Entrants
Non-exporter	1994	2000	-0.461	9.90	-0.450	3.02	1375	627
	2001	2007	-0.315	11.11	-0.300	2.86	1639	545
	2009	2012	-0.328	13.88	-0.210	1.47	1557	154
	2013	2016	-0.289	14.38	-0.040	0.58	1343	62
Exporter	1994	2000	-0.428	73.80	-0.530	13.27	1890	469
	2001	2007	-0.362	76.36	-0.328	9.67	1887	266
	2009	2012	-0.205	78.40	-0.143	6.25	1662	135
	2013	2016	-0.138	79.64	-0.220	5.40	1591	66

[a] The columns $\Omega_{G,j}$ and $S_{G,j}$ with $G = \{S, X, E\}$ and $j = \{1, 2\}$, denote the aggregate productivity and the aggregate sales share of the firm groups survivors, exitors, and entrants - measured for the initial year (Year 1) and the last year of the period (Year 2). All sales shares $S_{G,j}$ are given in %.

Investigating productivity differences w.r.t. firms' export status

I am interested in investigating productivity differences between the two firm groups of exporter and non-exporter. For this purpose, I follow Fariñas and Ruano (2005) who analyzed productivity differences for different groups of firms active in the Spanish manufacturing industry. The analysis is conducted in two parts: (i) by a graphically comparison between the empirical cumulative density function (ECDF) of the firms belonging to the different groups and (ii) by statistically testing differences among these distributions.

(i) Graphical comparison
In order to graphically analyze the distributions between different groups of firms I visualize the CDF's of the corresponding firm group. This allows to compare the whole productivity distributions of different groups of firms, instead of only comparing single moments, such as the mean or median.

Let $\widehat{F}_G(c)$ be the productivity ECDF of a specific firm group, where

$$\widehat{F}_G(c) = \frac{1}{N_G} \sum_{n \in G} \mathbf{1}_{[\widehat{\omega}_n \leq c]}, \tag{16}$$

where $\mathbf{1}_{[A]}$ denotes a dummy variable equal to 1 if the condition A in brackets is satisfied and 0 otherwise. The intuition of the concept of (first-order) stochastic dominance is, if the position of productivity ECDF of group one is consistently located to the right of the ECDF of group two, then the distribution of group two stochastically dominates the distribution of group one. This implies that for each percentile, firms' productivity levels belonging to group two are higher compared to group one.

(ii) Testing procedure
Let F_1 and F_2 be the CDF's of firm productivity of exporters and non-exporters, respectively, for a given period t. First order stochastic dominance of F_1 with respect to F_2 implies $F_1(\omega) - F_2(\omega) \leq 0$, with strict inequality for a specific productivity level ω, where $P(\omega \in \mathbb{R}) = 1$. The Kolmogorov-Smirnov test allows to test for stochastic dominance.[35] First, the two-sided test allows to test whether the distributions F_1 and F_2 follow the same law and is given by

$$H_0 : \sup_{\omega \in \mathbb{R}} |F_1(\omega) - F_2(\omega)| = 0 \quad \text{vs.} \quad H_A : \sup_{\omega \in \mathbb{R}} |F_1(\omega) - F_2(\omega)| \neq 0, \tag{17}$$

[35] See Kolmogorov (1933) and Smirnov (1939).

The one-sided test, allows to specifically test which of the two distributions (first order) stochastically dominates the other and is given by

$$H_0 : \sup_{\omega\in\mathbb{R}}\{F_1(\omega) - F_2(\omega)\} \leq 0 \quad \text{vs.} \quad H_A : \sup_{\omega\in\mathbb{R}}\{F_1(\omega) - F_2(\omega)\} > 0. \tag{18}$$

The respective test statistics for the two- and one-side test are given by

$$\text{KS}_N^{\text{two}} = \sqrt{\frac{N_1 \cdot N_2}{N}} \sup_{\omega\in\mathbb{R}} |T_N(\omega)| \quad \text{and} \quad \text{KS}_N^{\text{one}} = \sqrt{\frac{N_1 \cdot N_2}{N}} \sup_{\omega\in\mathbb{R}} T_N(\omega), \tag{19}$$

where $T_N(\omega) = \widehat{F}_{1,N_1}(\omega) - \widehat{F}_{2,N_2}(\omega)$, with $\widehat{F}_{1,N_1}$ and $\widehat{F}_{2,N_2}$ the empirical CDF's of F_1 and F_2 and $N = N_1 + N_2$ denotes the total number of observations from both distributions.

E.2.2 Aggregate productivity w.r.t. firms' domestic and export activity

Table E6 relates to the productivity decomposition presented in equation (13), i.e. the Olley-Pakes productivity decomposition, extended to the case of domestic and export economic activity. The table shows both aggregate productivity and sales shares related to firms' domestic and export economic activity, measured in the initial year of a given period (Panel A) as well as for the end year of a given period (Panel B)

Table E6: Aggregate productivity and sales share w.r.t. firms domestic and export activity*

Panel A: Measures in Year 1							
Year 1	Year 2	Ω_1	$S_{d,1}$	$\Omega_{d,1}$	$S_{exp,1}$	$\Omega_{exp,2}$	No. firms
1994	2000	-0.542	76.87	-0.388	23.13	-0.154	3265
2001	2007	-0.441	72.70	-0.297	27.30	-0.144	3526
2009	2012	-0.229	76.47	-0.171	23.53	-0.059	3219
2013	2016	-0.202	77.34	-0.157	22.66	-0.046	2934
Panel B: Measures in Year 2							
Year 1	Year 2	Ω_2	$S_{d,2}$	$\Omega_{d,2}$	$S_{exp,2}$	$\Omega_{exp,2}$	No. firms
1994	2000	-0.448	75.40	-0.316	24.60	-0.133	3265
2001	2007	-0.366	73.39	-0.252	26.61	-0.114	3526
2009	2012	-0.235	75.71	-0.171	24.29	-0.064	3219
2013	2016	-0.169	76.61	-0.138	23.39	-0.031	2934

* The columns $\Omega_{G,j}$ and $S_{G,j}$ with $G = \{d, exp\}$ and $j = \{1, 2\}$, denote the aggregate productivity and the aggregate sales share related to firms' domestic and export activity, measured in the initial year (Year 1) and the last year of the period (Year 2). All sales shares $S_{G,j}$ are given in %.

References

Ackerberg, D. A., Caves, K. and Frazer, G. (2015). Identification properties of recent production function estimators, *Econometrica* **83**(6): 2411–2451.

Andrews, D. W. and Fair, R. C. (1988). Inference in nonlinear econometric models with structural change, *The Review of Economic Studies* **55**(4): 615–640.

Baily, M. N., Hulten, C. and Campbell, D. (1992). Productivity dynamics in manufacturing plants, *Brookings Papers on Economic Activity: Microeconomics* **4**: 187–267.

Baldwin, J. R. and Gu, W. (2006). Plant turnover and productivity growth in Canadian manufacturing, *Industrial and Corporate Change* **15**(3): 417–465.

Bellone, F. (2017). Comment-Productivity slowdown and loss of allocative efficiency: A French disease?, *Économie et Statistique* **494**(1): 37–43.

Bellone, F., Kiyota, K., Matsuura, T., Musso, P. and Nesta, L. (2014). International productivity gaps and the export status of firms: Evidence from France and Japan, *European Economic Review* **70**: 56–74.

Bellone, F., Musso, P., Nesta, L. and Quere, M. (2008). The U-shaped productivity dynamics of French exporters, *Review of World Economics* **144**(4): 636–659.

Bellone, F., Musso, P., Nesta, L. and Warzynski, F. (2016). International trade and firm-level markups when location and quality matter, *Journal of Economic Geography* **16**(1): 67–91.

Ben Hassine, H. (2019). Productivity growth and resource reallocation in France: The process of creative destruction, *Economie et Statistique* **507**(1): 115–133.

Bernard, A. B., Eaton, J., Jensen, J. B. and Kortum, S. (2003). Plants and productivity in international trade, *American Economic Review* **93**(4): 1268–1290.

Bernard, A. B. and Jensen, J. B. (1999). Exceptional exporter performance: cause, effect, or both?, *Journal of International Economics* **47**(1): 1–25.

Bernard, A. B. and Jensen, J. B. (2004). Why some firms export, *Review of Economics and Statistics* **86**(2): 561–569.

Bernard, A. B., Jensen, J. B., Redding, S. J. and Schott, P. K. (2007). Firms in international trade, *Journal of Economic Perspectives* **21**(3): 105–130.

Blanchard, P., Huiban, J. P. and Mathieu, C. (2014). The shadow of death model revisited with an application to French firms, *Applied Economics* **46**(16): 1883–1893.

Blanchard, P. and Mathieu, C. (2016). Multinationals and domestic firms in France: who gains from knowledge spillovers?, *Review of Agricultural, Food and Environmental Studies* **97**(2): 109–125.

Busso, M., Madrigal, L. and Pagés, C. (2013). Productivity and resource misallocation in Latin America, *The BE Journal of Macroeconomics* **13**(1): 903–932.

Calligaris, S., Del Gatto, M., Hassan, F., Ottaviano, G. I., Schivardi, F. et al. (2016). Italy's productivity conundrum. A study on resource misallocation in Italy, *European Comission, Discussion Paper* **030**.

Caselli, F. (2005). Accounting for cross-country income differences, *Handbook of economic growth* **1**: 679–741.

Cette, G., Corde, S. and Lecat, R. (2017). Stagnation of productivity in France: a legacy of the crisis or a structural slowdown?, *Economie et Statistique* **494**(1): 11–36.

Chaussé, P. (2010). Computing generalized method of moments and generalized empirical likelihood with R, *Journal of Statistical Software* **34**(11): 1–35.

De Loecker, J. (2013). Detecting learning by exporting, *American Economic Journal: Microeconomics* **5**(3): 1–21.

De Loecker, J., Eeckhout, J. and Unger, G. (2020). The rise of market power and the macroeconomic implications, *The Quarterly Journal of Economics* **135**(2): 561–644.

De Loecker, J. and Warzynski, F. (2012). Markups and firm-level export status, *American Economic Review* **102**(6): 2437–71.

De Monte, E. (2021). Productivity, markups, entry, and exit: Evidence from French manufacturing firms from 1994-2016, *BETA Working Paper, Université de Strasbourg* .

Demirer, M. (2020). Production function estimation with factor-augmenting technology: An application to markups, *MIT Working Paper* .

Donald, S. G., Imbens, G. W. and Newey, W. K. (2009). Choosing instrumental variables in conditional moment restriction models, *Journal of Econometrics* **152**(1): 28–36.

Doraszelski, U. and Jaumandreu, J. (2018). Measuring the bias of technological change, *Journal of Political Economy* **126**(3): 1027–1084.

Fariñas, J. C. and Ruano, S. (2005). Firm productivity, heterogeneity, sunk costs and market selection, *International Journal of Industrial Organization* **23**(7-8): 505–534.

Foster, L., Haltiwanger, J. C. and Krizan, C. J. (2001). *Aggregate productivity growth. Lessons from microeconomic evidence*, University of Chicago Press.

Foster, L., Haltiwanger, J. and Krizan, C. J. (2006). Market selection, reallocation, and restructuring in the U.S. retail trade sector in the 1990s, *Review of Economics and Statistics* **88**(4): 748–758.

Foster, L., Haltiwanger, J. and Syverson, C. (2008). Reallocation, firm turnover, and efficiency: Selection on productivity or profitability?, *American Economic Review* **98**(1): 394–425.

Gandhi, A., Navarro, S. and Rivers, D. A. (2020). On the identification of gross output production functions, *Journal of Political Economy* **128**(8): 2973–3016.

Girma, S., Greenaway, A. and Kneller, R. (2004). Does exporting increase productivity? A microeconometric analysis of matched firms, *Review of International Economics* **12**(5): 855–866.

Griliches, Z. and Regev, H. (1995). Productivity and firm turnover in Israeli industry: 1979-1988, *Journal of Econometrics* **65**: 175–203.

Haltiwanger, J. (2011). Firm dynamics and productivity growth, *European Investment Bank Papers* **16**(1): 116–136.

Hansen, L. P. (1982). Large sample properties of generalized method of moments estimators, *Econometrica: Journal of the Econometric Society* pp. 1029–1054.

Hansson, P. and Lundin, N. N. (2004). Exports as an indicator on or promoter of successful Swedish manufacturing firms in the 1990s, *Review of World Economics* **140**(3): 415–445.

Harris, R. and Li, Q. C. (2008). Evaluating the contribution of exporting to uk productivity growth: some microeconomic evidence, *World Economy* **31**(2): 212–235.

Hayfield, T. and Racine, J. S. (2015). Nonparametric Econometrics: The np Package, *Journal of Statistical Software* **27**(5).

Hsieh, C.-T. and Klenow, P. J. (2009). Misallocation and manufacturing TFP in China and India, *The Quarterly Journal of Economics* **124**(4): 1403–1448.

Koebel, B. M., Levet, A. L., Nguyen-Van, P., Purohoo, I. and Guinard, L. (2016). Productivity, resource endowment, and trade performance of the wood product sector, *Journal of Forest Economics* (22): 24–35.

Kolmogorov, A. (1933). Sulla determinazione empirica di una legge di distribuzione, *Giorn. Inst. Ital. Attuari* **4**: 83–91.

Levet, A.-L., Guinard, L., Koebel, B., Nguyen Van, P. and Purohoo, I. (2015). Compétitivité à l'exportation du secteur forêt-bois française, *FCBA Working Paper* (6).

Levet, A.-L., Guinard, L. and Purohoo, I. (2014). Le commerce extérieur des produits bois: existe t-il réellement un paradoxe français?/ Foreign trade in wood products: is there truly a French paradox?, *Revue Forestière Française* (66): 51–66.

Levinsohn, J. and Petrin, A. (2003). Estimating production functions using inputs to control for unobservables, *The Review of Economic Studies Review of Economic Studies* **70**(2): 317–341.

Lundmark, R. (2010). European trade in forest products and fuels, *Journal of Forest Economics* **16**(3): 235–251.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity, *Econometrica* **71**(6): 1695–1725.

Melitz, M. J. and Ottaviano, G. I. (2008). Market size, trade, and productivity, *The Review of Economic Studies* **75**(1): 295–316.

Melitz, M. J. and Polanec, S. (2015). Dynamic Olley-Pakes Productivity Decomposition with entry and exit, *RAND Journal of Economics* **46**(2): 362–375.

Morlacco, M. (2017). Market power in input markets: Theory and evidence from French manufacturing, *Yale University, Technical Report* .

Olley, G. S. and Pakes, A. (1996). The dynamics of productivity in the telecommunications equipment industry, *Econometrica* **64**(6): 1263–1297.

Pavcnik, N. (2002). Trade liberalization, exit, and productivity improvements: Evidence from Chilean plants, *Review of Economic Studies* **69**: 245–276.

Restuccia, D. and Rogerson, R. (2013). Misallocation and productivity, *Review of Economic Dynamics* **16**: 1–10.

Schumpeter, J. (1942). *Capitalism, socialism, and democracy*, 3d ed., New York: Harper and Row.

Smirnov, N. V. (1939). On the estimation of the discrepancy between empirical curves of distribution for two independent samples, *Bull. Math. Univ. Moscou* **2**(2): 3–14.

Wooldridge, J. M. (2009). On estimating firm-level production functions using proxy variables to control for unobservables, *Economics Letters* **104**(3): 112–114.