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News from the Frontier: Increased Productivity Dispersion across Firms and Factor Reallocation

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Abstract: Analysing French firms over 1991-2016, we find first that since the beginning of the century, one or two downward significant productivity breaks have occurred in all industries, both at the frontier and for laggard firms, suggesting a decline in the contribution of technological progress to productivity growth. Second, the median labour share is always higher for the laggard firms, with no clear trend, than for the frontier firms, with a sharp decrease from the mid-1990s to 2008, and an increase from 2008 onwards. Third, factor reallocation decreased significantly in the 2000s, at the time when we observed an increase in productivity dispersion, with a growing productivity gap between frontier and laggard firms. It appears also that reallocation has been lower on average over the whole period for sectors with a high import share, which can be related to the impact of global value chains.

JEL classification: D24; E24; J23; L25
Keywords: productivity; frontier firms; reallocation

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1 Introduction

Over the past decades, productivity has suffered from a dramatic slowdown in all developed countries (see for instance Bergeaud, et al., 2016, 2018). In the United States, a short productivity revival linked to ICT production and diffusion occurred during the decade 1995-2005, after which we observe the continuation of the previous slowdown. This slowdown concerns labour productivity (LP) per head or per hour and, as the capital deepening contribution used to explain it is marginal, total factor productivity (TFP). Over the past 15 years, productivity growth has been lower than that observed on average over such a period between the end of the 19th century and the beginning of the second industrial revolution, except during the war sub-periods. The current situation could correspond to a long-term one, which would mean that the third industrial revolution, originally linked to ICTs, has had only a short and small impact on productivity, and that developed countries could now suffer from a long period of low productivity growth. This approach is for instance defended by Gordon in numerous papers (2012, 2013, 2014, 2016). However, low productivity growth could also correspond to a pause before a huge and long productivity revival linked to the diffusion of the digital economy across all activities, as suggested for instance by Van Ark (2016)[1] or Branstetter and Sichel (2017). Depending on which of these two approaches are confirmed, developed countries will face with difficulty or, on the contrary, with ease the headwinds that are already blowing on them at the beginning of the 21st century, such as the ageing of the population, the indebtedness of general government, global warming and more generally the environmental sustainability of economic development, and rising inequalities. In order to better understand the reasons for the current low productivity growth, it is crucial to devise some long-term scenarios for the future.

The main goal of this paper is to analyse on a large dataset of French firms whether the productivity slowdown has resulted from a slowdown at the productivity frontier, which would suggest a decline in the contribution of technological progress to productivity growth, as mentioned by Gordon (2012, 2013, 2014 and 2016), or whether it has resulted from a misallocation of production factors, associated with a growing productivity dispersion among firms and a growing productivity gap between the firms at the frontier and laggard firms. Such growing productivity dispersion was shown on firm level data for several developed countries by Andrews et al. (2015) and for France by Cette et al. (2017, 2018).

Abundant literature shows that production factor misallocation could be at least partly the result of lower financial constraints and real interest rates over the past two decades (see Reis, 2013 or Aghion et al., 2019). Due to

[1] For Van Ark (2016), this pause would mean that "the New Digital Economy is still in its 'installation phase' and productivity effects may occur once the technology enters the 'deployment phase' ".

lower financial constraints and real interest rates, the firms with the highest productivity have not crowded out the least efficient ones, which corresponds to a decrease in cleansing mechanisms. In other words, low productivity firms have survived longer and firm productivity dispersion has increased, which has had a detrimental impact on average productivity growth. At the same time, this phenomenon has reduced the efficiency of factor allocation, which has also had a detrimental impact on average productivity growth. Several papers show that such mechanisms could contribute to explaining the huge productivity slowdown in southern European countries before the financial crisis (see for instance Reis, 2013, Gopinath et al., 2017 or Cette et al., 2016). On industry data over a large set of countries, Borio et al. (2016) find that fast credit growth leads to lower productivity growth. Using data on about 260 US metropolitan statistical areas (MSA) over the period 2007-2014, Gropp et al. (2018) show that higher financial constraints have increased cleansing mechanisms and job destruction with a positive impact on MSA average productivity growth. Aghion et al. (2019) show, on a large dataset of French firms, that two channels linking financial development and economic growth are in fact at work. In an environment of low interest rates, a negative channel where low productivity firms exit the market less often and reallocate resources towards these firms coexists with a positive channel where firms that had previously suffered from financial constraints have easier access to credit to finance their innovations and therefore become more productive. Then, lower credit constraints can have both a counteracting effect on innovation-led growth through lower efficient resource allocation towards more innovative firms and a positive effect through easier innovation financing.[2] At an aggregate level, financial development would have an overall concave effect on innovation and growth. The aggregate productivity slowdown, associated with lower financial constraints and real interest rates, means that the mechanisms on the left-hand side of this concave relation would have had, over the past decades, a greater productivity impact than the mechanisms on the right-hand side.

In this paper, we use a large unbalanced dataset of four million observations on French firms over the 1991-2016 period, extracted from the FIBEN company dataset built by the Banque de France, to analyse the firm productivity dispersion, the productivity behaviour of firms at the efficiency frontier and low-productivity laggard firms, and labour allocation. France is a particularly interesting country for testing these different hypotheses, as it displays a high level of aggregate productivity, a significant productivity slowdown and a balanced sectoral composition of its productive sector, with a mix of technologically advanced firms and laggard firms. The frontier firms are here the most productive ones, defined as a constant number of firms at the industry level, this constant number

[2] Other more recent empirical papers, using an individual firm dataset in the context of the financial crisis, have shown this detrimental channel of financial constraints on productivity growth. See for instance, Duval et al. (2020) on US firms and Manaresi and Pierri (2017) on Italian ones.

corresponding to 10% of the average number of firms in our dataset. Laggard firms are the other ones.

The three main results, obtained both for LP and TFP, are the following.

First, econometric estimates reveal that since the beginning of the century, one or two significant downward productivity breaks have occurred in all industries, both at the frontier and for laggard firms. The downward breaks at the frontier suggest a decline in the contribution of technological progress to productivity growth.

The second main result concerns the labour share. The median labour share is always higher for the laggard firms (and consequently the whole dataset) than for the frontier firms. The median labour share does not exhibit any clear trend on the whole dataset or on the laggard firms. At the frontier, the labour share decreased sharply (by more than ten percentage points) from the mid-1990s to 2008, and has increased since 2008 to offset about half of the previous decrease. These developments can be linked to the firm renewal rate at the frontier, which was on a downtrend before 2008. They suggest that before the crisis, as a result of becoming more and more efficient in terms of productivity compared to the laggard firms, the frontier firms were less and less obliged to compete with the other firms and were then able to increase their margin rate.

Third, other estimates indicate that labour reallocation decreased significantly in the 2000s. This lower reallocation efficiency occurred at the time when we observed an increase in productivity dispersion, with a growing productivity gap between frontier and laggard firms. These two simultaneous phenomena contribute to the downward breaks in aggregate productivity trends, and could, at least partly, be linked to the decrease in financial constraints and real interest rates, as described by Aghion et al. (2019). It also appears that the reallocation has been significantly lower since the 2000s, and on average over the whole period for sectors with a high import share, which can be related to the impact of global value chains. Both these features contribute to explaining the productivity slowdown and are consistent with several explanations, including Aghion et al. (2019).

The paper is organised as follows. Section 2 presents the data and the productivity index measurement. Section 3 looks at productivity and margin rate developments at the frontier and for laggard firms. Section 4 presents estimate results of a labour reallocation relation. Section 5 sets out our conclusions.

2 Data and Measurement

The core database of this study is the FIBEN company database, which gathers accounting data (both balance sheets and profit and loss accounts established for the tax administration) of all French companies (Metropolitan France and Overseas Departments) whose annual turnover exceeds EUR 750,000 or which hold more than EUR 380,000 in bank loans. This database focuses on the companies which account for most of the added value and the private sector workforce (market sector with the exception of the financial sector) and whose accounting data are of higher quality. Moreover, the database is managed by the Banque de France, which performs quality controls over the data. We will use this database over the period 1991-2016.

This study focuses on two productivity indicators calculated for each firm: labour productivity (LP) and total factor productivity (TFP). The first one is the ratio of value added to the number of employees (L). The second one, in accordance with a Cobb-Douglas function, is the ratio of value added to a geometric average of labour and capital factors (K) usually written as $K\alpha.L\beta$. The data treatment as well as the estimation of the parameters α and β are detailed in Appendix 1.

The data treatment led to the constitution of two separate databases, each of them dedicated to one of the two indicators, LP and TFP. Using the cleaned FIBEN database, we obtain an unbalanced sample made up of between 86,000 and 210,000 companies per year over the study period. The LP database contains 3,995,230 observations and the TFP one 3,894,480.

In order to characterise the possible heterogeneity of the dates of productivity breaks, we distinguished 13 business sectors, whatever the firm size or six business sectors (agriculture and silviculture, manufacturing industries, construction, retail, transport, and other services, with the classifications having been conducted on the basis of NAF rev 2) and two size classes of companies: less or more than 50 employees. The first size represents around 90% of the companies.

Some descriptive data are presented in Tables 1 (Labour productivity database) and 2 (TFP productivity database). Statistics on the variables common to both databases (employment, real turnover, real turnover growth rate, labour share) show the robustness of our methodology regarding the treatment of outliers. Not surprisingly, the medians are not or slightly modified; neither are the quartiles and the first and last deciles nor – this has to be stressed - the averages, employment being the noteworthy exception. The median workforce amounts to 12 employees, with an average of 40 for the LP database against 80 for the TFP database, and it lies between 4 and 49 employees for 80% of firms. Real turnovers are on average close to EUR 9 million (2010 equivalent), with a median around EUR 2 million.The FIBEN entrance condition of a minimum turnover explains that the first decile is around EUR 0.9 million and that the 10 percent richest firms have a turnover above EUR 11 million. Even if the average turnover growth rate is between 5 and 6%, it varies significantly across firms: from -20% for the first decile to +20% for the ninth. The median growth rate is a trade-off between these behaviours and reaches 0.8%. Finally, the labour share, defined individually during the TFP computation (see above), lies above 50% for 90% of the population and equals 100% for at least 10% of the population. Medians and averages are quite close, respectively around 79.5% and 76%.

Table 1: Labour Productivity Database

Variable Name	Mean	10th Percentile	25th Percentile (Lower Quartile)	50th Percentile (Median)	75th Percentile (Upper Quartile)	90th Percentile
Employment (Full time equivalent)	39.3	4.0	7.0	12.0	25.0	49.0
LP (k€)	65.0	27.8	38.0	52.5	74.6	108.9
Real turnover (k€ 2010)	8990.5	886.9	1210.1	1998.1	4253.0	10971.3
LP growth rate (%)	-0.3	-27.2	-12.5	-0.6	11.2	27.1
Real turnover growth rate (%)	5.1	-19.0	-7.2	0.8	9.0	21.2
Labour Share (%)	76.5	50.4	65.3	79.6	91.2	100.0

Table 2: Total Factor Productivity Database

Variable Name	Mean	10th Percentile	25th Percentile (Lower Quartile)	50th Percentile (Median)	75th Percentile (Upper Quartile)	90th Percentile
Employment (Full time equivalent)	80.3	4.0	7.0	12.0	25.0	49.0
TFP	26.0	10.0	14.1	20.9	31.7	46.7
Real turnover (k€ 2010)	9055.8	892.9	1214.4	2001.9	4252.8	10959.7
TFP growth rate (%)	-1.7	-25.0	-12.3	-1.7	8.7	21.8
Real turnover growth rate (%)	5.9	-18.3	-7.0	0.8	9.1	21.3
Labour share (%)	76.2	50.1	65.1	79.4	90.9	100.0

The levels of specific productivity variables, LP and TFP, cannot be compared. In both cases, the mean is above the median: EUR 65 thousand against EUR 52 thousand for LP and EUR 26 thousand against EUR 21 thousand for TFP. This reflects the "heavy tail" distribution of the variables. The interdecile spread is greater for TFP (D1= EUR 10 thousand, D9= EUR 46.7 thousand) than for LP (D1= EUR 27.8 thousand, D9= EUR 108.9 thousand). However, the LP and TFP growth rates follow similar patterns. For both of them, the median and the average are negative (-0.6% and -0.3% for LP and -1.7% for the two statistics for TFP). The first and ninth deciles are almost as symmetric as they were for the turnover growth rate: from -27% to + 27% for LP growth and from -25% to +22% for TFP growth.

3 News from the Frontier

Global productivity has suffered from a huge slowdown since the early 1990s (see introduction). This slowdown could result statistically from a growing productivity dispersion among firms without any slowdown at the technological frontier, or from a slowdown at the frontier. In the first case, it would correspond to a decline in the dissemination of technologies from companies at the frontier and those away from it, possibly related to

an increasingly inefficient reallocation of production factors, as described by Andrew et al. (2015). In the second case, it could also correspond to a decline in the contribution of technological progress to productivity growth, as commented by Gordon (2012, 2013, 2014 and 2016).
We look at these two possible explanations and for that we compare productivity developments for frontier firms and laggard firms. As described in the previous section, frontier firms are the most productive ones, taking for that a constant number of firms at the industry level, this constant number corresponding to 10% of the average number of firms in our dataset. Laggard firms are the other ones.
We consider the median productivity level of these two groups of firms to compare their evolutions (3.1) and to look at possible breaks (3.2). We also look at the frontier renewal (3.3), as a slowdown of technology dissemination could imply a decline in this renewal.
Finally, we compare the labour share of the two groups of firms (3.4), to see whether the most efficient firms are also the most profitable ones. Two productivity indicators are considered: productivity per employee (LP) and total factor productivity (TFP).

3.1 Productivity Developments of Frontier Firms and Laggard Firms

Compared to Cette et al. (2017, 2018) or the main specification of Andrew et al. (2015), we introduce a substantial modification in the frontier's definition. Instead of considering the same proportion of most productive firms in each sector and each year, we decide to fix a constant number of firms and define it as the fixed frontier, which enables us to compute meaningful renewal rates at the frontier (see section 3.3 below).
The constant total number of firms selected each year corresponds to 10% of the annual average size of the dataset. The number of firms at the frontier thus amounts to 14,768 for each year over the whole period.
To determine the constant number of firms at the frontier in each sector,[3] since the sum of sectoral averages is not congruent with the overall average, we take into account the relative contribution of each sector to the average added value over the period, to maintain the representativeness of each sector.[4] For instance, the sector "Agriculture" represents on average 3.4% of total added value over the period. Consequently, the number of firms at the frontier from this sector totals 506 each year (3.4% of the 14,768 frontier firms).
The productivity frontier is defined as the median value of productivity of the overall (cross-sectoral) fixed number of the most productive firms in

[3] The sectoral breakdown is presented in Appendix 3.
[4] The sectoral shares in value added are fairly stable over the period, with changes below 1 point for all sectors, apart from an expansion of the share of scientific and technical activities.

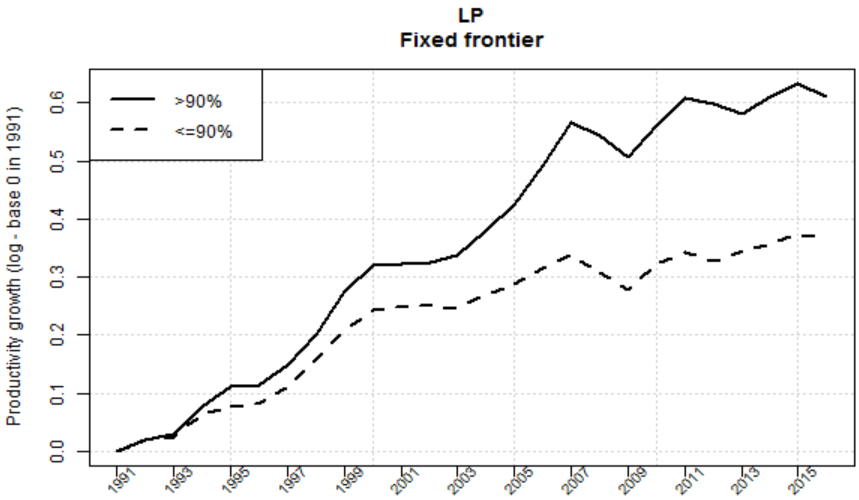
each sector. The median value of the remaining firms will be compared to this frontier.[5]

Figure 1 shows the median productivity level of frontier firms and laggard firms, over the period 1991-2016, productivity being measured by LP (A) or by TFP (B).

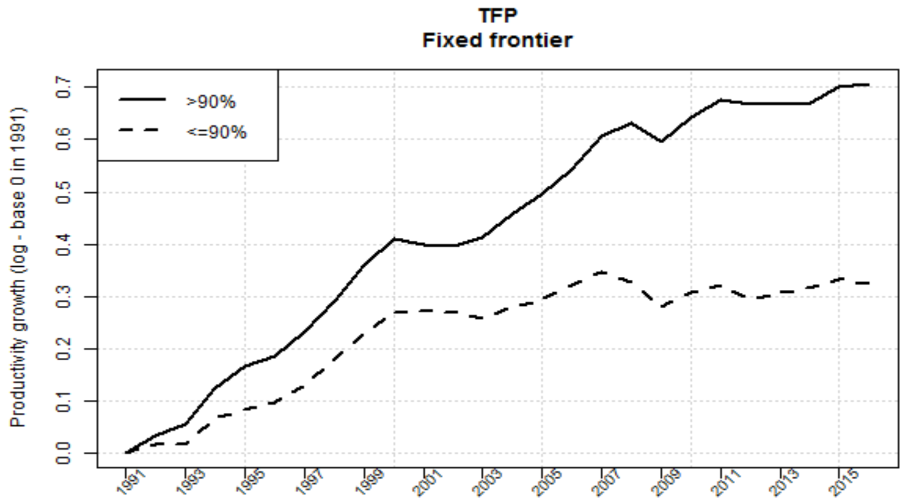
Figure 1: Productivity Level of Frontier Firms and Laggard Firms

Median by Category – log in base 0 in 1991

A – Productivity per Employee



B – Total Factor Productivity



[5] This is therefore an unweighted indicator, not taking into account firm size. However, the FIBEN database excludes the smallest firms, which reduces the bias, and frontier firms are not characterised by a strongly biased size composition.

Two main results emerge, which are similar for the two productivity measurements. First, we observe a growing productivity gap between frontier firms and laggard firms. Over the period, this gap has increased by about 25 percentage points for LP and 30 percentage points for TFP. Andrews et al. (2015) obtained the same results over a multinational database and Cette et al. (2017, 2018) for France. This growing gap suggests an increasing productivity dispersion which could have contributed to the global productivity slowdown, and which could correspond to an increasingly inefficient reallocation of production factors. Section 4 below deals with such reallocation through estimates. The second main result is that we observe a productivity slowdown both at the frontier and for the laggard firms, at the beginning and at the end of the 2000s. These breaks could also have contributed to the global productivity slowdown. The following sub-section presents estimates of such breaks.
There are two possible explanations for the global productivity slowdown: an increasingly inefficient factor reallocation, with as a result a growing productivity gap between frontier firms and laggard firms, and a productivity slowdown both at the frontier and for laggard firms. These two explanations, which visually appear in Figure 1, nevertheless need to receive further statistical confirmation (see section 3.2).

3.2 Productivity Trend Breaks

We continue to detect productivity breaks over our firm dataset using the median of labour productivity per employee (LP) and total factor productivity (TFP) indicators calculated within different scopes: the whole market economy, two company sizes (size 1: fewer than 50 employees; size 2: 50 or more employees), six business sectors (agriculture, industry, construction, retail, transportation, other services[6]), and the productivity level position (being at the frontier or laggard). As much as possible, we cross these different dimensions when there are enough observations for that. The breaks are characterised by the Bai and Perron method (2003). The effects of cyclical economic variations are taken into account by introducing the real turnover growth rate into the regression as an explanatory variable. It must be highlighted that as size 1 (fewer than 50 employees) represents around 90% of the companies in our database, the evolutions of the medians of our productivity indicators are, over all other dimensions, fairly close to those of size 1.
For each productivity indicator considered (Z), the productivity trends are defined over the logarithm of the indicator (z = Log(Z)):

$$z_t = \alpha + \sum_{k=0}^{m} \beta_k.(t - T_k).\mathbf{1}\{t \geq T_k\} + \gamma.\Delta_t + u_t$$

With z, the productivity logarithm; m, the number of breaks; t, the dates of the breaks; 1{.}, an indicative function such that **1{.}** = 1 if t ≥ Tk and **1{.}** = 0

[6] See Appendix 3 for the composition of these sectors.

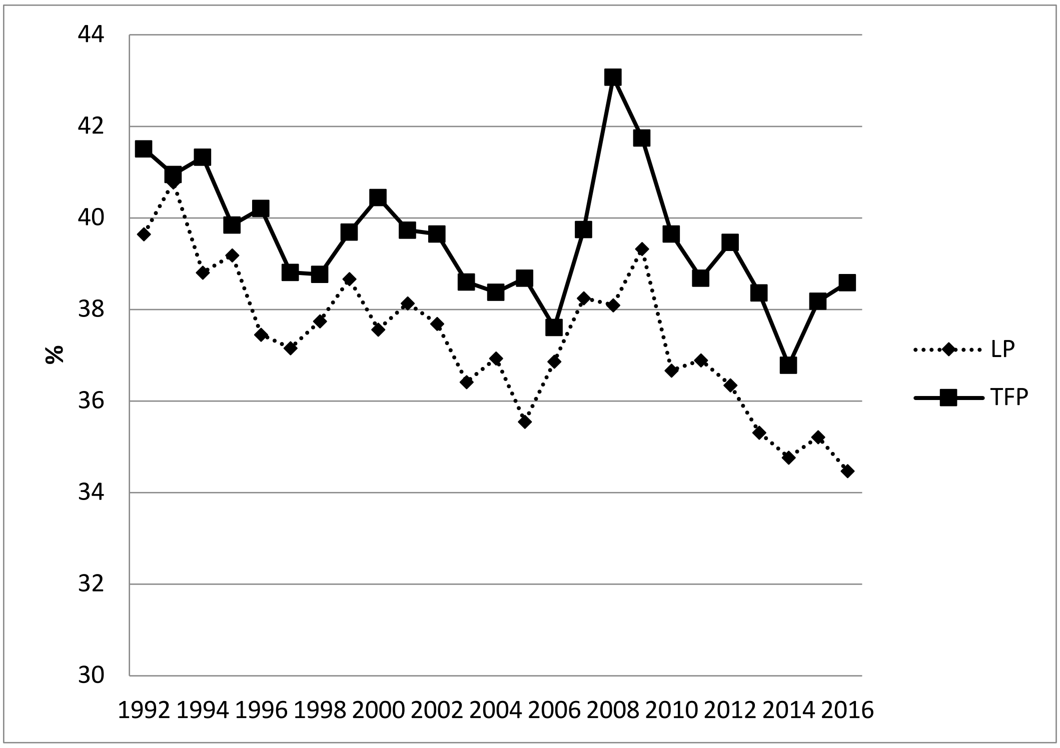
otherwise; $\beta = \{\beta 0,...,\beta m\}$ the difference in productivity growth trends between two consecutive periods; Δ, the real turnover growth rate (at the corresponding decomposition level); and u, the error term.
This relation is estimated for each sector on the productivity median values of the frontier firms and of the laggard firms. Bai and Perron (2003) have developed a methodology for calculating simultaneously the number of breaks, their dates and trends (on the methodologies of breaks in trend, see Aue & Horváth, 2013). The main idea is to estimate $\beta = \{\beta 0,...,\beta m\}$ for each division $\tau = \{T1,…,Tm\}$ by minimising the sum of the residual squares. A suitable value of τ is then chosen with the help of the statistic supF (τ +1 | τ), with F as the Fisher statistic.
Appendix 2 presents the estimate results, over the period 1991-2016, productivity being measured by LP (A) or by TFP (B).
Over the whole dataset, three significant trend breaks appear on the two productivity indicators (LP and TFP), both at the frontier and for laggard firms: in the mid-1990s, at the start of the 2000s and at the start of the 2008 crisis. The first break in the mid-1990s reflects a strong acceleration in productivity, which corresponds to the economic recovery after the recession of 1993. This cyclical recovery is thus only partially captured by the indicator of the real turnover growth rate. The second break at the start of the 2000s corresponds to a severe slowdown in productivity, as observed on macroeconomic data in other analyses (see for instance Bergeaud et al., 2016, or Cette et al., 2018). Finally, the third break, at the start of the 2008 crisis, also corresponds to a slowdown observed at the country level. This last break is not always statistically significant. For some groups of firms (for instance the frontier firms for LP), the last two breaks are replaced by one break that appears in the mid-2000s. More or less, for the two productivity indicators (LP and TFP), the same breaks are detected for each group of firms corresponding to the cross of different dimensions (industry, size, being frontier or laggard firm); only one downward break is often detected, at the end of the 2000s, concerning larger firms at the frontier. For each group of firms, productivity growth over the last sub-period is lower than over the previous sub-periods, except in retail where, for the laggard firms, it is sometimes above productivity growth over the first sub-period, and where even the last break is an upward one.
Three other main observations may be made from these estimate results, which confirm previous observations. First, most firm categories, across sectors, sizes and productivity levels, follow a similar downward trend over the period, pointing to a common global factor. Second, the downward productivity break during the 2000s for the frontier firms, and the fact that productivity gains are lower at the end of the period than during any other sub-period (except for retail), suggests that the contribution of technological progress to productivity growth could have declined. If lasting, such a decline would correspond to the prediction put forward by Gordon in numerous papers (for instance 2012, 2013, 2014 and 2016) of a possible supply side originated long period of 'secular stagnation'. While we cannot reject this prediction, it is still too early to consider it as likely. Indeed, as the renewal of frontier firms is high (see section 3.3), these firms may not

represent the technological frontier but rather benefit from a temporary shock. Third, except in some industry X sub-period X firm size rare cases, productivity growth is always higher for frontier firms than for laggard firms. This suggests a decline in the dissemination of technologies across companies at the frontier and those not, as explained by Andrews et al. (2015), or a weakening of the cleansing mechanisms, possibly related to the decrease in real interest rates, as described by Aghion et al. (2019), both of these explanations corresponding to an increasing inefficiency of factor allocation. The global productivity slowdown would then be explained both by a decline in the contribution of technological progress and an increasing inefficiency of factor allocation.

3.3 Firm Renewal at the Frontier and Margin Rates

As firm-level TFP does not fully take into account the degrees of utilisation of all production factors, it is not possible to distinguish a firm that enters the frontier because its technological efficiency has significantly increased from another that enters because it has used more extensively its production factors (e.g. by increasing hours worked per employee or the utilisation of its capital stock). Increasing factor utilisation above usual practices may not be sustainable over the longer run: for example, the number of hours worked per employee is regulated and cannot be maintained lastingly over legal or conventional thresholds; the intensive use of the capital stock may lead to its premature depreciation and its renewal. Hence, studying the renewal rate, which is sensible with a fixed frontier definition, provides an insight into the nature of this frontier. In case of a high renewal, we cannot exclude that the frontier may comprise firms that face a temporary demand shock, which would weaken the explanation of a frontier made up of "winners-take-all" firms that benefit from a lasting competitive edge. Nevertheless, our estimates are done on the median values of frontier firms and laggard firms, which mean that they are not influenced by a temporary high intensity of factor utilization by a few firms. And this problem could not explain by itself the growing gap between the median productivity levels of frontier firms and of laggard firms. It would mainly contribute to explaining a constant gap between these two types of firms. For this reason, we do not consider that this problem could influence our diagnosis.
Firm renewal at the frontier appears to be large: each year, the firm composition of the frontier changes by 34% to 41% for LP and by 37% to 43% for TFP (see Figure 2).

***Figure 2: Firm Renewal at the Frontier** – in %*



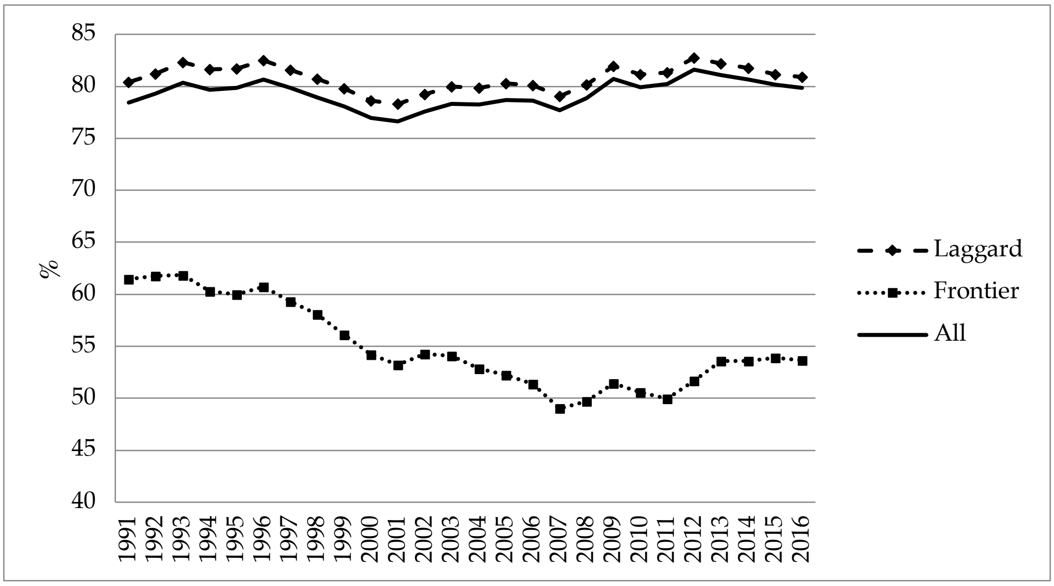
Note: Renewal is the proportion of "new" firms joining the frontier in a given year, which corresponds to the proportion of firms at the frontier this year but not the previous one. In 2008, for instance, there were 38% of new firms at the LP fixed frontier, compared to 43% for the TFP frontier.

This renewal rate declined over the period,[7] except during the most difficult years of the financial crisis, from 2008 to 2010. The increase in the renewal rate between 2007 and 2010 suggests that during these years even some efficient firms faced particular difficulties, possibly linked to specific decreases in demand which impact productivity if the factors take time in adjusting to this fall in demand. The declining trend in the renewal rate, more pronounced for LP than for TFP, could be a consequence of the increasing productivity gap between frontier firms and laggard firms. It suggests that it is more and more difficult for laggard firms to catch up with the productivity performances of the frontier firms. With similar evolutions over the period, we observe a higher renewal rate for firms in industries with a higher financial dependence rate, or a higher ICT investment rate, or a higher import rate.[8] It means that competition between firms would be positively linked to these three dimensions, which is not surprising.
Over the past few years, a large number of papers have been devoted to the labour share. A usual statement of this literature is that the labour share has decreased over the past decades in all developed countries, except in some such as France where it has remained constant or even slightly increased (for international comparisons, see for instance IMF, 2017; Chi Dao et al.,

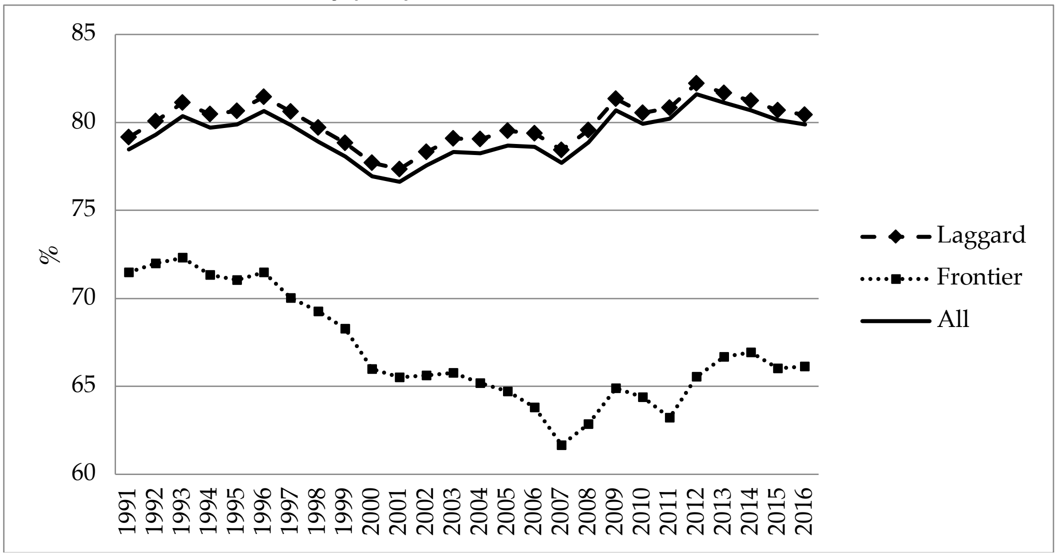
[7] This was also observed on a multinational basis (Andrews et al., 2016).
[8] These results may be obtained from the authors, on request.

2017; OECD, 2018; Cette et al., 2019,[9] and for France, see Cette and Ouvrard, 2018). Figure 3 presents the median labour share, on the whole firm dataset, for the frontier firms and the laggard firms, the productivity index being LP (A) or TFP (B).

***Figure 3: Median Labour Share** – In %*
A – Labour Productivity (LP) Frontier



B – Total Factor Productivity (TFP) Frontier



Note: The labour share is the ratio of payroll to added value, expressed here as a percentage.

Three observations can be made, for both definitions of the productivity frontier (LP and TFP). First, the median labour share is always higher for the laggard firms (and consequently the whole dataset) than for the frontier

[9] Cette, Koehl and Philippon (2019) show that, after taking into account different types of potential biases, there is no global decline in the labour share.

firms. Second, the median labour share does not exhibit any clear trend on the whole dataset or on the laggard firms. This is quite consistent with the results obtained with country level data for France (see Cette and Ouvrard, 2018), on which no trend appears before 2008 but which show a huge increase in 2008-2009, followed by a progressive return to the pre-crisis level. Third, the labour share decreases sharply (by more than ten percentage points) from the mid-1990s to 2008, to increase from 2008 and offset about half of the previous decrease. These developments can be linked to those of the firm renewal rate at the frontier, which was on a downtrend before 2008. They suggest that before the crisis, as a result of becoming more and more efficient in terms of productivity compared to laggard firms, frontier firms were less and less obliged to compete with other firms and were then able to increase their margin rate. However, a significant renewal was found at the frontier, weakening the explanation of an entrenched share of highly competitive firms.

4 Production Factor Reallocation

The impact on aggregate productivity of the growing dispersion in productivity levels across firms is not straightforward. If the allocation of production factors matches this increased dispersion, leading highly productive firms to grow faster than low productive firms, aggregate productivity could not be affected. On the contrary, if this increased firm-level dispersion is associated with a deterioration in the factor reallocation mechanism, aggregate productivity growth could slow, if this increased dispersion is not offset by higher average within-firm productivity growth. Our estimates support a deterioration in reallocation mechanisms regarding production factors, as observed in the United States by Decker et al. (2018). This deterioration in reallocation mechanisms may stem either from increases in factor adjustment frictions or from lower incentives for factor adjustment. In particular, the Information and Communication Technology (ICT) shock may have led to higher labour adjustment frictions, as the skills required by high-productivity firms may be more demanding. Another explanation could be a toughening in employment protection, which does not appear to be the case in France over the period: OECD's Employment Protection Indicators for individual dismissals increased slightly in 2003, but do not take into account jurisprudential developments for temporary employment, which supported higher labour market flexibility. Globalisation has ambiguous effects on reallocation: on the one hand, it heightens competition and incentives for factor adjustment; on the other, global value chains have developed, leading to factor adjustment across countries rather than within countries. Finally, reallocation may be more difficult in financially dependent sectors, both for labour and capital, as they are partly complementary.

4.1 Estimation Methodology and Results

To estimate the efficiency of reallocation, we relate the growth of production factors at the firm level to the past level of productivity, as in Decker et al. (2018). A well-functioning reallocation mechanism should lead firms with higher levels of productivity to experience faster employment and capital growth.

$$g(F_{i,t}) = \beta prod_{i,t-1} + \sum_t \gamma_{1,p} D_p prod_{i,t-1} + \gamma_2 1\{varint\} prod_{i,t-1} + \theta f_{i,t-1} + \mu age_{i,t} + \delta_{s,t} + \varepsilon_{i,t}$$

with $g(F_{i,t}) = \frac{(F_{i,t}-F_{i,t-1})}{F_{i,t-1}} \times 100$ and $F_{i,t}$, production factor i.e. the number of employees or the capital stock; $prod$, the log of the productivity level indicator (either LP or TFP); D_p, a period dummy; $1\{varint\}$, a dummy for high financial dependency, high import share or high ICT share sectors (see Appendix 3 for definition); f, the production factor in log (l for the number of employees and k for the capital stock); age, firm age; $\delta_{s,t}$, sector X year dummy to capture sectoral cycle and trends. Subscripts i for firms, t for years, p for time periods and s for sectors.

We expect $\beta + \gamma_{1,p}$ to be significantly positive, as production factor growth should be faster in more productive firms during all periods. A decrease in $\gamma_{1,p}$ during the period would be consistent with a less efficient production factor reallocation mechanism. Combined with higher productivity dispersion, this would contribute to explaining the slowdown in aggregate productivity. We control for the level of the production factor as production factor growth rates should be lower in larger firms. The age of the firm should capture several unobserved firm characteristics, among which an easier access to credit as firms age and build closer relationships with banks and larger pools of collateral (see Fougère et al., 2019 for the relationship between age, real estate holdings and access to credit) or, on the contrary, the fact that it takes time for young firms to discover their potential, which will lead them to grow faster (Jovanovic, 1982). Despite these controls and the explanatory variable lags, we cannot exclude that endogeneity problems could subsist. Nevertheless, the estimated relation does not correspond to a behavioral one and its goal is only to empirically evaluate the intensity of factor reallocation. We estimate this reallocation efficiency indicator for different sectors and across different time periods. In particular, we can divide sectors according to their exposure to import competition, financial dependency or use of ICT (ICT capital stock as a share of total capital stock)[10]. First, we may note that employment growth at the firm level does not take into account outsourcing, as the firm is defined on a social, non-consolidated basis. This would bias downward the

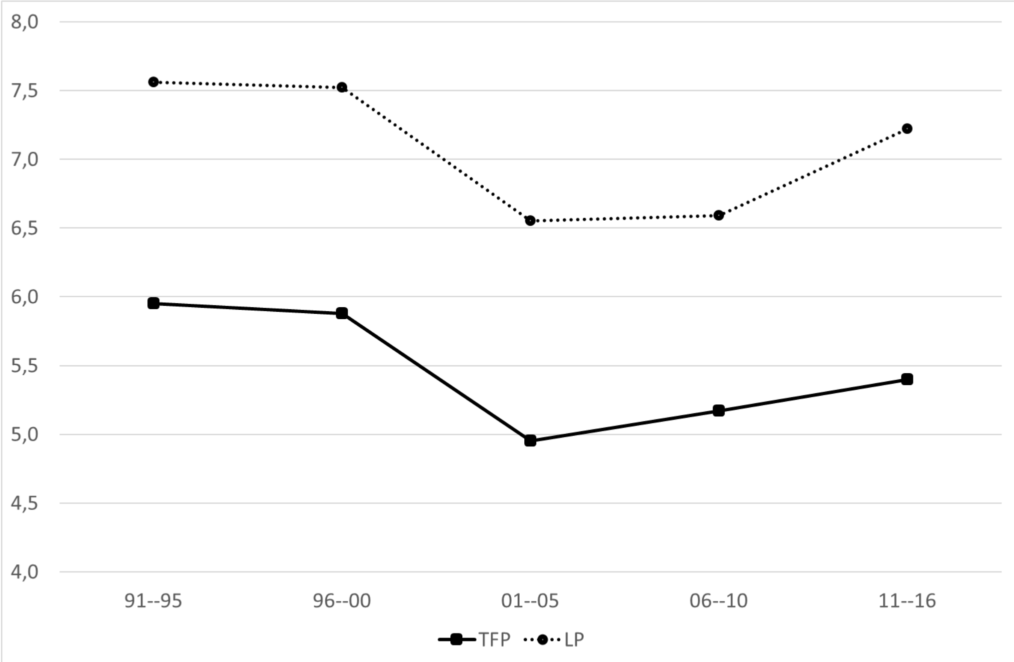
[10] Exposure to import competition is based on the ratio of import to total production (INSEE database), financial dependency is based on Rajan-Zingales (1998) definition, i.e. the ratio of investment minus gross operating surplus to investment and the ICT capital stock share is based on EU-KLEMS database. Sectors are then divided in two categories, according to their relative position to the median.

reallocation coefficient, as a highly productive firm could decide to hire in its subsidiaries or sister companies, in France or elsewhere, rather than in-house. Second, we are only taking into account the reallocation for one production factor, although capital-labour substitution may have taken place during this period. This would also bias downward the reallocation coefficient. Hence, a positive and significant coefficient would ascertain the existence of an efficient reallocation mechanism. However, across periods, it is hard to say whether these potential biases have evolved significantly.

4.2 Production Factor Reallocation and Reallocation Shocks

The estimates are presented in Table 3-A (LP) and 3-B (TFP) for labour and in Table 3-C (LP) and 3-D (TFP) for capital. As expected, $\beta + \gamma_{1,t}$, the production factor reallocation coefficient, is always positive and significant, over the whole period, as well as for each sub-period, for labour and capital. Employment and capital stock growth is faster for firms with higher levels of productivity. In our baseline equation (column 2, with sector X year dummies), a 1pp increase in firm level labour productivity (resp. TFP) leads to a 7pp (resp. 5.4pp) increase in employment growth and to a 3.3pp (resp. 5.2pp) rise in capital growth. Reallocation seems to be slightly faster for labour than for capital, which is consistent with a stronger capital stock inertia (Cette, et al., 2016). As expected, the employment and capital stock log-level coefficient is negative, reflecting a return to the mean statistical phenomena or, in other words, the fact that larger companies will post lower employment and capital growth rates. The age coefficient is negative, as older firms tend to grow more slowly. Whereas labour and capital reallocation coefficients were stable in the 1990s, they decreased significantly in the 2000s (see Figures 4 and 5).

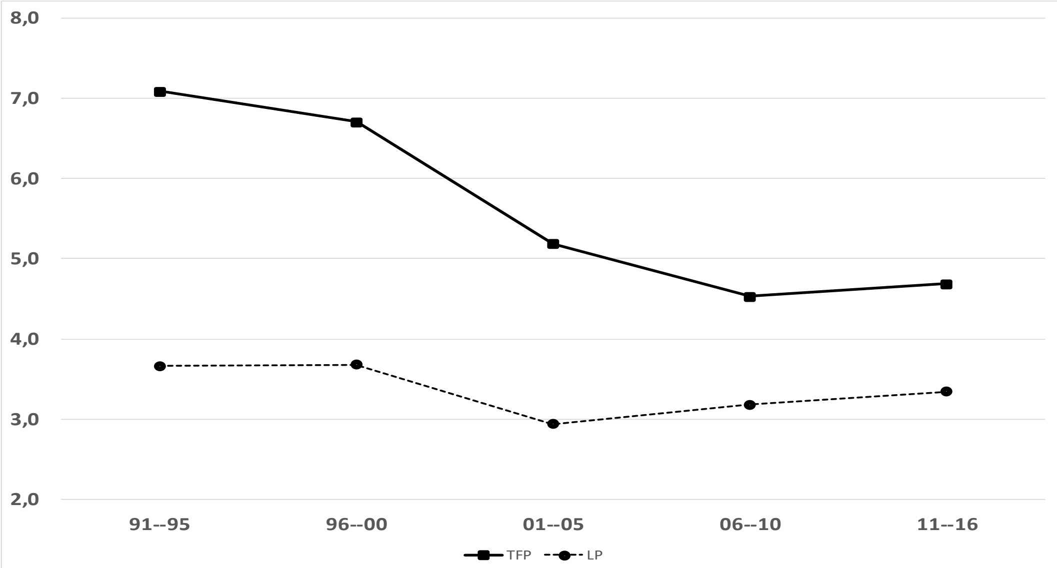
Figure 4: Employment Reallocation Coefficient across Time Periods ($\beta + \gamma_{1,t}$)



Note: Graphical representation of the coefficients $\gamma1,t + \beta$ for the regressions without additional variable.

This decline in reallocation efficiency occurs at the time when we observe an increase in productivity dispersion, especially between frontier and other firms. These two simultaneous phenomena may contribute to explaining the downward break in the aggregate productivity trend. Greater productivity dispersion would have required higher employment and capital reallocation efficiency, whereas simultaneously the reallocation mechanism deteriorated. The employment reallocation coefficient has been significantly lower on average over the whole period for sectors with high financial dependency, a high import share or a high ICT share (see Tables 3-A and 3-B). A 1pp increase in firm-level labour productivity leads to a 1pp greater decline in employment growth for sectors that are highly dependent on external financing, 1.3 pp for sectors with high import shares and 3pp for ICT sectors, compared to other sectors. The ranking is similar for TFP. When taken simultaneously, ICT sectors have the lowest reallocation coefficient, while financially dependent sectors have non-significantly different or even higher reallocation coefficients than other sectors. As regards the capital stock share (see Tables 3-C and 3-D), ICT sectors also display the lowest reallocation coefficient, but coefficients are non-significantly different or higher than other sectors for the financially dependent or high-import sectors.

Figure 5: Capital Reallocation Coefficient across Time Periods ($\beta + \gamma_{1,t}$)



Note: Graphical representation of the coefficients γ1,t + β for the regressions without additional variables.

Table 3: Production Factor Reallocation and Productivity
A – Employment/Labour Productivity

Dependent Variable: Firm-level Employment Growth Rate (in %)

	Without $\delta_{s,t}$	Baseline	Reallocation by periods	Financial dependency	Import	ICT	Dependency & ICT & Import
$prod_{i,t-1}$	6.52 (***)	7.03 (***)	7.56 (***)	7.83 (***)	7.96 (***)	8.73 (***)	8.87 (***)
$D_1 prod_{i,t-1}$	-	-	-0.04 (NS)	-0.06 (NS)	-0.07 (NS)	-0.05 (NS)	-0.07 (NS)
$D_2 prod_{i,t-1}$	-	-	-1.01 (***)	-1.05 (***)	-1.09 (***)	-1.07 (***)	-1.1 (***)
$D_3 prod_{i,t-1}$	-	-	-0.97 (***)	-1.03 (***)	-1.08 (***)	-1.06 (***)	-1.11 (***)
$D_4 prod_{i,t-1}$	-	-	-0.34 (***)	-0.41 (***)	-0.47 (***)	-0.43 (***)	-0.5 (***)
$1\{depfin\}prod_{i,t-}$	-	-	-	-0.98 (***)	-	-	0.59 (***)
$1\{import\}prod_{i,t-}$	-	-	-	-	-1.26 (***)	-	-1.1 (***)
$1\{ICT\}prod_{i,t-1}$	-	-	-	-	-	-2.99 (***)	-2.89 (***)
$l_{i,t-1}$	-2.9 (***)	-3.1 (***)	-3.1 (***)	-3.1 (***)	-3.1 (***)	-3.1 (***)	-3.11 (***)
$age_{i,t}$	-0.1 (***)	-0.1 (***)	-0.1 (***)	-0.1 (***)	-0.1 (***)	-0.1 (***)	-0.09 (***)
$\delta_{s,t}$	No	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.05	0.05	0.05	0.05	0.05	0.05	0.05
No. of observations	3,402,146	3,402,146	3,402,146	3,402,146	3,402,146	3,402,146	3,402,146

Note: *: pvalue <0.1; **: pvalue <0.05; ***: pvalue <0.01; D_1: 1996-2000; D_2: 2001-2005; D_3: 2006-2010; D_4: 2011-2016

B - Employment/Total Factor Productivity

Dependent Variable: Firm-level Employment Growth Rate (in %)

	Without $\delta_{s,t}$	Baseline	Reallocation by periods	Financial dependency	Import	ICT	Dependency & ICT & Import
$prod_{i,t-1}$	4.01 (***)	5.38 (***)	5.95 (***)	6.09 (***)	6.14 (***)	6.41 (***)	6.44 (***)
$D_1 prod_{i,t-1}$	-	-	-0.07 (NS)	-0.08 (NS)	-0.09 (NS)	-0.07 (NS)	-0.07 (NS)
$D_2 prod_{i,t-1}$	-	-	-1 (***)	-1.01 (***)	-1.03 (***)	-1.02 (***)	-1.03 (***)
$D_3 prod_{i,t-1}$	-	-	-0.78 (***)	-0.8 (***)	-0.83 (***)	-0.82 (***)	-0.84 (***)
$D_4 prod_{i,t-1}$	-	-	-0.55 (***)	-0.58 (***)	-0.62 (***)	-0.6 (***)	-0.62 (***)
$1\{depfin\}prod_{i,t-}$	-	-	-	-0.54 (***)	-	-	0.11 (NS)
$1\{import\}prod_{i,t-}$	-	-	-	-	-0.61 (***)	-	-0.27 (**)
$1\{ICT\}prod_{i,t-1}$	-	-	-	-	-	-1.27 (***)	-1.20 (***)
$l_{i,t-1}$	-2.19 (***)	-2.16 (***)	-2.16 (***)	-2.16 (***)	-2.16 (***)	-2.17 (***)	-2.17 (***)
$age_{i,t}$	-0.03 (***)	-0.03 (***)	-0.03 (***)	-0.03 (***)	-0.03 (***)	-0.03 (***)	-0.03 (***)
$\delta_{s,t}$	No	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.04	0.05	0.05	0.05	0.05	0.05	0.05
No. of observations	2,762,641	2,762,641	2,762,641	2,762,641	2,762,641	2,762,641	2,762,641

Note: *: pvalue <0.1; **: pvalue <0.05; ***: pvalue <0.01; D_1: 1996-2000; D_2: 2001-2005; D_3: 2006-2010; D_4: 2011-2016

C- Capital Stock/Labour Productivity

Dependent Variable: Firm-level Capital Growth Rate (in %)

	Without $\delta_{s,t}$	Baseline	Reallocation by periods	Financial dependency	Import	ICT	Dependency & ICT & Import
$\boldsymbol{lp}_{i,t-1}$	2.82 (***)	3.31 (***)	3.66 (***)	3.5 (***)	3.47 (***)	3.91 (***)	3.72 (***)
$D_1\boldsymbol{lp}_{i,t-1}$	-	-	0.02 (NS)	0.03 (NS)	0.04 (NS)	0.01 (NS)	0.03 (NS)
$D_2\boldsymbol{lp}_{i,t-1}$	-	-	-0.72 (***)	-0.7 (***)	-0.68 (***)	-0.74 (***)	-0.69 (***)
$D_3\boldsymbol{lp}_{i,t-1}$	-	-	-0.48 (***)	-0.44 (***)	-0.42 (***)	-0.5 (***)	-0.43 (***)
$D_4\boldsymbol{lp}_{i,t-1}$	-	-	-0.32 (***)	-0.28 (***)	-0.26 (***)	-0.35 (***)	-0.27 (***)
$1\{depfin\}\boldsymbol{lp}_{i,t-1}$	-	-	-	0.57 (***)	-	-	0.18 (NS)
$1\{import\}\boldsymbol{lp}_{i,t-1}$	-	-	-	-	0.6 (***)	-	0.64 (***)
$1\{ICT\}\boldsymbol{lp}_{i,t-1}$	-	-	-	-	-	-0.67 (***)	-0.82 (***)
$\boldsymbol{k}_{i,t-1}$	-1.97 (***)	-2.2 (***)	-2.2 (***)	-2.21 (***)	-2.21 (***)	-2.2 (***)	-2.2 (***)
$age_{i,t}$	-0.15 (***)	-0.14 (***)	-0.14 (***)	-0.15 (***)	-0.15 (***)	-0.15 (***)	-0.15 (***)
$\delta_{s,t}$	No	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.04	0.04	0.04	0.04	0.04	0.04	0.04
No. of observations	3,088,201	3,088,201	3,088,201	3,088,201	3,088,201	3,088,201	3,088,201

Note: *: pvalue <0.1; **: pvalue <0.05; ***: pvalue <0.01; D_1: 1996-2000; D_2: 2001-2005; D_3: 2006-2010; D_4: 2011-2016

D- Capital Stock / Total factor Productivity

Dependent Variable: Firm-level Capital Growth Rate (in %)

	Without $\delta_{s,t}$	Baseline	Reallocation by periods	Financial dependency	Import	ICT	Dependency & ICT & Import
$\boldsymbol{tfp}_{i,t-1}$	3.65 (***)	5.23 (***)	7.09 (***)	7.11 (***)	7.09 (***)	7.76 (***)	7.61 (***)
$D_1\boldsymbol{tfp}_{i,t-1}$	-	-	-0.38 (***)	-0.39 (***)	-0.38 (***)	-0.39 (***)	-0.36 (***)
$D_2\boldsymbol{tfp}_{i,t-1}$	-	-	-1.9 (***)	-1.9 (***)	-1.9 (***)	-1.94 (***)	-1.9 (***)
$D_3\boldsymbol{tfp}_{i,t-1}$	-	-	-2.56 (***)	-2.56 (***)	-2.56 (***)	-2.64 (***)	-2.57 (***)
$D_4\boldsymbol{tfp}_{i,t-1}$	-	-	-2.4 (***)	-2.4 (***)	-2.4 (***)	-2.48 (***)	-2.4 (***)
$1\{depfin\}\boldsymbol{tfp}_{i,t-1}$	-	-	-	-0.06 (NS)	-	-	-0.11 (NS)
$1\{import\}\boldsymbol{tfp}_{i,t-1}$	-	-	-	-	0 (NS)	-	0.84 (***)
$1\{ICT\}\boldsymbol{tfp}_{i,t-1}$	-	-	-	-	-	-1.86 (***)	-2.07 (***)
$\boldsymbol{k}_{i,t-1}$	-0.8 (***)	-0.85 (***)	-0.87 (***)	-0.87 (***)	-0.87 (***)	-0.87 (***)	-0.87 (***)
$age_{i,t}$	-0.12 (***)	-0.11 (***)	-0.11 (***)	-0.11 (***)	-0.11 (***)	-0.11 (***)	-0.11 (***)
$\delta_{s,t}$	No	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.04	0.04	0.04	0.04	0.04	0.04	0.04
No. of observations	2,812,886	2,812,886	2,812,886	2,812,886	2,812,886	2,812,886	2,812,886

Lower reallocation is hence particularly prevalent for high ICT share sectors, both for labour and capital reallocation. This may be consistent with several hypotheses. First, firms gain market shares through network effects, leading to an increase in productivity, while labour and capital may not need to adjust to serve new clients. Second, labour in these sectors is more skilled and reallocation therefore more complex as these skills are more difficult to find.

Results are particularly surprising for the financially dependent sectors, but they are mostly non-significant when all three types of sectors are included. We may expect dependency on external financing to constrain investment, but financial constraints may have been low over the period.

As regards high-import sectors, global value chains may have led to faster capital-labour substitution as higher relative labour costs in France resulted in a more intense specialisation of highly productive French firms in capital intensive tasks. Lower reallocation for employment, but higher reallocation for capital may hinge on the substitution of domestic labour for capital and foreign labour through imports. Employment reallocation could therefore proceed in these sectors, but through employment growth in foreign subsidiaries or task outsourcing abroad. This result is consistent with the findings of Ito and Lechevalier (2009), which showed on Japanese firms that internationalization led to higher firm productivity dispersion. Overall, the increase in the import content of value added may have contributed to foster within-firm productivity (cf. Zaclicever and Pellandra, 2018), but with divergent impacts on labour and capital reallocation across firms. The impact on aggregate productivity of these lower reallocation coefficients depends, first, on the share of these sectors in the economy and, second, on the evolution of these coefficients over time. It appears that the shares of the high ICT intensity sectors in aggregate value added increased over the whole period (from 27% of value added in volume terms in 1991 to 31% in 2016). The shares of high import sectors decreased slightly over the whole period, after an initial increase in the 1990s and at the start of the 2000s. The development of ICT sectors may therefore have contributed to the decreasing reallocation at the start of the 2000s. These features are also consistent with a lower cleansing mechanism due to lower financial constraints/lower real interest rates, as emphasised by Aghion et al. (2019), and to the absence of significant negative coefficient for financially dependent sectors over the period.

5 Conclusion

The productivity slowdown observed in most advanced economies since the 2000s has led to a historically low productivity momentum, questioning the future of growth and many of the features of their economic and social models. The economic literature has increasingly focused its attention on firm-level explanations of this slowdown and on the impact of the ongoing technological revolution.

Several hypotheses have been put forward to explain this slowdown. One explanation is that it has resulted from a slowdown at the productivity frontier, which would suggest a decline in the contribution of technological progress to productivity growth, as mentioned by Gordon (2012, 2013, 2014 and 2016). Another is that it has resulted from a misallocation of production factors, associated with a growing productivity dispersion among firms and a growing productivity gap between firms at the frontier and laggard firms. Andrews et al. (2015) relate this misallocation to specific features of the ICT revolution, leading frontier firms to capture large market shares through network effects, while laggard firms are prevented from catching up.

In this paper, we have focused on the French economy, which has several interesting features with regard to these issues: a high initial level of productivity, a significant productivity slowdown, a diversified production structure and a mix of firms at the global frontier and laggard firms. We have observed similar stylised facts on the French economy and on the global economy, in particular a growing dispersion of the productivity distribution (labour productivity and total factor productivity), both for synthetic dispersion indicators (see Cette et al., 2017 and 2018) and between frontier and laggard firms.

Among the hypotheses put forward to explain the slowdown, Gordon's lower contribution of technological progress cannot be discarded: we observe breaks in productivity trends in many sectors before 2008, pointing to the technological explanation rather than to the consequences of the financial crisis; moreover, econometric estimates show significant productivity breaks in all industries, both at the frontier and for laggard firms.

However, we also estimate a significant decline in labour reallocation at the start of the 2000s, at the time when we have observed an increase in productivity dispersion, with a growing productivity gap between frontier and laggard firms. The explanation based on specific ICT characteristics is not fully confirmed in the French case. On the one hand, the labour share at the frontier decreased sharply (by more than ten percentage points) from the mid-1990s to 2008 and the firm renewal rate at the frontier was on a downtrend before 2008. These two stylised facts suggest that, before the crisis, frontier firms increased their productive edge over laggards firms, were less and less obliged to compete with the other firms and were then able to increase their margin rate. On the other, since 2008, the median labour share has risen, offsetting about half of the previous decrease, and the firm renewal rate at the frontier has been structurally significant, with a minimum of a third of the firms leaving the frontier each year.

On the contrary, increased dispersion and lower reallocation efficiency may be consistent with a decrease in financial constraints and real interest rates, as described by Aghion et al. (2019). It also appears that reallocation has been significantly lower on average over the whole period for sectors with a high ICT share. The combination of a rise in the share of ICT sectors and lower reallocation efficiency in these sectors may explain both the increased dispersion in productivity and its overall slowdown.

In any case, results of this analysis might be important for policy-makers. They mean that one way to enhance global productivity could consist in reducing all types of brakes on factor reallocation, and for instance those from product and labor market regulations. Lifelong training should also be fostered to promote labor reallocation. Such a strategy would be even more relevant in times of low financial constraints and real interest rates, which decrease firm cleansing mechanisms (see Aghion et al., 2019). The current post-COVID period corresponds to such a situation…

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Appendix 1: Data Treatment

The FIBEN database contains, before treatment for missing values or outliers, more than 5.9 million observations. The FIBEN database has seen its coverage increase over the considered period, being affected by different factors, mainly due to the fixing of thresholds in nominal and non-real terms. The companies present in this database correspond to legal units, and to a legal definition of companies. The database covers 84% of employment of the companies present in BIC-BRN in 2004. Estimates of the capital stock are based on Bond et al. (2003). We use the accounting capital stock to compute the economic capital stock: we first estimate the age of capital using amortization, then we deflate the accounting capital according to its age, correcting for the faster accounting amortization compared to economic depreciation.

As regards the estimation of the Cobb-Douglas parameters, we focus on β since a standard approach is to set α = 1- β and its computation is straightforward: it is the labour share. For each firm, it is derived from the ratio of the payroll (wages and overall social contributions) to value added. After removing outliers (β<0 or β>1), the overall average is 0.71 (hence α= 0.29). But we chose to use sectoral values of α and β, equal to the sectoral averages of individual labour shares.

The hypothesis of constant returns to scale (α = 1- β) could seem strong. But Cette et al. (2015) have shown on a dataset of French firms that this hypothesis seems realistic when intensity of factor utilization is taken into account. According to this analysis, estimation of non-constant returns to scale may be explained by the usual omission of variables measuring intensity of factor utilization. Our analysis aims to estimate productivity structural breaks and for this reason it seems reasonable to assume constant returns to scale, as we do. Nevertheless, we have also estimated the production function parameters (α and β) through the Levinsohn and Petrin (2003) methodology, allowing returns to scale not to be necessarily constant.[11] The estimate results correspond in almost all sectors to returns to scale very close to the constant hypothesis. And our estimates of total factor productivity breaks are only slightly changed compared to the ones presented in the paper. For this reason, we present only results corresponding to the hypothesis of constant returns to scale, using for the computation of β the methodology described above.

A clean-up of this database was conducted in order to avoid the presence of outliers. A first clean-up (for instance removing firms for which the number of employees is not available, or those with a negative turnover) leads to a database containing 4.4 million observations. We decided to create two databases from that one, each of them dedicated to one of the two indicators, LP and TFP. The reason behind this split is that the filters applied to one indicator could be irrelevant for the other one. For the LP database, we filter LP at a 1% level (on each side of the distribution) by

[11] These results are available upon request from the authors.

sector X year. We then apply a method based on the outliers principle developed by John Tukey (Kremp, 1995), which deletes values of LP *growth* located beyond quartiles 1 (and 3) which are less (and more) than three times the interquartile spread. The methodology is the same for the TFP database, adding a first filter on the capital stock growth at a 1% level by firm size category. The LP database contains 3,995,230 observations and the TFP one 3,894,480.

Appendix 2: Breaks

Table A1 – Breaks on Labour Productivity

<table>
<tr><th>SECT</th><th>front_90_PT</th><th>1991</th><th>1992</th><th>1993</th><th>1994</th><th>1995</th><th>1996</th><th>1997</th><th>1998</th><th>1999</th><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th></tr>
<tr><td>AZ</td><td>1</td><td colspan="12">5.32</td><td colspan="7">8.14</td><td colspan="7">-2.34</td></tr>
<tr><td>AZ</td><td>0</td><td colspan="18">4.6</td><td colspan="8">0.07</td></tr>
<tr><td>C1</td><td>1</td><td colspan="5">-0.51- N.S.</td><td colspan="6">1.98- N.S.</td><td colspan="10">3.4- N.S.</td><td colspan="5">-1.38</td></tr>
<tr><td>C1</td><td>0</td><td colspan="8">0.34- N.S.</td><td colspan="6">1.84</td><td colspan="5">3.18</td><td colspan="7">0.19</td></tr>
<tr><td>C3</td><td>1</td><td colspan="15">5.81</td><td colspan="11">3.41</td></tr>
<tr><td>C3</td><td>0</td><td colspan="9">5.29</td><td colspan="10">6- N.S.</td><td colspan="7">0.63</td></tr>
<tr><td>C4</td><td>1</td><td colspan="5">2.65</td><td colspan="6">2.12- N.S.</td><td colspan="7">5.03</td><td colspan="8">-1.8</td></tr>
<tr><td>C4</td><td>0</td><td colspan="5">0.63- N.S.</td><td colspan="6">3.49- N.S.</td><td colspan="5">5.22- N.S.</td><td colspan="5">0.93</td><td colspan="5">-4.07</td></tr>
<tr><td>C5</td><td>1</td><td colspan="8">3.06</td><td colspan="8">4.42</td><td colspan="5">2.79</td><td colspan="5">0.66</td></tr>
<tr><td>C5</td><td>0</td><td colspan="8">2.6</td><td colspan="7">3.81</td><td colspan="5">2.44</td><td colspan="6">0.8</td></tr>
<tr><td>DE</td><td>1</td><td colspan="6">2.97</td><td colspan="5">-2.9</td><td colspan="5">2.62</td><td colspan="5">-0.78</td><td colspan="5">-5.37</td></tr>
<tr><td>DE</td><td>0</td><td colspan="18">0.42</td><td colspan="8">-2.8</td></tr>
<tr><td>FZ</td><td>1</td><td colspan="8">2.04</td><td colspan="9">3.75- N.S.</td><td colspan="9">-4.85</td></tr>
<tr><td>FZ</td><td>0</td><td colspan="6">0.15- N.S.</td><td colspan="5">2.71</td><td colspan="5">-2.36</td><td colspan="5">-3.33</td><td colspan="5">0.34</td></tr>
<tr><td>GZ</td><td>1</td><td colspan="8">3.27</td><td colspan="8">3.81- N.S.</td><td colspan="10">2.19</td></tr>
<tr><td>GZ</td><td>0</td><td colspan="6">0.9</td><td colspan="6">2.88</td><td colspan="6">0.74</td><td colspan="8">2.16</td></tr>
<tr><td>HZ</td><td>1</td><td colspan="7">5.09</td><td colspan="13">2.68</td><td colspan="6">-0.62</td></tr>
<tr><td>HZ</td><td>0</td><td colspan="9">3.26</td><td colspan="6">0.34</td><td colspan="5">1.4- N.S.</td><td colspan="6">-0.6</td></tr>
<tr><td>IZ</td><td>1</td><td colspan="5">0.51- N.S.</td><td colspan="5">4.56</td><td colspan="5">-0.08</td><td colspan="5">2.54</td><td colspan="6">-2.28</td></tr>
<tr><td>IZ</td><td>0</td><td colspan="7">-0.67- N.S.</td><td colspan="6">-0.3- N.S.</td><td colspan="7">0.56- N.S.</td><td colspan="6">-1.38</td></tr>
<tr><td>JZ</td><td>1</td><td colspan="5">5.15</td><td colspan="7">3.81- N.S.</td><td colspan="5">7.85</td><td colspan="9">-0.08</td></tr>
<tr><td>JZ</td><td>0</td><td colspan="5">4.21</td><td colspan="7">1.21</td><td colspan="5">5.32</td><td colspan="9">0.53</td></tr>
<tr><td>MN</td><td>1</td><td colspan="8">2.39</td><td colspan="6">1.93- N.S.</td><td colspan="5">5.71</td><td colspan="7">2.6</td></tr>
<tr><td>MN</td><td>0</td><td colspan="10">0.62</td><td colspan="16">0.66- N.S.</td></tr>
<tr><td>RU</td><td>1</td><td colspan="6">3.9</td><td colspan="8">3.9- N.S.</td><td colspan="7">3.03- N.S.</td><td colspan="5">-0.68</td></tr>
<tr><td>RU</td><td>0</td><td colspan="5">3.37</td><td colspan="13">2.18- N.S.</td><td colspan="8">0.36</td></tr>
</table>

<table>
<tr><th></th><th>1991</th><th>1992</th><th>1993</th><th>1994</th><th>1995</th><th>1996</th><th>1997</th><th>1998</th><th>1999</th><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th></tr>
<tr><td>F -Agriculture - Size 1</td><td colspan="11">3.53</td><td colspan="8">5.66- N.S.</td><td colspan="7">0.9</td></tr>
<tr><td>L -Agriculture - Size 1</td><td colspan="12">3.57</td><td colspan="8">4.28- N.S.</td><td colspan="6">-0.74</td></tr>
<tr><td>F -Agriculture - Size 2</td><td colspan="12">4.6</td><td colspan="6">3.22- N.S.</td><td colspan="8">0.97- N.S.</td></tr>
<tr><td>L -Agriculture - Size 2</td><td colspan="8">2.19</td><td colspan="10">4.18- N.S.</td><td colspan="8">1.49</td></tr>
<tr><td>F -Agriculture - All</td><td colspan="11">3.7</td><td colspan="7">5.69- N.S.</td><td colspan="8">1.5</td></tr>
<tr><td>L -Agriculture - All</td><td colspan="18">4</td><td colspan="8">0.87</td></tr>
<tr><td>F -Industry - Size 1</td><td colspan="8">1.91</td><td colspan="11">3.65</td><td colspan="7">0.45</td></tr>
<tr><td>L - Industry - Size 1</td><td colspan="8">1.81</td><td colspan="7">3.98</td><td colspan="6">2.39</td><td colspan="5">0.33</td></tr>
<tr><td>F - Industry - Size 2</td><td colspan="14">3.63</td><td colspan="12">1.89</td></tr>
<tr><td>L - Industry - Size 2</td><td colspan="12">2.91</td><td colspan="7">4.29</td><td colspan="7">1.33</td></tr>
<tr><td>F - Industry - All</td><td colspan="8">2.06</td><td colspan="11">3.66</td><td colspan="7">0.41</td></tr>
<tr><td>L - Industry - All</td><td colspan="8">1.93</td><td colspan="7">3.95</td><td colspan="6">2.58</td><td colspan="5">0.46</td></tr>
<tr><td>F -Construction - Size 1</td><td colspan="5">-2.89</td><td colspan="5">4.2</td><td colspan="6">1.01</td><td colspan="5">-5.52</td><td colspan="5">-0.74</td></tr>
<tr><td>L -Construction - Size 1</td><td colspan="5">-0.7- N.S.</td><td colspan="5">2.81</td><td colspan="6">-1.01</td><td colspan="5">-4.32</td><td colspan="5">0.03</td></tr>
<tr><td>F -Construction - Size 2</td><td colspan="6">1.69- N.S.</td><td colspan="6">2.48- N.S.</td><td colspan="8">-2.58</td><td colspan="6">-2.68- N.S.</td></tr>
<tr><td>L -Construction - Size 2</td><td colspan="6">0.57</td><td colspan="5">2.08</td><td colspan="5">-1.1</td><td colspan="5">-3.63</td><td colspan="5">-0.71</td></tr>
<tr><td>F -Construction - All</td><td colspan="5">-2.3</td><td colspan="5">3.92</td><td colspan="6">1.03</td><td colspan="5">-5.53</td><td colspan="5">-0.73</td></tr>
<tr><td>L -Construction - All</td><td colspan="6">-0.25- N.S.</td><td colspan="5">2.79</td><td colspan="5">-1.7</td><td colspan="5">-3.98</td><td colspan="5">-0.13</td></tr>
<tr><td>F -Retail - Size 1</td><td colspan="6">0.02- N.S.</td><td colspan="6">3.6</td><td colspan="6">1.68</td><td colspan="8">1.79- N.S.</td></tr>
<tr><td>L - Retail - Size 1</td><td colspan="6">0.18- N.S.</td><td colspan="6">3.09</td><td colspan="6">0.6</td><td colspan="8">1.97</td></tr>
<tr><td>F - Retail - Size 2</td><td colspan="14">1.77</td><td colspan="5">1.6- N.S.</td><td colspan="7">1.54- N.S.</td></tr>
<tr><td>L - Retail - Size 2</td><td colspan="7">0.92</td><td colspan="6">1.56- N.S.</td><td colspan="6">1.02- N.S.</td><td colspan="7">1.43- N.S.</td></tr>
<tr><td>F - Retail - All</td><td colspan="7">0.48- N.S.</td><td colspan="5">3.91</td><td colspan="6">1.64</td><td colspan="8">1.77- N.S.</td></tr>
<tr><td>L - Retail - All</td><td colspan="6">0.22- N.S.</td><td colspan="6">3</td><td colspan="6">0.62</td><td colspan="8">1.93</td></tr>
<tr><td>F -Transport - Size 1</td><td colspan="5">1.33- N.S.</td><td colspan="5">3.15- N.S.</td><td colspan="10">1.2</td><td colspan="6">-0.02- N.S.</td></tr>
<tr><td>L -Transport - Size 1</td><td colspan="5">2.04</td><td colspan="5">3.6- N.S.</td><td colspan="5">-0.13</td><td colspan="5">1.2- N.S.</td><td colspan="6">-0.2</td></tr>
<tr><td>F -Transport - Size 2</td><td colspan="7">3.25</td><td colspan="6">0.62</td><td colspan="7">1.08- N.S.</td><td colspan="6">0.73- N.S.</td></tr>
<tr><td>L -Transport - Size 2</td><td colspan="7">3.64</td><td colspan="7">0.34</td><td colspan="6">1.43- N.S.</td><td colspan="6">-0.05</td></tr>
<tr><td>F -Transport - All</td><td colspan="7">2.85</td><td colspan="14">1.54</td><td colspan="5">-0.87</td></tr>
</table>

<table>
<tr><td>L -Transport - All</td><td colspan="9">3.14</td><td colspan="6">0.48</td><td colspan="5">1.02- N.S.</td><td colspan="6">-0.14- N.S.</td></tr>
<tr><td>F -Other - Size 1</td><td colspan="8">-1.97</td><td colspan="8">1.26</td><td colspan="5">0.27- N.S.</td><td colspan="5">1.84- N.S.</td></tr>
<tr><td>L - Other - Size 1</td><td colspan="8">-0.89</td><td colspan="6">-0.06</td><td colspan="7">0.52- N.S.</td><td colspan="5">-0.14- N.S.</td></tr>
<tr><td>F - Other - Size 2</td><td colspan="7">-0.11- N.S.</td><td colspan="5">-1.94- N.S.</td><td colspan="14">-0.14</td></tr>
<tr><td>L - Other - Size 2</td><td colspan="5">-0.42- N.S.</td><td colspan="11">-1.05- N.S.</td><td colspan="5">-0.21</td><td colspan="5">-1.67</td></tr>
<tr><td>F - Other - All</td><td colspan="8">-1.23</td><td colspan="5">0.79</td><td colspan="6">0.94- N.S.</td><td colspan="7">1.06- N.S.</td></tr>
<tr><td>L - Other - All</td><td colspan="8">-0.69</td><td colspan="6">-0.23- N.S.</td><td colspan="7">0.52</td><td colspan="5">-0.22- N.S.</td></tr>
<tr><td>F -All sectors – Size 1</td><td colspan="8">2.51</td><td colspan="5">3.76- N.S.</td><td colspan="5">4.04- N.S.</td><td colspan="8">1.28</td></tr>
<tr><td>L - All sectors – Size 1</td><td colspan="7">1.43</td><td colspan="5">3.23</td><td colspan="6">0.92</td><td colspan="8">0.68- N.S.</td></tr>
<tr><td>F - All sectors – Size 2</td><td colspan="8">1.66</td><td colspan="5">1.21- N.S.</td><td colspan="6">3.13</td><td colspan="7">1.42</td></tr>
<tr><td>L - All sectors Size 2</td><td colspan="7">1.91</td><td colspan="8">1.38</td><td colspan="5">1.78- N.S.</td><td colspan="6">0.35</td></tr>
<tr><td>F - All sectors - All</td><td colspan="8">2.53</td><td colspan="8">3.93</td><td colspan="10">1.51</td></tr>
<tr><td>L - All sectors All</td><td colspan="7">1.44</td><td colspan="5">3.03</td><td colspan="6">0.96</td><td colspan="8">0.67- N.S.</td></tr>
<tr><td></td><td>1991</td><td>1992</td><td>1993</td><td>1994</td><td>1995</td><td>1996</td><td>1997</td><td>1998</td><td>1999</td><td>2000</td><td>2001</td><td>2002</td><td>2003</td><td>2004</td><td>2005</td><td>2006</td><td>2007</td><td>2008</td><td>2009</td><td>2010</td><td>2011</td><td>2012</td><td>2013</td><td>2014</td><td>2015</td><td>2016</td></tr>
</table>

Table A2 – Breaks on total factor productivity

<table>
<tr><th>SECT</th><th>front_90_PGF</th><th>1991</th><th>1992</th><th>1993</th><th>1994</th><th>1995</th><th>1996</th><th>1997</th><th>1998</th><th>1999</th><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th><th>2016</th></tr>
<tr><td>AZ</td><td>1</td><td colspan="12">4.13</td><td colspan="7">4.75- N.S.</td><td colspan="7">-0.06</td></tr>
<tr><td>AZ</td><td>0</td><td colspan="18">2.65</td><td colspan="8">-0.12</td></tr>
<tr><td>C1</td><td>1</td><td colspan="9">0.37- N.S.</td><td colspan="10">2.54</td><td colspan="7">0.88- N.S.</td></tr>
<tr><td>C1</td><td>0</td><td colspan="14">0.26- N.S.</td><td colspan="5">2.79</td><td colspan="7">-0.52</td></tr>
<tr><td>C3</td><td>1</td><td colspan="18">5.42</td><td colspan="8">1.73</td></tr>
<tr><td>C3</td><td>0</td><td colspan="5">4.31</td><td colspan="13">6.02- N.S.</td><td colspan="8">-0.12</td></tr>
<tr><td>C4</td><td>1</td><td colspan="5">1.8- N.S.</td><td colspan="6">2.39- N.S.</td><td colspan="8">3.11- N.S.</td><td colspan="7">-2.74</td></tr>
<tr><td>C4</td><td>0</td><td colspan="5">1.29- N.S.</td><td colspan="12">3.51- N.S.</td><td colspan="9">-2.2</td></tr>
<tr><td>C5</td><td>1</td><td colspan="5">2.21</td><td colspan="5">4.64</td><td colspan="6">3.16</td><td colspan="5">1.44</td><td colspan="5">-0.7</td></tr>
<tr><td>C5</td><td>0</td><td colspan="8">2.64</td><td colspan="11">2.23- N.S.</td><td colspan="7">-0.37</td></tr>
<tr><td>DE</td><td>1</td><td colspan="6">2.83</td><td colspan="5">-2.85</td><td colspan="5">3.17</td><td colspan="5">-1.48</td><td colspan="5">-3.45- N.S.</td></tr>
<tr><td>DE</td><td>0</td><td colspan="9">0.02- N.S.</td><td colspan="6">-1.83</td><td colspan="11">-3.02- N.S.</td></tr>
<tr><td>FZ</td><td>1</td><td colspan="6">0.91</td><td colspan="5">5.47</td><td colspan="5">0.77</td><td colspan="5">-3.88</td><td colspan="5">-1.56</td></tr>
<tr><td>FZ</td><td>0</td><td colspan="6">0.19- N.S.</td><td colspan="5">2.41</td><td colspan="5">-2.81</td><td colspan="5">-4.34</td><td colspan="5">-0.13</td></tr>
<tr><td>GZ</td><td>1</td><td colspan="7">4.2</td><td colspan="5">3.53- N.S.</td><td colspan="6">3.02- N.S.</td><td colspan="8">2.11- N.S.</td></tr>
<tr><td>GZ</td><td>0</td><td colspan="7">1.53</td><td colspan="5">2.25- N.S.</td><td colspan="6">-0.16</td><td colspan="8">1.53</td></tr>
<tr><td>HZ</td><td>1</td><td colspan="9">5.66</td><td colspan="6">1.29</td><td colspan="5">2.65- N.S.</td><td colspan="6">-0.03</td></tr>
<tr><td>HZ</td><td>0</td><td colspan="9">4.64</td><td colspan="6">-0.04</td><td colspan="5">0.74- N.S.</td><td colspan="6">-0.29- N.S.</td></tr>
<tr><td>IZ</td><td>1</td><td colspan="7">2.57</td><td colspan="5">0.25- N.S.</td><td colspan="8">1.22- N.S.</td><td colspan="6">-0.51- N.S.</td></tr>
<tr><td>IZ</td><td>0</td><td colspan="7">-0.2- N.S.</td><td colspan="6">-1.11- N.S.</td><td colspan="7">0.45</td><td colspan="6">-1.76</td></tr>
<tr><td>JZ</td><td>1</td><td colspan="5">7.65</td><td colspan="6">2.51</td><td colspan="6">7.39</td><td colspan="9">1.6</td></tr>
<tr><td>JZ</td><td>0</td><td colspan="5">18.35</td><td colspan="8">2.77</td><td colspan="5">6.69</td><td colspan="8">0.44</td></tr>
<tr><td>MN</td><td>1</td><td colspan="6">4.13</td><td colspan="6">0.72</td><td colspan="6">3.97</td><td colspan="8">2.85</td></tr>
<tr><td>MN</td><td>0</td><td colspan="6">3.07</td><td colspan="5">-0.35</td><td colspan="6">1.35</td><td colspan="9">0.4</td></tr>
<tr><td>RU</td><td>1</td><td colspan="6">3.23</td><td colspan="15">3.22- N.S.</td><td colspan="5">0.43</td></tr>
<tr><td>RU</td><td>0</td><td colspan="4">34.21</td><td colspan="22">0.56</td></tr>
</table>

<table>
<tr><td></td><td>1991</td><td>1992</td><td>1993</td><td>1994</td><td>1995</td><td>1996</td><td>1997</td><td>1998</td><td>1999</td><td>2000</td><td>2001</td><td>2002</td><td>2003</td><td>2004</td><td>2005</td><td>2006</td><td>2007</td><td>2008</td><td>2009</td><td>2010</td><td>2011</td><td>2012</td><td>2013</td><td>2014</td><td>2015</td><td>2016</td></tr>
</table>

F -Agriculture - Size 1	4.27	4.78- N.S.	0.67		
L -Agriculture - Size 1	2.77	2.49- N.S.	-0.44		
F -Agriculture - Size 2	3.11	2.86- N.S.	4.89- N.S.	-1.9	
L -Agriculture - Size 2	2.52	0.98- N.S.	4.49- N.S.	-1.3	
F -Agriculture - All	4.21	4.77- N.S.	0.67		
L -Agriculture - All	2.73	0.38			
F -Industry - Size 1	2.17	4.02	0.41		
L - Industry - Size 1	1.92	3.12	-0.62		
F - Industry - Size 2	1.97	3.12- N.S.	4.65	1.09	
L - Industry - Size 2	1.43	3.63	0.33		
F - Industry - All	2.16	4.02	0.57		
L - Industry - All	1.82	3.05	-0.52		
F -Construction - Size 1	-0.05- N.S.	5.19	2.48	-3.86	-1.88
L -Construction - Size 1	0- N.S.	2.88	-2.01	-4.69	-0.83
F -Construction - Size 2	2.43	-0.9			
L -Construction - Size 2	-0.87- N.S.	3.06	-2.59	-2.98- N.S.	
F -Construction - All	-0.32- N.S.	5.06	2.26	-3.61	-1.97- N.S.
L -Construction - All	-0.06- N.S.	2.81	-1.99	-4.7	-0.84
F -Retail - Size 1	3.65	4- N.S.	3.18- N.S.	2.03- N.S.	
L - Retail - Size 1	0.99	3.09	-0.24	1.43	
F - Retail - Size 2	3.25	2.56- N.S.			
L - Retail - Size 2	0.42- N.S.	1.28- N.S.	-0.21	0.45- N.S.	
F - Retail - All	4.12	3.3- N.S.	2.34- N.S.		
L - Retail - All	0.98	2.97	-0.22	1.33	
F -Transport - Size 1	6.34	1.84	2.32- N.S.	0.56- N.S.	
L -Transport - Size 1	5.18	0.43	0.55- N.S.	-0.05- N.S.	
F -Transport - Size 2	4.96	0.76	3.5	1.19	
L -Transport - Size 2	4.75	1.21	0.25- N.S.	0.32- N.S.	
F -Transport - All	5.98	1.61	2.5- N.S.	0.67	
L -Transport - All	5.01	0.43	0.55- N.S.	0.01- N.S.	

<table>
<tr><td>F -Other - Size 1</td><td colspan="6">5.93</td><td colspan="6">1.41</td><td colspan="6">4.71</td><td colspan="8">2.66</td></tr>
<tr><td>L - Other - Size 1</td><td colspan="5">4.19</td><td colspan="6">1.14</td><td colspan="6">1.16- N.S.</td><td colspan="9">0.36- N.S.</td></tr>
<tr><td>F - Other - Size 2</td><td colspan="10">1.35</td><td colspan="9">1.97- N.S.</td><td colspan="7">1.86- N.S.</td></tr>
<tr><td>L - Other - Size 2</td><td colspan="12">0.21- N.S.</td><td colspan="5">2.58</td><td colspan="9">0.28</td></tr>
<tr><td>F - Other - All</td><td colspan="6">5.03</td><td colspan="6">1.3</td><td colspan="6">4.34</td><td colspan="8">2.57</td></tr>
<tr><td>L - Other - All</td><td colspan="10">1.83</td><td colspan="7">1- N.S.</td><td colspan="9">0.43- N.S.</td></tr>
<tr><td>F -All sectors – Size 1</td><td colspan="7">3.33</td><td colspan="5">3.43- N.S.</td><td colspan="6">2.74- N.S.</td><td colspan="8">1.4</td></tr>
<tr><td>L - All sectors – Size 1</td><td colspan="7">2.05</td><td colspan="5">3.05</td><td colspan="6">0.83</td><td colspan="8">0.01</td></tr>
<tr><td>F - All sectors – Size 2</td><td colspan="21">1.8</td><td colspan="5">0.99</td></tr>
<tr><td>L - All sectors Size 2</td><td colspan="12">1.58</td><td colspan="6">1.39- N.S.</td><td colspan="8">-0.19</td></tr>
<tr><td>F - All sectors - All</td><td colspan="7">2.11</td><td colspan="5">3.74</td><td colspan="6">1.29</td><td colspan="8">-0.19</td></tr>
<tr><td>L - All sectors All</td><td colspan="7">1.48</td><td colspan="5">2.67</td><td colspan="6">0.47</td><td colspan="8">-0.2- N.S.</td></tr>
<tr><td></td><td>1991</td><td>1992</td><td>1993</td><td>1994</td><td>1995</td><td>1996</td><td>1997</td><td>1998</td><td>1999</td><td>2000</td><td>2001</td><td>2002</td><td>2003</td><td>2004</td><td>2005</td><td>2006</td><td>2007</td><td>2008</td><td>2009</td><td>2010</td><td>2011</td><td>2012</td><td>2013</td><td>2014</td><td>2015</td><td>2016</td></tr>
</table>

Appendix 3: Sector nomenclature

There are 17 sectors in INSEE's NAF definition of sectoral activities. Each of them is attributed a two-letter code. However, we decided to remove four sectors from this classification because productivity cannot be measured consistently for these sectors compared to the remaining ones. These sectors are Financial and insurance activities (KZ), Air conditioning, steam, gas and electricity production and distribution (DZ), Real estate activities (LZ) and Mainly non-merchant services (OQ). The remaining sectors are presented in the table below.

Code	Sector
AZ	Agriculture, silviculture and fishing
C1	Manufacturing of comestibles, beverages, and tobacco products
C3	Manufacturing of electric, electronic, IT equipment; machines manufacturing
C4	Manufacturing of transport materials
C5	Manufacturing of other industrial products
DE	Extractive industries, energy, water, waste management and remediation
FZ	Building
GZ	Trade; car and motorcycle repairing
HZ	Transport and warehousing
IZ	Accommodation and food services
JZ	Information and communication
MN	Technical and scientific activities; administrative and support services
RU	Other services

The six business sectors used for trend break analysis are compounded as follows:

Cluster	Sectors
Agriculture	AZ
Industry	C1, C3, C4, C5
Construction	FZ
Retail	GZ
Transport	HZ
Other	IZ, JZ, MN, RU

For sector dummies, we divided the 13 sectors into two groups, one made up of 6 sectors and the other of 7, according to the value of the criteria.
Sectors with a high ICT capital intensity (high ICT capital stock over total capital stock from EU-KLEMS) are either related to technology-oriented (such as Information and communication) or to high-technology manufacturing (Manufacturing of transport material) activities.

Conversely, sectors that require heavy physical capital (Extractive industries) or labour with particular technical or social skills (Car repairing, Food services) are clustered in the "low-ICT" group. The two other classifications are quite close and differ in only one sector. Financially dependent sectors, defined as sectors for which the ratio of capital expenditure minus current cash flows to total capital expenditure is the highest, are diverse: they require important investments (Manufacturing of transport materials), are subject to postponed settlements (Transport and warehousing), face important economic competition or require government financial support (Agriculture). Less dependent sectors are usually high value added sectors (Manufacturing of electric, electronic, IT equipment) and do not match with the previous characteristics. Sectors displaying a high ratio of imports to output are mostly manufacturing sectors (machines, industrial products, etc.) which require raw materials or equipment from foreign countries. The precise breakdown of sectors within the clusters is presented in the table below.

High ICT using sectors	**Low ICT using sectors**
- Information and communication - Other services - Manufacturing of electric, electronic, IT equipment; machines manufacturing - Manufacturing of other industrial products - Technical and scientific activities; administrative and support services - Manufacturing of transport materials	- Trade; car and motorcycle repairing - Manufacturing of comestibles, beverages, and tobacco products - Building - Accommodation and food services - Transport and warehousing - Extractive industries, energy, water, waste management and remediation - Agriculture, silviculture and fishing
High financial dependency sectors	**Low financial dependency sectors**
- Transport and warehousing - Agriculture, silviculture and fishing - Extractive industries, energy, water, waste management and remediation - Manufacturing of comestibles, beverages, and tobacco products - Manufacturing of transport materials - Other services - Manufacturing of other industrial products	- Building - Accommodation and food services - Technical and scientific activities; administrative and support services - Manufacturing of electric, electronic, IT equipment; machines manufacturing - Trade; car and motorcycle repairing - Information and communication
High import sectors	**Low import sectors**
- Transport and warehousing - Agriculture, silviculture and fishing - Manufacturing of electric, electronic, IT equipment; machines manufacturing - Extractive industries, energy, water, waste management and remediation - Manufacturing of comestibles, beverages, and tobacco products - Manufacturing of transport materials - Manufacturing of other industrial products	- Building * - Accommodation and food services * - Technical and scientific activities; administrative and support services - Information and communication - Other services - Trade; car and motorcycle repairing

*These sectors have no imports. They are therefore clustered in the "low import" group.