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# Selection and market dynamics. Some comparative evidence

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Abstract

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Is market selection a major determinant of aggregate productivity growth? To what extent does market selection account for the dynamics of firms' growth? These two questions are crucial for understanding the properties of markets and firms processes across time and across countries. Decompositions of productivity growth provide an answer, admittedly indirect, to the first question. Empirical evidence, mostly concerning the manufacturing industries in USA at different levels of disaggregation, shows that the reallocation of shares from less productive to more productive firms - the so called "between effect" - and the turnover between entrant and exiters do indeed contribute positively to the aggregate performance. The productivity growth which takes place within each firm is, however, almost always the most important component. How widespread is this pattern across countries? In our paper, we compare the results of the decomposition of labor productivity growth in manufacturing industries in four big economies: France, Germany, UK and USA. The analysis draws upon Amadeus for the European countries and Compustat for the American ones. The results are in agreement with the previous literature. In particular, we find that the between effect has most of the time the expected positive sign even if the within component dominates the between component almost uniformly across sectors and across countries. Decomposing labor productivity growth just says which fraction of productivity growth is accounted for by the reallocation of shares to most productive firms. In order to answer our second question, we would like to know also to what extent the productivity of a firm contributes to its own growth. Indeed, diverse models of industry dynamics posit the differential efficiency of firms as the main determinant of their differential growth. How grounded is this prediction in empirical data? In the second part of our paper, we try to analyze this question by exploiting the panel structure of our data. In particular, we estimate a correlated random effect model à la Mundlak in which the dependent variable is our proxy for the relative firm's rate of growth (the rate of growth of sales) and the independent variable is the relative labor productivity. Results show that across industries and across countries only a small part of the variation in the rate of growth of firms is explained by the variation in productivity. Together, the two exercises suggest that selection forces are less important than usually assumed.

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# Selection and market dynamics. Some comparative evidence

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# 1 Introduction

A lot of empirical studies have documented by now the turbulent dynamics underlying the process of productivity growth in manufacturing sectors.[1] A central concern has been the extent to which the reallocation of shares from less productive to more productive firms - the so called "between effect" - and the turnover between entrant and exiters contributes to the aggregate performance. Baily et al. (1992), analyzing American data from 1972 to 1987 on a five-years basis, find a positive and significant role for the between effect, which increases during periods of slowdown in productivity growth. They also stress the little contribution given by entry and exit and the persistence in the productivity ranking among firms. Griliches and Regev (1995) also attribute to turnover a small effect on productivity growth in their study on Israeli industry from 1979 to 1988 on a three-years basis. Baldwin and Gu (2006) provide a picture of Canadian manufacturing industries from 1973 to 1997 on a multiple-span basis, finding a significant contribution to productivity growth from plant turnover. Bottazzi et al. (2010) analyze French and Italian data from 1991 to 2004, focusing mainly on the perfomance of incumbents. Clearly, all these studies adopt different formulas to decompose productivity growth so that it is not so simple to compare the results across countries in an homogeneous way.[2] A common lesson emerging from them is however that the productivity growth which takes place within each firm - the so called "within effect" - is the biggest component in accounting for the total productivity growth.

Decomposition of productivity growth gives only a first, indirect measure of the selection amongst incumbent, via the bewteen component. Indeed, it just says which fraction of productivity growth is accounted for by the reallocation of shares to the most productive firms. What we would like to know is also to what extent the productivity of a firm contributes to its growth. This question has not received the deserved attention in the empirical literature, even if it is at the center of many models of industry dynamics which postulate a relationship between the relative growth of a firm and its relative efficiency. In neoclassical models, this usually happens because the more efficient a firm is, in term of relative productivity, the lower the price it can charge, thus capturing an higher share of the demand (see Jovanovic (1982) and the extension to trade in Melitz (2003)). In models sharing an evolutionary perspective, the differential efficiency of firms spur their differential growth via profitability, as only the more productive firms - making more profits - can invest and grow in presence of imperfect capital markets (see Nelson and Winter (1982)).

In this paper, we present first the results of the decomposition of productivity growth in four big economies: USA, France, UK and Germany. This allow us to compare the contributions of the different effects across countries using an homogeneous methodology. Then, we investigate the relationship between productivity and growth by exploiting the panel dimension of our data.

This paper is organized as follows. In Section 2 we describe the dataset of European and American firms. In Section 3 we present the results of the decomposition of productivity growth. In Section 4 we turn to panel data regression.

# 2 Data and Variables

The present analysis draws upon two distinct datasets. For European firms, we use Amadeus, a commercial database provided by Bureau van Dijk. In the edition at our disposal,[3] it contains informations from the balance sheet and the income statement account of over fourteen million european firms. The data are standardized to allow comparisons across countries. The database includes up to ten years of accounting information of firms that have to file their accounts by law. Because of different disclosure requirements, coverage varies by countries. Moreover, the yearly update drops all the firms for which there is no information in the last five years; as a consequence, coverage also varies by years. In order to have a set of countries and a time interval with a good coverage of variables of interest, we limit our sample to three countries, France, United Kingdom and Germany, with a slightly different span of years. For France and United Kingdom, we use data for seven years, from 2001 to 2007. For Germany, the starting year is 2003. For USA firms, our source is COMPUSTAT, which contains data on listed companies classified according to both NAICS and SIC code. The time period covered is 1985-2000.

The choice of variables is dictated by the kind of analysis we perform. We are interested in corporate perfomances across countries as revealed by two major dimensions: productivity and growth. As for productivity, we use the simple ratio of value added over the number of employees instead of multifactor productivity mea-

[1] see Bartelsman and Doms (2000) for a critical survey.

[2] see Foster et al. (2001) for a discussion of sensitivity of decomposition to measurement methodology.

[3] i.e. March 2010.

sures.[4] Value added is calculated as operating profits plus cost of labour. Finally, growth is the log difference of total sales at constant prices, in two consecutive years. Figures over operating profits and cost of employees are present in Amadeus, but they have to be constructed in Compustat. In particular, operating profits are calculated as sales minus total costs (which we have), while data on cost of employees are obtained by multiplying the number of employees for their average cost as reported by BLS at 4-Digits level of disaggregation. We concentrate our analysis on the manufacturing sectors at the finest possible level of disaggregation. For European countries, we consider industries at 2-Digits level according to NACE rev1.1 classification. For USA, at 3-Digits level according to NAICS classification, which, for manufacturing sectors, corresponds roughly to a 2-Digits classification in the NACE standard. For some industries for which we have a sufficient number of observations, we considered also 3-Digits (NACE rev1.1) and 4-Digits level (NAICS). The current values of the variables are deflated using price production index from EUROSTAT and from BLS.

# 3 Decomposition of productivity growth

Industry-level productivity growth in a given time interval is the aggregate outcome of a firm-level process, which includes the productivity growth of the continuing firms, the reallocation of shares between them and the turnover between exiting and entrant firms. In order to disentangle the different components of this process, we have first to define a general index of productivity for sector $j$ as a weighted sum of individual firms' productivities:

$$\Pi_{j,t} = \sum_{i \in j} s_{i,t} \pi_{i,t}$$

where $\pi_{i,t}$ is the labour productivity of firm $i$ at time $t$ and $s_{i,t}$ is the share of firm $i$ in sector $j$. Then, we can decompose the index according to the following formula:[5]

$$\Delta\Pi_{j,t} = \Delta \sum_{i \in j} s_{i,t}\pi_{i,t} = \sum_{i \in j} s_{i,t-1}\Delta\pi_{i,t} + \sum_{i \in j} \Delta s_{i,t}\pi_{i,t-1} + \sum_{i \in j} \Delta s_{i,t}\Delta\pi_{i,t}$$

The three components are (1) a within-firm effect, i.e the productivity growth of firms weighted by initial shares; (2) a between-firms effect, i.e. the variation in firms' shares weighted by initial productivity levels; (3) an interaction effect, i.e. the product of variation in shares and productivities. Using this formula, we compute the contribution of the three components for each year in our datasets and sum them across years. All in all, we are using the following formula:[6]:

$$\sum_t \Delta\Pi_{j,t} = \sum_t \sum_{i \in j} s_{i,t-1}\Delta\pi_{i,t} + \sum_t \sum_{i \in j} \Delta s_{i,t}\pi_{i,t-1} + \sum_t \sum_{i \in j} \Delta s_{i,t}\Delta\pi_{i,t}$$

The formula does non take into account the contribution of entry and exit to productivity growth because we do not have data on firms' births and deaths. This means that we are going to restrict our attention to the issue of selection among incumbent firms. Notice also that in the above formula firms' productivities can be seen both as absolute productivities and as relative productivities, i.e. deviations from yearly industry level productivities. Indeed, the sum of shares of continuing firms is constant without entry and exit so that any term with the industry productivity index would cancel out. As for shares, we use both employment and sales. The first weight seems to be the most appropriate choice since we are using a labor productivity measure. With the employment weight, we secure a direct connection with most measures of labor productivity at the industry-level. By using the sales weight, we loose on the contrary a clear relation with more standard aggregate indices. Anyway, we chose to use also this second measure since in the next section we are going to analyze the link between productivity and sales growth.

Results by sector and by country are shown in the Appendix A. Sectoral averages display a lot of variabilities, and the relative magnitudes change depending on the weights used. What does not change is the general picture emerging from the exercise. The within component dominates the between component in almost the totality of sectors, in all the countries under analysis, whatever is the weight used. Similar conclusions can be reached by looking, for each country, at the weighted average contributions across sectors. In this case, the

[4] see Bottazzi et al. (2010, p. 5) for a discussion of this point.

[5] see Foster et al. (2001) and Baldwin and Gu (2006) for examples of other possible decompositions.

[6] Notice that the contribution in share of each component obtained with this formula is equivalent to the weighted sum of the yearly contributions. Take for example the within-firm effect. Its total contribution will be equal to $(\sum_t \sum_{i \in j} s_{i,t-1}\Delta\pi_{i,t})/(\sum_t \Delta\Pi_{j,t}) = \sum_t [(\frac{\sum_{i \in j} s_{i,t-1}\Delta\pi_{i,t}}{\Delta\Pi_{j,t}})(\frac{\Delta\Pi_{j,t}}{\sum_t \Delta\Pi_{j,t}})]$.

weight used for each sector is the share of that sector, in terms of employment or sales, on total manufacturing.[7] The aggregated results, presented in Table 1, confirms the disaggregated ones. In particular, the table shows how the within component tends to be higher when the employment weight is used.[8] Notice also that the difference in sign in the interaction term is also in accordance with the fact that labor productivity growth is usually negatively correlated with employment growth but positively correlated with sales growth.

| | Within Share | Between Share | Interaction Share |
|---|---|---|---|
| | A. Employment weight | | |
| France | 2.55 | 1.10 | -2.64 |
| Germany | 1.29 | -0.07 | -0.22 |
| UK | 1.10 | 0.09 | -0.19 |
| USA | 1.10 | 0.16 | -0.26 |
| | B. Sales weight | | |
| France | 0.61 | 0.41 | -0.01 |
| Germany | 0.87 | 0.12 | 0.01 |
| UK | 0.65 | 0.25 | 0.09 |
| USA | 1.02 | -0.07 | 0.05 |

Table 1: Productivity decomposition by country.

# 4 Regression analysis

In this section we are going to answer the following question: is there any significant relationship between the labor productivity, as a proxy of production efficiency, and the firm growth rate? In order to answer this question, we start with the following linear model with additive heterogeneity:

$$y_{i,t} = a + b_t + \beta x_{i,t} + u_i + \epsilon_{i,t}$$

where $y_{i,t}$ is the firm growth rate as measured by the log difference of total sales at constant prices, $x_{i,t}$ is our measure of labor productivity, $b_t$ is a time dummy, $\beta$ is the coefficient of interest, $u_i$ is a firm-specific, time invariant, unobserved effect, and $\epsilon_{i,t}$ is the idiosyncratic error. The presence of time dummies is equivalent to considering all the variables as deviations from their cross-sectional averages so that, once again, we are dealing with a relative productivity and a relative growth rate measure.

It is clear that the unobserved heterogeneity, $u_i$, is possibly correlated with productivity: some relevant candidates affecting both the growth rate and the labor productivity are, for example, managerial practices and "dynamic capabilities".[9] The traditional way of dealing with such a problem is the "fixed effect" estimation. The main shortcoming of this tecnique is that it imposes a strict exogeneity assumption on the idiosyncratic error term which, in this case, seems to be quite restrictive.[10] Growth shocks can be correlated with past and future values of productivities. Correlation of growth shocks with past productivity is in place if, for example, there are adjustment costs. Correlation of shocks with future productivity is realized whenever a firm revises its production plan for the future based on unexpected growth today.

We take the safest way and estimate more than one specification of our equation, with different lags and leads. We run fixed-effect estimations of the following equations:

$$y_{i,t} = a + b_t + \beta x_{i,t} + \beta_l x_{i,t-1} + u_i + \epsilon_{i,t}$$
$$y_{i,t} = a + b_t + \beta x_{i,t} + \beta_l x_{i,t-1} + \beta_{ll} x_{i,t-2} + u_i + \epsilon_{i,t}$$
$$y_{i,t} = a + b_t + \beta x_{i,t} + \beta_l x_{i,t-1} + \beta_f x_{i,t+1} + u_i + \epsilon_{i,t}$$

[7] This way of accounting for the total manufacturing productivity growth is legitimate because we are interested in the dynamics of reallocation within sectors, and not in the reallocation between sectors, which is in principle a different thing. However, the differences between the two indices tends to be quite small, as it is clear by looking at the first rows in the Appendix tables.

[8] This finding is in agreement with Foster et al. (2001), p. 323.

[9] See Winter (2003) for a definition of "dynamic capability" and Syverson (2011) for a discussione of the effects of managerial practices on productivity.

[10] In more formal terms, the requirement is that $E(\epsilon_{i,t}|\mathbf{x_i}, u_i) = 0$. When this assumption does not hold, the fixed-effect estimator is consistent only if both $N \to \infty$ and $T \to \infty$.

In all countries, the coefficients $\beta_{ll}$ and $\beta_f$ are statistically different from zero at 5% confidence level only in few sectors. This is consistent with the null hypothesis that they are equal to zero. On the other hand, the coefficient $\beta_l$ turns out to be significantly different from zero in the majority of sectors. In the end, our final specification is the following one:

$$y_{i,t} = a + b_t + \beta x_{i,t} + \beta_l x_{i,t-1} + u_i + \epsilon_{i,t} \tag{1}$$

Fixed effect estimators of coefficients in equation 1 are consistent, but badly in tune with our interest in the relationship between the growth rate and the productivity. Indeed, the firm-specific effect $u_i$ is possibly correlated with the average productivity, so that by getting rid of it we also loose a productivity variable influencing growth. What we would like to do is to disentagle, within the unobserved effect $u_i$, the part which is correlated with the productivity from the part which is not. In order to do so, we estimate equation (1) by applying the "correlated random effect" model. In practice, we apply the traditional "random effect" estimation to the following equation:

$$y_{i,t} = a + b_t + \beta x_{i,t} + \beta_l x_{i,t-1} + \bar{\beta}\bar{x}_i + \bar{\beta}_l \bar{x}_{i,-1} + c_i + \epsilon_{i,t} \tag{2}$$

where $\bar{x}_i$ and $\bar{x}_{i,-1}$ are respectively the time series average of productivity and lagged productivity. The underlying assumption is that the new heterogeneity term $c_i$ is uncorrelated with the regressors after controlling for their averages. Notice that this assumption is not going to affect the results with respect to a fixed effect estimation, as far as the coefficients of $x_{i,t}$ and $x_{i,t-1}$ are concerned. In fact, as shown in Mundlak (1978) for the balanced panels and Wooldridge (2009) for the unbalanced ones, the coefficients $\beta$ and $\beta_l$ obtained from a fixed effect estimation of (1) are equal to the corresponding coefficients obtained from a random effect estimation of (2).[11]

Results from estimation of equation (2) are not directly informative. For one hand, the values of coefficients depend on the unit of measurement of the variables; on the other hand, we have more than one coefficient, while what we need is a synthetic measure of the relation between the productivity and the growth rate. We prefer to measure the degree of association between them by using the following index:

$$S^2 = \frac{Var(\mathbf{x_i'b})}{Var(y_i)} \tag{3}$$

where $\mathbf{x_i'}$ is the row vector containing the productivity variables and $\mathbf{b}$ is the column vector containing the corresponding coefficients. In the Appendix B, we present the results from estimation of equation 2 for each sector and each country. The following table reports the summary statistics for $S^2$ by country:

| | average | min | max |
|---|---|---|---|
| France | 0.07 | 0.01 | 0.24 |
| Germany | 0.22 | 0.02 | 0.59 |
| UK | 0.10 | 0.00 | 0.34 |
| USA | 0.10 | 0.01 | 0.32 |

Table 2: Summary statistics for $S^2$

As it clearly emerges from table 2, the "explanatory power" of labor productivity with respect to the growth rate is, on average, quite low across country. In three out of four countries, no more than 10% of the variance of the dependent variable is associated with the productivity variables, with the maximum value being around 30%. Germany is the big "outlier" in this comparison, in that its average value is more than double than the average value of the other countries, with a maximum which is about 60%. Appenix B presents a more detailed account of sectoral results, from which it can be easily seen that no clear sectoral pattern exist in the distribution of coefficients across countries.

# 5 Conclusions

The first exercise proposed in this paper supports with further evidence the claim that the aggregate productivity growth is, for the most part, the resultant of a process which takes place within the firm. We have

[11] Actually, this is not exactly true in our case because we do not include the averages of time dummies in (2); as a consequence, the result is going to be slightly different. Notice that averages of time dummies would not matter in a balanced panel estimated with a common constant term.

decomposed the labor productivity growth in four different countries, characterised by different institutional set-ups. Notwithstanding these differences, the process of reallocation of market shares has been shown to contribute little to the aggregate performance. The small relative magnitude of the between component seems to point in the direction of a weak market selection, even if complementary evidence on the impact of entry and exit should be taken into account.

The second exercise push toward a reconsideration of diverse theories that posit differential efficiency as the major driver of firm growth. Indeed, the process of growth seems to be explained only to a little extent by the productivity dynamics. Also in this case, the result holds irrespectively of the country analyzed. Together, the two exercises imply that selection forces are less important than usually assumed.

## 6 Appendix A

Here we present the results of productivity growth decomposition by sector. Tables 3 and 4 report decomposition effects obtained by weighting firm level productivities with employment shares, respectively for European data and American ones. In table 5 and 6 the weights used are the sale shares.

| NACE 1.1 | France | | | Germany | | | UK | | |
|---|---|---|---|---|---|---|---|---|---|
| Sector | WithEff | BetwEff | IntEff | WithEff | BetwEff | IntEff | WithEff | BetwEff | IntEff |
| 0. Total Manufacture | 1.93 | 0.76 | -1.69 | 1.30 | -0.04 | -0.27 | 1.18 | 0.06 | -0.25 |
| 15. Food and beverage | 3.06 | 0.15 | -2.21 | 1.52 | 0.05 | -0.57 | 1.95 | -0.15 | -0.80 |
| 16. Tobacco | 0.69 | 0.17 | 0.13 | 1.05 | -0.03 | -0.01 | 1.11 | 0.03 | -0.14 |
| 17. Textiles | 1.08 | 0.34 | -0.42 | 0.88 | 0.24 | -0.13 | -6.35 | -3.82 | 11.17 |
| 18. Wearing | 0.95 | 0.38 | -0.33 | 7.02 | -7.87 | 1.85 | 1.05 | 0.53 | -0.58 |
| 19. Leather | 0.50 | 0.87 | -0.37 | 0.55 | 0.46 | -0.00 | 0.99 | 0.04 | -0.04 |
| 20. Wood products | 1.40 | 0.51 | -0.91 | 1.11 | 0.14 | -0.25 | 1.02 | 0.05 | -0.07 |
| 21. Pulp and paper | 1.29 | 0.55 | -0.84 | 0.99 | 0.21 | -0.20 | 1.32 | -0.09 | -0.22 |
| 22. Publishing and printing | 1.45 | 0.61 | -1.06 | 1.18 | 0.15 | -0.33 | 1.07 | 0.32 | -0.39 |
| 23. Coke and petroleum | 1.19 | 0.14 | -0.32 | 1.24 | -0.13 | -0.11 | 1.09 | -0.03 | -0.05 |
| 24. Chemicals(no pharma) | 7.99 | 5.95 | -12.94 | 1.43 | -0.26 | -0.18 | 0.87 | 0.21 | -0.08 |
| 244. Pharma | 10.26 | 9.10 | -18.36 | 3.17 | -1.50 | -0.66 | 1.08 | -0.04 | -0.03 |
| 25. Rubber and plastic | 1.22 | 0.13 | -0.35 | 1.27 | -0.12 | -0.15 | 1.11 | 0.15 | -0.26 |
| 26. Non-metallic minerals | 1.20 | 0.07 | -0.28 | 1.05 | 0.06 | -0.11 | 1.05 | 0.09 | -0.14 |
| 27. Basic metals | 3.12 | 1.90 | -4.01 | 2.15 | 0.05 | -1.20 | 1.21 | -0.08 | -0.13 |
| 28. Fabr. metal products | 1.26 | 0.54 | -0.80 | 1.04 | 0.14 | -0.18 | 1.00 | 0.13 | -0.13 |
| 29. Machinery and equipment | 1.42 | 0.10 | -0.53 | 1.36 | 0.03 | -0.40 | 0.99 | 0.09 | -0.08 |
| 30. Computers | 0.94 | 0.11 | -0.06 | 0.72 | 0.21 | 0.07 | 0.70 | -0.40 | 0.69 |
| 31. Electrical machinery | 1.75 | -0.15 | -0.60 | 1.47 | -0.14 | -0.32 | 1.35 | -0.24 | -0.11 |
| 32. Television and communication | 1.19 | -0.06 | -0.13 | 1.04 | -0.06 | 0.02 | 1.38 | -0.47 | 0.09 |
| 33. Medical instruments | 1.11 | 0.22 | -0.34 | 1.33 | -0.24 | -0.09 | 0.63 | -0.92 | 1.28 |
| 34. Motor vehicles | 1.02 | 0.04 | -0.05 | 1.09 | -0.03 | -0.07 | 1.15 | -0.05 | -0.09 |
| 35. Other transport equipment | -2.98 | -1.07 | 5.05 | 1.04 | 0.35 | -0.39 | 1.01 | 0.05 | -0.06 |
| 36. Furniture | 1.00 | 0.63 | -0.63 | 1.03 | 0.02 | -0.04 | 0.96 | 0.14 | -0.10 |

Table 3: Decomposition of labor productivity growth: France, Germany and UK. Employment weight.

| NAICS | USA | | |
|---|---|---|---|
| Sector | WithEff | BetwEff | IntEff |
| 0. Total Manufacture - 3 | 1.08 | 0.23 | -0.31 |
| 1. Food and Beverages-311+312 | 1.79 | -0.08 | -0.72 |
| 2. Tobacco-3122 | 0.86 | 0.21 | -0.07 |
| 3. Textiles-313+314 | 0.95 | 0.67 | -0.62 |
| 4. Appareal-315 | 0.37 | 0.68 | -0.06 |
| 5. Leather and Footwear-316 | -0.26 | 1.56 | -0.30 |
| 6. Wood-321 | -6.50 | -2.51 | 10.01 |
| 7. Paper-322 | 1.16 | 0.04 | -0.20 |
| 8. Printing-323 | 0.90 | 0.11 | -0.01 |
| 9. Petroleum and Coal-324 | 1.09 | -0.03 | -0.07 |
| 10. Chemical (no Pharma)-325 | 2.18 | 1.85 | -3.04 |
| 11. Pharma-3254 | 1.08 | -0.00 | -0.08 |
| 12. Plastic and Rubber-326 | 0.84 | 0.33 | -0.16 |
| 13. Non-Metal Minerals-327 | 1.17 | 0.04 | -0.22 |
| 14. Metals-331 | 0.99 | 0.06 | -0.06 |
| 15. Fabr. Metal Products-332 | 0.85 | 0.32 | -0.16 |
| 16. Machinery Manuf.-333 | 0.76 | 0.22 | 0.03 |
| 17. Computer -3341 | 0.72 | 0.31 | -0.03 |
| 18. Commun.-3342 + Aud/Vid-3343 | 0.74 | 0.28 | -0.03 |
| 19. Semicond./Electr.Component.-3344 | 1.02 | 0.04 | -0.05 |
| 20. M/Control-3345+Mag/opt media-3346 | 1.02 | 0.10 | -0.12 |
| 21. Electrical Eq.-335 | 0.92 | 0.26 | -0.19 |
| 22. Transport EQ.(Motor Veh.) | -1.72 | 4.62 | -1.90 |
| 23. Transport EQ.(Other) | 0.84 | 0.22 | -0.06 |
| 24. Furnitures-337 | 0.87 | 0.25 | -0.11 |
| 25. Misc. Manufact (Medical) | 0.79 | 0.52 | -0.31 |
| 26. Misc. Manufact (Others) | 0.46 | 0.86 | -0.31 |

Table 4: Decomposition of labor productivity growth: USA. Employment weight.

| NACE 1.1 | France | | | Germany | | | UK | | |
|---|---|---|---|---|---|---|---|---|---|
| Sector | WithEff | BetwEff | IntEff | WithEff | BetwEff | IntEff | WithEff | BetwEff | IntEff |
| 0. Total Manufacture | 0.72 | 0.35 | -0.08 | 0.57 | 0.28 | 0.15 | 0.68 | 0.20 | 0.11 |
| 15. Food and beverage | 0.80 | 0.27 | -0.07 | 0.41 | 0.17 | 0.42 | 1.43 | -0.24 | -0.20 |
| 16. Tobacco | 0.83 | 0.56 | -0.39 | 3.78 | -3.03 | 0.25 | 0.87 | 0.32 | -0.19 |
| 17. Textiles | 0.81 | 0.22 | -0.03 | 0.59 | 0.78 | -0.36 | -3.40 | 3.92 | 0.47 |
| 18. Wearing | 0.70 | 0.25 | 0.06 | 1.70 | -0.78 | 0.08 | 0.38 | 0.81 | -0.19 |
| 19. Leather | 0.66 | 0.34 | -0.00 | 0.83 | 0.09 | 0.08 | 0.90 | 0.12 | -0.02 |
| 20. Wood products | 1.30 | 0.72 | -1.01 | 0.64 | 0.26 | 0.10 | 0.97 | 0.07 | -0.04 |
| 21. Pulp and paper | 0.94 | -0.18 | 0.23 | 0.88 | 0.14 | -0.03 | 1.25 | 0.08 | -0.33 |
| 22. Publishing and printing | 0.66 | 0.54 | -0.19 | 1.13 | 0.08 | -0.21 | 0.63 | 0.59 | -0.22 |
| 23. Coke and petroleum | 3.89 | -2.91 | 0.02 | 0.88 | 0.08 | 0.04 | 1.03 | 0.04 | -0.07 |
| 24. Chemicals(no pharma) | 0.27 | 0.76 | -0.03 | 0.80 | 0.23 | -0.03 | 0.41 | 0.27 | 0.31 |
| 244. Pharma | -0.07 | 1.04 | 0.03 | 0.62 | 0.48 | -0.10 | 0.27 | 0.75 | -0.02 |
| 25. Rubber and plastic | 0.84 | 0.28 | -0.12 | 0.94 | 0.01 | 0.05 | 1.07 | -0.01 | -0.06 |
| 26. Non-metallic minerals | 0.87 | 0.14 | -0.01 | 0.98 | 0.03 | -0.01 | 0.90 | 0.12 | -0.03 |
| 27. Basic metals | 0.53 | 0.35 | 0.12 | 0.87 | 0.09 | 0.04 | 0.38 | 1.38 | -0.76 |
| 28. Fabr. metal products | 0.78 | 0.25 | -0.03 | 0.84 | 0.19 | -0.03 | 0.83 | 0.14 | 0.02 |
| 29. Machinery and equipment | 0.86 | 0.03 | 0.11 | 0.84 | 0.10 | 0.06 | 0.95 | 0.06 | -0.00 |
| 30. Computers | 0.84 | 0.08 | 0.09 | 0.63 | 0.56 | -0.18 | 1.12 | -0.42 | 0.30 |
| 31. Electrical machinery | 1.03 | 0.04 | -0.07 | 0.82 | 0.06 | 0.12 | 1.22 | -0.06 | -0.16 |
| 32. Television and communication | 0.98 | 0.14 | -0.12 | 0.40 | 0.57 | 0.03 | 1.40 | -0.45 | 0.04 |
| 33. Medical instruments | 0.52 | 1.17 | -0.70 | 0.66 | 0.34 | 0.00 | 1.14 | 0.37 | -0.51 |
| 34. Motor vehicles | 1.08 | -0.05 | -0.02 | 1.01 | -0.02 | 0.01 | 1.01 | 0.03 | -0.04 |
| 35. Other transport equipment | -0.34 | 1.12 | 0.22 | 0.05 | 2.08 | -1.13 | 1.00 | 0.01 | -0.01 |
| 36. Furniture | 0.55 | 0.40 | 0.05 | 0.75 | 0.14 | 0.11 | 0.56 | 0.46 | -0.02 |

Table 5: Decomposition of labor productivity growth: France, Germany and UK. Sales weight.

| NAICS | USA | | |
|---|---|---|---|
| Sector | WithEff | BetwEff | IntEff |
| 0. Total Manufacture - 3 | 0.76 | -0.02 | 0.26 |
| 1. Food and Beverages-311+312 | 1.06 | -0.08 | 0.02 |
| 2. Tobacco-3122 | 0.50 | 0.38 | 0.12 |
| 3. Textiles-313+314 | 0.45 | 0.07 | 0.47 |
| 4. Appareal-315 | -0.29 | 1.04 | 0.25 |
| 5. Leather and Footwear-316 | -9.20 | 6.24 | 3.96 |
| 6. Wood-321 | -0.28 | -0.28 | 1.56 |
| 7. Paper-322 | 0.88 | -0.05 | 0.17 |
| 8. Printing-323 | 0.98 | -0.01 | 0.03 |
| 9. Petroleum and Coal-324 | 1.01 | -0.04 | 0.03 |
| 10. Chemical (no Pharma)-325 | 9.07 | -6.10 | -1.97 |
| 11. Pharma-3254 | 0.92 | -0.03 | 0.11 |
| 12. Plastic and Rubber-326 | 0.73 | 0.23 | 0.05 |
| 13. Non-Metal Minerals-327 | 1.00 | -0.15 | 0.14 |
| 14. Metals-331 | 0.78 | -0.01 | 0.23 |
| 15. Fabr. Metal Products-332 | 0.62 | 0.28 | 0.10 |
| 16. Machinery Manuf.-333 | 0.50 | 0.10 | 0.40 |
| 17. Computer -3341 | 0.34 | -0.47 | 1.13 |
| 18. Commun.-3342 + Aud/Vid-3343 | 0.60 | 0.16 | 0.24 |
| 19. Semicond./Electr.Component.-3344 | 0.76 | 0.07 | 0.18 |
| 20. M/Control-3345+Mag/opt media-3346 | 0.77 | 0.00 | 0.23 |
| 21. Electrical Eq.-335 | 0.71 | 0.11 | 0.18 |
| 22. Transport EQ.(Motor Veh.) | 1.60 | 0.39 | -0.99 |
| 23. Transport EQ.(Other) | 0.83 | 0.11 | 0.07 |
| 24. Furnitures-337 | 0.80 | 0.05 | 0.15 |
| 25. Misc. Manufact (Medical) | 0.51 | 0.21 | 0.28 |
| 26. Misc. Manufact (Others) | -0.26 | 0.62 | 0.64 |

Table 6: Decomposition of labor productivity growth: USA. Sales weight.

# 7 Appendix B

The following tables show the results by sector of random effect estimation of equation 2. We report the value of coefficients for each of the four productivity variables, the standard error (in parenthesis) and the level of significance (i.e., if the coefficient is significant at 1%, 5% or 10% confidence level). The last column of each table reports our measure of determination, calculated according to formula 3.

| NACE 1.1 | France | | | | |
| --- | --- | --- | --- | --- | --- |
| Sector | $\beta_p$ | $\beta_{Lp}$ | $\beta_{\bar{p}}$ | $\beta_{\bar{L}p}$ | $S^2_\beta$ |
| 0. Total Manufacture | 0.01(0.00)*** | -0.48(0.02)*** | 0.03(0.01)*** | 0.40(0.02)*** | 0.01 |
| 15. Food and beverage | 0.85(0.06)*** | -0.44(0.04)*** | 0.40(0.11)*** | -0.91(0.11)*** | 0.02 |
| 16. Tobacco | nan(nan). | nan(nan). | nan(nan). | nan(nan). | nan |
| 17. Textiles | 0.47(0.14)*** | -1.12(0.16)*** | 0.77(0.25)*** | -0.41(0.31). | 0.03 |
| 18. Wearing | 2.63(0.24)*** | -2.71(0.23)*** | 0.73(0.47). | -0.62(0.48). | 0.09 |
| 19. Leather | 4.39(0.64)*** | -5.88(0.60)*** | 2.37(1.07)** | -1.06(1.07). | 0.15 |
| 20. Wood products | 3.33(0.23)*** | -4.14(0.24)*** | -0.22(0.42). | 1.14(0.43)*** | 0.08 |
| 21. Pulp and paper | 3.38(0.43)*** | -2.66(0.37)*** | -0.02(0.73). | -0.65(0.70). | 0.06 |
| 22. Publishing and printing | 0.72(0.11)*** | -1.39(0.11)*** | 2.39(0.24)*** | -1.81(0.25)*** | 0.06 |
| 23. Coke and petroleum | 0.03(0.04). | -0.02(0.04). | 0.11(0.11). | -0.13(0.11). | 0.02 |
| 24. Chemicals(no pharma) | 0.11(0.03)*** | -0.11(0.04)*** | 0.09(0.06). | -0.08(0.06). | 0.01 |
| 244. Pharma | 0.07(0.03)** | -0.06(0.05). | 0.09(0.09). | -0.09(0.08). | 0.03 |
| 25. Rubber and plastic | 2.95(0.22)*** | -4.54(0.22)*** | 0.59(0.42). | 1.19(0.42)*** | 0.09 |
| 26. Non-metallic minerals | 1.50(0.16)*** | -1.46(0.16)*** | 1.43(0.32)*** | -1.52(0.32)*** | 0.04 |
| 27. Basic metals | 0.00(0.00). | -1.31(0.33)*** | 0.29(0.17)* | 0.64(0.51). | 0.01 |
| 28. Fabr. metal products | 2.11(0.08)*** | -3.28(0.10)*** | 1.32(0.18)*** | -0.57(0.21)*** | 0.08 |
| 29. Machinery and equipment | 3.91(0.21)*** | -4.08(0.19)*** | -2.35(0.26)*** | 2.35(0.27)*** | 0.07 |
| 30. Computers | 5.66(1.09)*** | -4.50(1.25)*** | 3.95(1.85)** | -5.91(2.15)*** | 0.24 |
| 31. Electrical machinery | 3.98(0.47)*** | -5.12(0.39)*** | 0.44(0.62). | 0.67(0.57). | 0.14 |
| 32. Television and communication | 3.47(0.40)*** | -4.66(0.38)*** | -0.66(0.82). | 1.88(0.80)** | 0.09 |
| 33. Medical instruments | 2.62(0.21)*** | -3.79(0.24)*** | 0.10(0.33). | 1.10(0.35)*** | 0.11 |
| 34. Motor vehicles | 2.75(0.26)*** | -2.96(0.26)*** | 1.36(0.73)* | -1.32(0.75)* | 0.09 |
| 35. Other transport equipment | 1.50(0.57)*** | -1.99(0.55)*** | 5.48(1.23)*** | -5.32(1.27)*** | 0.07 |
| 36. Furniture | 2.70(0.23)*** | -4.25(0.24)*** | 2.50(0.43)*** | -0.88(0.44)** | 0.11 |

Table 7: Random effect estimation. France

| NACE 1.1 | Germany | | | | |
| --- | --- | --- | --- | --- | --- |
| Sector | $\beta_p$ | $\beta_{Lp}$ | $\beta_{\bar{p}}$ | $\beta_{\bar{L}p}$ | $S^2_\beta$ |
| 0. Total Manufacture | 1.14(0.10)*** | -1.47(0.09)*** | -0.54(0.11)*** | 0.74(0.10)*** | 0.07 |
| 15. Food and beverage | 1.71(0.39)*** | -0.33(0.13)*** | -1.16(0.44)*** | -0.39(0.21)* | 0.06 |
| 16. Tobacco | -1.23(1.65). | 0.07(0.87). | 0.82(1.85). | 0.27(1.08). | 0.14 |
| 17. Textiles | 29.87(4.21)*** | -18.88(3.61)*** | -26.98(4.57)*** | 15.64(4.00)*** | 0.36 |
| 18. Wearing | 2.69(1.93). | -5.63(1.81)*** | 0.22(2.34). | 3.61(2.22). | 0.18 |
| 19. Leather | 2.80(2.98). | -3.12(1.45)** | 7.80(3.95)** | -9.82(2.89)*** | 0.59 |
| 20. Wood products | -2.90(4.84). | -24.25(3.38)*** | 17.20(5.24)*** | 8.40(4.00)** | 0.49 |
| 21. Pulp and paper | 1.34(0.77)* | -1.40(0.79)* | 2.84(1.06)*** | -4.43(1.28)*** | 0.27 |
| 22. Publishing and printing | -0.79(2.44). | -3.30(2.58). | 1.48(2.48). | 2.58(2.62). | 0.03 |
| 23. Coke and petroleum | 0.94(0.47)** | -1.28(0.37)*** | 1.44(0.86)* | -1.88(1.01)* | 0.34 |
| 24. Chemicals(no pharma) | 0.45(0.15)*** | -1.74(0.13)*** | 0.95(0.21)*** | 0.55(0.17)*** | 0.28 |
| 244. Pharma | 1.51(0.36)*** | -1.85(0.12)*** | 0.32(0.44). | 0.45(0.23)** | 0.51 |
| 25. Rubber and plastic | 3.07(0.98)*** | -1.09(0.55)** | -2.91(1.02)*** | 0.96(0.72). | 0.02 |
| 26. Non-metallic minerals | 4.63(1.50)*** | -3.01(0.92)*** | -0.46(1.67). | -1.45(1.25). | 0.13 |
| 27. Basic metals | 4.42(0.46)*** | -2.56(0.41)*** | -1.10(0.63)* | -0.93(0.69). | 0.29 |
| 28. Fabr. metal products | 1.92(0.55)*** | -2.78(0.57)*** | 0.91(0.68). | 0.39(0.67). | 0.10 |
| 29. Machinery and equipment | 0.51(0.20)*** | -1.96(0.33)*** | -0.19(0.20). | 1.58(0.33)*** | 0.05 |
| 30. Computers | -1.43(2.34). | -7.11(2.01)*** | 6.50(3.48)* | -0.03(2.96). | 0.37 |
| 31. Electrical machinery | 2.84(0.70)*** | -2.44(1.08)** | -1.72(0.76)** | 1.22(1.12). | 0.07 |
| 32. Television and communication | 2.41(0.64)*** | -5.61(1.18)*** | 0.65(0.85). | 2.02(1.36). | 0.24 |
| 33. Medical instruments | 5.41(1.03)*** | -3.36(0.82)*** | -1.48(1.23). | -0.86(1.10). | 0.22 |
| 34. Motor vehicles | 2.78(1.40)** | -4.14(1.63)** | 2.32(1.83). | -1.51(2.17). | 0.09 |
| 35. Other transport equipment | 1.00(1.34). | -0.74(1.65). | 3.50(1.84)* | -4.32(2.08)** | 0.19 |
| 36. Furniture | 4.71(0.76)*** | -2.03(1.30). | -0.52(1.31). | -2.39(1.79). | 0.18 |

Table 8: Random effect estimation. Germany

| NACE 1.1 | UK | | | | |
|---|---|---|---|---|---|
| Sector | $\beta_p$ | $\beta_{Lp}$ | $\beta_{\bar{p}}$ | $\beta_{\bar{L}p}$ | $S^2_\beta$ |
| 0. Total Manufacture | 0.08(0.01)*** | -0.27(0.03)*** | 0.50(0.06)*** | -0.41(0.08)*** | 0.01 |
| 15. Food and beverage | 1.48(0.18)*** | -0.88(0.16)*** | 1.11(0.52)** | -1.89(0.53)*** | 0.05 |
| 16. Tobacco | 0.10(0.12). | -0.08(0.12). | 4.88(7.20). | -4.90(7.12). | 0.08 |
| 17. Textiles | -0.37(0.49). | -0.73(0.47). | 17.87(1.41)*** | -17.49(1.45)*** | 0.21 |
| 18. Wearing | 2.02(0.71)*** | -4.34(0.88)*** | 1.62(1.44). | 1.22(1.42). | 0.07 |
| 19. Leather | 8.20(2.04)*** | -5.92(1.52)*** | -6.74(3.06)** | 5.07(2.62)* | 0.14 |
| 20. Wood products | 9.84(0.72)*** | -8.92(0.89)*** | 0.94(1.54). | -4.28(1.79)** | 0.34 |
| 21. Pulp and paper | 2.10(0.45)*** | -1.39(0.41)*** | 0.63(1.45). | -2.09(1.55). | 0.05 |
| 22. Publishing and printing | 5.27(0.51)*** | -1.94(0.48)*** | -2.32(0.63)*** | -2.52(0.77)*** | 0.10 |
| 23. Coke and petroleum | 0.60(0.30)** | -0.44(0.28). | 1.56(0.52)*** | -2.20(0.56)*** | 0.16 |
| 24. Chemicals(no pharma) | 0.02(0.01)* | -0.08(0.04)** | 0.06(0.07). | -0.00(0.09). | 0.00 |
| 244. Pharma | 0.10(0.15). | -0.15(0.07)** | 1.71(0.84)** | -1.87(0.93)** | 0.03 |
| 25. Rubber and plastic | 5.34(0.58)*** | -5.93(0.64)*** | -2.84(0.67)*** | 3.17(0.77)*** | 0.11 |
| 26. Non-metallic minerals | 1.73(0.32)*** | -3.97(0.48)*** | 3.55(1.29)*** | -2.53(1.59). | 0.10 |
| 27. Basic metals | 1.29(0.35)*** | -0.91(0.26)*** | 2.82(1.07)*** | -4.16(1.29)*** | 0.08 |
| 28. Fabr. metal products | 3.85(0.24)*** | -5.81(0.33)*** | -1.01(0.44)** | 2.66(0.55)*** | 0.10 |
| 29. Machinery and equipment | 1.52(0.20)*** | -2.08(0.24)*** | 3.19(0.75)*** | -3.27(0.89)*** | 0.06 |
| 30. Computers | 5.19(1.25)*** | -1.39(0.79)* | -5.58(1.93)*** | 2.29(1.56). | 0.04 |
| 31. Electrical machinery | 6.40(0.56)*** | -7.13(0.60)*** | 2.88(1.24)** | -3.39(1.38)** | 0.16 |
| 32. Television and communication | 4.24(0.54)*** | -5.36(0.72)*** | -3.61(0.70)*** | 4.58(0.91)*** | 0.08 |
| 33. Medical instruments | 6.18(0.57)*** | -3.46(0.53)*** | -0.37(1.18). | -2.73(1.21)** | 0.12 |
| 34. Motor vehicles | 4.33(1.56)*** | -5.97(1.17)*** | 0.92(2.29). | 1.06(2.13). | 0.06 |
| 35. Other transport equipment | 0.85(0.46)* | -3.05(0.47)*** | 5.27(1.09)*** | -3.81(1.26)*** | 0.12 |
| 36. Furniture | 0.64(0.12)*** | -0.83(0.11)*** | 2.95(0.52)*** | -2.78(0.54)*** | 0.04 |

Table 9: Random effect estimation. UK

| NAICS | USA | | | | |
|---|---|---|---|---|---|
| Sector | $\beta_p$ | $\beta_{Lp}$ | $\beta_{\bar{p}}$ | $\beta_{\bar{L}p}$ | $S^2_\beta$ |
| 0. Total Manufacture - 3 | 0.34(0.03)*** | -0.26(0.04)*** | 1.43(0.19)*** | -0.72(0.21)*** | 0.02 |
| 1. Food and Beverages-311+312 | 2.60(0.52)*** | -2.66(0.56)*** | 0.27(1.14). | 0.24(1.37). | 0.03 |
| 2. Tobacco-3122 | nan(nan). | nan(nan). | nan(nan). | nan(nan). | nan |
| 3. Textiles-313+314 | 4.06(3.32). | -15.14(3.30)*** | 3.12(16.47). | 10.73(16.75). | 0.14 |
| 4. Appareal-315 | 6.19(1.54)*** | 2.00(1.74). | 14.00(6.49)** | -12.17(6.20)** | 0.20 |
| 5. Leather and Footwear-316 | 8.90(0.94)*** | -5.18(1.01)*** | -4.40(5.27). | 3.02(4.93). | 0.32 |
| 6. Wood-321 | 11.10(2.95)*** | -4.63(2.87). | 11.05(14.99). | -15.76(15.99). | 0.07 |
| 7. Paper-322 | 3.56(0.74)*** | -4.69(0.91)*** | -1.08(3.55). | 2.72(3.94). | 0.09 |
| 8. Printing-323 | nan(nan). | nan(nan). | nan(nan). | nan(nan). | nan |
| 9. Petroleum and Coal-324 | 0.83(0.19)*** | -0.87(0.23)*** | -1.95(0.79)** | 2.09(0.89)** | 0.04 |
| 10. Chemical (no Pharma)-325 | -0.06(0.04). | -0.15(0.04)*** | 0.66(0.60). | -0.52(0.54). | 0.01 |
| 11. Pharma-3254 | 1.52(0.30)*** | -2.20(0.36)*** | 1.96(1.05)* | -0.78(0.96). | 0.05 |
| 12. Plastic and Rubber-326 | 5.77(1.71)*** | -6.16(1.70)*** | 8.95(4.85)* | -7.67(4.76). | 0.08 |
| 13. Non-Metal Minerals-327 | 5.21(1.21)*** | -5.03(1.45)*** | -6.01(4.17). | 5.75(4.12). | 0.05 |
| 14. Metals-331 | 5.47(0.67)*** | -7.17(0.70)*** | 5.18(2.61)** | -2.91(2.69). | 0.14 |
| 15. Fabr. Metal Products-332 | 5.97(1.06)*** | -8.16(1.49)*** | -5.37(2.92)* | 7.17(3.78)* | 0.03 |
| 16. Machinery Manuf.-333 | 14.03(0.60)*** | -9.06(0.58)*** | -0.06(1.89). | -2.14(1.96). | 0.19 |
| 17. Computer -3341 | 6.46(0.81)*** | -1.21(0.63)* | 2.67(1.24)** | -2.95(1.15)*** | 0.23 |
| 18. Commun.-3342 + Aud/Vid-3343 | 4.28(0.37)*** | -2.64(0.38)*** | 2.35(1.05)** | -1.36(1.29). | 0.13 |
| 19. Semicond./Electr.Component.-3344 | 0.52(0.09)*** | -1.95(0.27)*** | -0.29(0.28). | 3.49(0.53)*** | 0.07 |
| 20. M/Control-3345+Mag/opt media-3346 | 6.98(0.33)*** | -5.27(0.34)*** | 1.18(1.35). | -1.56(1.45). | 0.18 |
| 21. Electrical Eq.-335 | 6.68(0.93)*** | -2.58(0.90)*** | 0.44(4.26). | -3.85(4.54). | 0.05 |
| 22. Transport EQ.(Motor Veh.) | 23.58(3.58)*** | -14.35(3.83)*** | -6.98(11.63). | -0.03(11.84). | 0.14 |
| 23. Transport EQ.(Other) | 1.63(0.68)** | -1.17(0.47)** | 0.14(1.87). | 0.43(1.04). | 0.02 |
| 24. Furnitures-337 | 9.43(3.00)*** | -0.79(3.24). | 2.69(11.16). | -4.91(12.05). | 0.08 |
| 25. Misc. Manufact (Medical) | 6.34(0.58)*** | -5.04(0.54)*** | -0.97(2.80). | 2.36(2.64). | 0.11 |
| 26. Misc. Manufact (Others) | 3.38(0.63)*** | -2.48(0.61)*** | 5.73(1.90)*** | -3.11(1.64)* | 0.10 |

Table 10: Random effect estimation. USA

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