The Sources of Productivity Growth: Micro-level Evidence for the OECD

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Introduction

It is now well acknowledged that productivity can grow in two ways (see e.g. Bartelsman and Doms (2000) and Foster, Haltiwanger and Krizan (1998)). First, productivity can grow due to changes within existing enterprises, such as the introduction of new technology and organisational change. Second, productivity can grow due to the process of market selection whereby low productivity establishments exit and are replaced by higher productivity entrants, while higher productivity incumbents gain market share. This note reports some cross-country evidence on these two effects. It summarises the work done in a number of countries under the auspices of the OECD Firm-Level Study co-ordinated by Eric Bartelsman[2].

Method

Write sector-wide productivity in year t, P_t as

$$P_t = \sum_i q_{it} p_{it} \tag{1}$$

where q_i is the employment share of establishment i and P_t and p_{it} are a productivity measure (which may be labour or TFP). The decomposition proposed by Foster, Haltiwanger and Krizan (1998) (FHK) [3] is in terms of productivity relative to the average:

$$\Delta P_t = \sum_{i\in S} q_{it-k} \Delta p_{it} + \sum_{i\in S} \Delta q_{it} (p_{it-k} - P_{t-k}) + \sum_{i\in S} \Delta q_{it} \Delta p_{it} + \sum_{i\in N} q_{it} (p_{it} - P_{t-k}) - \sum_{i\in X} q_{it-k} (p_{it-k} - P_{t-k}) \quad FHK\ (2)$$

where S, N and X denotes the establishments that survive, enter and exit respectively between t and t-k. The first term shows the contribution to DP of growth within the surviving establishments; the "within" effect. The second term shows the contribution of changes in shares of the survivors weighted by final period productivity relative to the average (often termed the "between" effect). It is positive when market shares increase for those survivors with above-average base year productivity. The third term is a covariance term that is positive when market share increases (falls) for establishments with growing

[1] This paper uses research databases and methodology. As such some numbers may differ from published statistics. The published statistics should be used where available. This paper is based on Barnes, Haskel and Maliranta (2002) (BHM) which provides more extensive analysis including alternative methodologies.

[2] Bartelsman, Scarpetta, and Schivardi (2001) summarise the demographics and survival analysis components of the project and OECD (2000, 2001) gives more details about the project and the OECD's broader "Sources of Growth" project of which the Firm Level Study is a part.

[3] Bartelsman and Doms (2000) also use this equation but date the exitors productivity in t; this appears to be a typo.

(falling) productivity. The entry and exit terms are positive when there is entry (exit) of above- (below-) average productivity establishments[4].

There are four different ways to calculate *P*. First, *P* is real output per head (Q/*L*). We do not have satisfactory cross-country data on industry hours. *L* is calculated as employment, where we cannot distinguish between part and full time. Second, P is calculated as real value added per head (V/L). Third, where data are available, *P* is calculated as *TFP*. *TFP* is the change in value added less the share weighted changes in capital and labour inputs. Fourth, we calculate P as *MFP*. Where *MFP* is the change in gross output less the share weighted changes in materials, capital and labour inputs. The changes are calculated at the micro level. To increase comparability, the shares are the average shares of industry costs (industry shares are used to avoid measurement error) across OECD countries that are participating in the project. The industry cost of capital is calculated as the residual from labour and material costs[5].

How would we expect the components of (2) to vary? Over time, FHK (for the US) and Disney, Haskel and Heden (DHH) (2000) for the UK both find evidence that the net entry rises in recessions (as the marginal entrant is a good plant) and falls in booms, with the within effect the reverse.

Of particular interest in the current setting is how one might expect (2) to vary across countries. Let us start by supposing that in the absence of institutions there is potentially an equal distribution of productivity across every nation (including productivity of potential plants). Suppose then that the EU has high wage floors as a result of high minimum wages and high benefits. This is clearly too crude since there are substantial differences across the EU, but we maintain this fiction for illustration. Then we would expect the US to have a long tail of unproductive plants which are not observed in Europe.[6] Regarding *entry*, entering plants in Europe would have higher *p* than entering plants in the in the US. Other things equal this would raise the entry effect in Europe. But there would be fewer entrants. If all firms had equal market shares, this would lower the entry effect, but if the firms who are more productive have higher market shares this which attenuate this second effect. Thus overall is it ambiguous, but one might expect the EU to have a higher entry effect. Looking at (2), for example, $\Sigma_N\ \theta(p-P)$ might even be positive since only very good firms with p>P could enter in Europe. In the US poor firms can enter, and so p<P, rendering $\Sigma_N\ \theta(p-P)$ potentially negative.

Turning to the *exit* effect, exiting plants in Europe would have higher *p* than exiting plants in the US. If we expect p<P for exiting plants then p-P for the US would be a large (in absolute value) negative number as only the very poorest firms exit. In Europe it would be closer to zero, perhaps even positive. Thus the exit effect in Europe would be lower. Against this however, there would be more exitors in Europe which would raise the European exit effect in absolute number. In sum, the prediction is ambiguous, but if the second effect is small we would expect Europe to have a lower entry effect i.e. either positive or negative but small in absolute value.

In the above example a floor is placed on wages with the rest of the distribution unaffected. The other possible effect of more labour market regulation, unions, taxes etc. is that European wage levels are raised relative to what they might have been. This would cause firms to substitute capital for labour. Thus plants would be more capital intensive in Europe, which would raise labour productivity. The effect on productivity relative to the average is hard to sign.

Data

Our objective is to undertake decompositions for as many countries, periods and industries as possible. Table 1 below shows countries, years and broad industries for which we have usable data and some brief comments on features of the data, to which we return below. In all cases data are for manufacturing.

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[4] As FHK point out however, problems might occur with measurement error. Alternative decomposition methodologies attempt to overcome such problems, see for example Griliches and Regev (1992).

[5] TFP and MFP analysis can be found in BHM, but are excluded from this paper.

[6] This would suggest that P is higher in Europe, which seems not to be true (O'Mahony (1996)). One possibility is that countries have very different distributions, which makes cross country predictions of the entry and exit effects very difficult. The other is that countries have the same distribution, but the mean is shifted by country-specific factors (culture etc.). Further study of this awaits more usable data on productivity distributions.

Table 1: Summary of the data used for productivity decompositions

Country	Periods		Productivity				Unit	Method	Threshold
	First	*Last*	*LPQ*	*LPV*	*TFP*	*MFP*			
Finland	75-80	89-94	✓	✓	✓	✓	F	C	Emp > 5
France	85-90	90-95	✓	✓	✓	✓	F	R	Turnover €0.58m
Netherlands	83-88	92-97	✓	✓	✓	✓	F	S	Emp>20, Emp<20→S
UK	80-85	87-92	✓	✓	✓	✓	F	S+R (PW)	Emp>100/250
	80-85	94-99	✓	✓	×	×	F	S+R (PW)	Emp<100/250→S
USA	87-92 & 92-97		✓	✓	✓	✓	P & F	C	Emp > 1

Source: Barnes, Haskel and Maliranta (2002)
Note: Key to Unit column: F: Firm, P: Plant. European 'firm' data means business reporting units as defined by Eurostat. US plant data is used as being closest to this. Key to Method column: C: Census, R: Register, S: Sample, (PW): Population weighted. Most countries impose some restriction on the size of firm/plant that is included in their data. LPQ is labour productivity using gross output, LPV is labour productivity using value added, TFP includes labour and capital inputs, and MFP includes labour, capital and materials.

The approach is to carry out FHK decompositions as described in (2) for 5 year rolling periods for all periods that are available for a particular country. Thus column 2 shows the first and last 5 year periods available. The priority is to look at labour productivity in all available sectors. Primarily this means manufacturing, which has also been broken down according to the OECD's STAN 2000 classification. As columns 5 and 6 show, for some countries we have TFP which subtracts off labour and capital inputs and for some MFP which additionally subtracts off materials.

For the results to be credible the data and calculations have to be comparable. We comment on the data below. Regarding the calculations, code was written by the current authors and then circulated to all countries. Thus all countries ran the same code (harmonised in both SAS and Stata). We tried to standardise the data in a number of ways in the code. First, we ensured that the data was cleaned in a consistent way to deal with missing or spurious observations. Second, a simple OLS regression was run of the inputs on the output variable and the top and bottom percentile of the residuals of that regression were dropped to ensure any extreme outliers were removed. Third, data were weighted by each country using sample-based data, where possible, to try to ensure results were representative of the population. Where possible information on the population was also used to ensure entries and exits due to sampling were eliminated.

Results: Comparison of shares

Table 2 presents results for FHK decompositions of manufacturing labour productivity for the participating countries. The results are for 1987-92 which is the most recent 5 year interval that maximises coverage across countries.

Table 2: Labour productivity (gross output) decompositions, Manufacturing, 1987-1992

Country	Prod Growth	Within	Between	Cross	Net Entry	Entry	Exit
Finland	5.6	51	20	2	27	6	-20
France	2.4	95	7	-10	8	-1	-9
Netherlands	2.5	88	16	-24	20	47	27
UK	2.7	63	22	-11	26	10	-16
USA	1.8	90	26	-36	21	-25	-46

Source: Barnes, Haskel and Maliranta (2002).
Note: The productivity growth rate quoted is the average over a five-year period. Method used is FHK (see equation (2)) with a five-year rolling window (see text for details). Manufacturing is defined as the 2-digit ISIC (rev. 3) sectors 15 to 37. All values in the remaining columns are per cent of total change in column 2. Net entry = entry - exit: Figures may not add up due to rounding.

The table reads as follows. The top row shows the data from Finland. Reading across the table, column 2 in the first row shows that labour productivity growth over this period was on average 5.6% per year[7]. The next cell shows the fraction of that productivity growth due to growth "within" firms, in this case 51%. The next cells show that 20% is due to the between effect, 2% due to the cross effect and 27% due to the net entry effect. Columns 7 and 8 then subdivide the net entry effect into the impact from entry, in this case 6% and that of exit, here –20%. Note that the net entry effect is column 7 *minus* column 8. Thus if column 7 (8) is negative, this signifies that productivity in the entering (exiting) plants is below average. So, if plants who exit are below average productivity, we expect column 8 to be negative.

Table 2 suggests the following. First, the within effect is substantial across countries, accounting for not less than 51% of productivity growth (Finland) and 95% in France. Second, net entry is about a quarter of productivity growth in Finland, Netherlands, the UK and the US. Third, the effects of entry are generally positive, suggesting that entering firms achieve higher productivity than the base year average in all countries bar France and the US. The exit effect is generally negative, suggesting that plants exit with lower productivity than the average in all countries. Finally, the cross term is generally negative, consistent with the FHK findings for the US. Since the weight is employment, this suggests that much of the productivity growth was occurring in plants that were downsizing.

Before drawing any strong conclusions however, we must be sure that these results reflect underlying economic differences and not just data problems. Starting with Finland, the data is based on a Census and entry and exit is for establishments with at least 5 persons. Thus we expect it to be reasonably representative of the population. The French data is a register, and is at the firm level where firms have to have at least 20 employees or more than €0.58m turnover. The employment data from the sample is well below the official employment data and so the sample is not likely to be representative of the population. We would also expect larger firms to be oversampled which would likely lower the net entry effect and raise the within effect. This appears to be the case. Since the data are at firm level then entry and exit of plants will be understated if occurring within multi-plant firms, but overstated if a merger is counted as an exit. The Netherlands data are based on a census of firms with over 20 persons plus a sample for under 20. The UK data are similar to the Netherlands, with partial sampling of smaller firms[8], but weighting to try to overcome this. Finally, the US data is a census at the establishment (or plant) level.

Overall then, we would expect the data for Finland, Netherlands, UK and USA to be fairly comparable, but that it is somewhat harder to compare these with France. Thus the very high within effect in France is likely to be due to the substantial overrepresentation of large firms. Comparing Finland, Netherlands, UK and USA therefore we see that the USA has the highest within effect, and the Finland the lowest.

An important feature of the data worth noting are the entry and exit effects. Leaving aside France, who have the data problems set out above, the US is notable in having the only negative entry effect,

[7] These productivity changes do not all accord well with "official" OECD data, likely due to numerous methodological differences. In particular the deflation method used and the definition of output (gross output versus value added). Further differences may occur due to aggregation and population weighting issues. This needs further investigation.

[8] In EU countries 'firm' level data generally means data at the business reporting unit level.

suggesting that US establishments who enter become, on average, low productivity[9]. This is in contrast to the other countries who show a positive entry effect, suggesting that these entrants become above average productivity establishments. This is in line with the argument set out above, namely that poor productivity firms can enter in the US but not in the EU. The exit effects are also interesting, with (again ignoring France) the US having a very high (in absolute terms) exit effect (-46 in the table). This suggests that the exiting plants in the US are very much less productive than those in the EU. Interestingly then, the net entry effects do not look very different across countries, but the underlying entry and exit patterns do differ.

Following from this, we know that the within component rises in booms whilst the net entry effect falls in recessions (see FHK for the US, and Maliranta (2001) for Finland on this). Thus the results in Table 2 might be due to the fact that different economies are in different cyclical periods. We therefore recomputed the results for 1985-90 which was, for almost all economies, an upturn. These results are set out in table 3, where due to data availability we are unable to perform a 1985-90 decomposition for the US. The numbers are somewhat different with a generally higher within component confirming pervious findings. Interestingly however the inter-country rankings are hardly changed. Thus for example the Netherlands, who had the second ranked within component in the 1987-92 decompositions have the second ranked in the 1985-90 decompositions.

Table 3: Labour productivity (gross output) decompositions, Manufacturing, 1985-1990

Country	Prod Growth	Within	Between	Cross	Net Entry	Entry	Exit
Finland	6.5	66	9	0	25	6	-19
France	3.5	88	3	-5	14	1	-13
Netherlands	2.3	70	2	-1	29	47	18
UK	3.5	77	6	-7	24	8	-16

Source: Barnes, Haskel and Maliranta (2002).
Note: The productivity growth rate quoted is the average over a five-year period. Method used is FHK (see equation (2)) with a five-year rolling window (see text for details). Manufacturing is defined as the 2-digit ISIC (rev. 3) sectors 15 to 37. All values in the remaining columns are per cent of total change in column 2. Net entry = entry - exit: Figures may not add up due to rounding.

Table 4 shows the equivalent results to table 2 using the value-added per head definition of labour productivity. Generally the results are very similar and again the French data seem to give some difficulties.

Table 4: Labour productivity (value added) decompositions, Manufacturing, 1987-1992

Country	Prod Growth	Within	Between	Cross	Net Entry	Entry	Exit
Finland	5.7	55	19	1	26	7	-19
France	0.6	121	16	-24	-14	-81	-67
Netherlands	1.8	72	15	-17	30	50	20
UK	1.6	60	12	-3	31	-9	-40
USA	1.4	85	26	-46	34	-29	-64

Source: Barnes, Haskel and Maliranta (2002).
Note: The productivity growth rate quoted is the average over a five-year period. Method used is FHK (see equation (2)) with a five-year rolling window (see text for details). Manufacturing is defined as the 2-digit ISIC (rev. 3) sectors 15 to 37. All values in the remaining columns are per cent of total change in column 2. Net entry = entry - exit: Figures may not add up due to rounding.

Table 5 shows the results for a more recent 5 year split, 1992-97. Data for this period are only available for Netherlands, UK and the USA. Within effects are generally somewhat higher than for the earlier period. Note again the US has the biggest negative entry and exit effects.

[9] They could have higher than average productivity but some high market share firms might have lower than average rendering the overall effect negative; we examine this by looking at each industry below.

Table 5: Labour productivity (gross output) decompositions, Manufacturing, 1992-1997

Country	Prod Growth	Within	Between	Cross	Net Entry	Entry	Exit
Netherlands	4.4	75	0	-11	35	28	-7
UK	3.3	83	0	-11	28	13	-15
USA	3.1	97	7	-21	17	-9	-26

Source: Barnes, Haskel and Maliranta (2002).
Note: The productivity growth rate quoted is the average over a five-year period. Method used is FHK (see equation (2)) with a five-year rolling window (see text for details). Manufacturing is defined as the 2-digit ISIC (rev. 3) sectors 15 to 37. All values in the remaining columns are per cent of total change in column 2. Net entry = entry - exit: Figures may not add up due to rounding.

Turning to individual industries, Tables 6 and 7 show data for the Textiles and Electrical Engineering sectors respectively. One has to be more careful here since some sectors can be very small in some countries and hence data error or entry or exit of only a few firms can have a very large impact. In textiles, leaving again France aside, the US is notable for the highest negative entry and negative exit effect. In Electrical engineering (Table 7) the US has a positive entry effect however.

Table 6: Labour productivity (gross output) decompositions, Textiles, Textile Products, Leather & Footwear, 1987-1992

Country	Prod Growth	Within	Between	Cross	Net Entry	Entry	Exit
Finland	3.3	0	42	2	56	6	-50
France	1.8	95	29	-16	-8	-37	-29
Netherlands	2.7	63	45	-32	24	36	12
UK	3.0	56	13	3	28	5	-24
USA	1.7	71	51	-39	17	-57	-74

Source: Barnes, Haskel and Maliranta (2002).
Note: The productivity growth rate quoted is the average over a five-year period. Method used is FHK (see equation (2)) with a five-year rolling window (see text for details). Textiles, Textile Products, Leather & Footwear is defined as the 2-digit ISIC (rev. 3) sectors 17 to 19. All values in columns 3 through 8 (7 in b) are per cent of total change in column 2. Net entry = entry - exit: Figures may not add up due to rounding.

Table 7: Labour productivity (gross output) decompositions, Electrical and Optical Equipment, 1987-1992

Country	Prod Growth	Within	Between	Cross	Net Entry	Entry	Exit
Finland	9.1	53	5	20	22	16	-5
France	2.6	88	-3	5	10	13	4
Netherlands	4.5	135	-6	-32	2	4	2
UK	5.3	49	28	-3	26	27	1
USA	5.4	88	9	-13	16	12	-4

Source: Barnes, Haskel and Maliranta (2002).
Note: The productivity growth rate quoted is the average over a five-year period. Method used is FHK (see equation (2)) with a five-year rolling window (see text for details). Electrical and Optical Equipment is defined as the 2-digit ISIC (rev. 3) sectors 30 to 33. All values in columns 3 through 8 (7 in b) are per cent of total change in column 2. Net entry = entry - exit: Figures may not add up due to rounding.

We investigated the entry and exit effects further in a number of ways. First, to explore the US negative entry and exit effect more, we used the within country decompositions by STAN and calculated the percentage of the industries in each country which had a negative entry and exit effect. As Table 8 shows this was the highest in the US. Thus we can be reasonably confident that the large negative US entry and exit figures are indicative of underlying economic behaviour.

Table 8: Proportion of STAN sectors with negative entry and exit

Country	% Entry < 0	% Exit < 0
Finland	23.1	81.5
France	32.6	63.9
Netherlands	10.5	58.9
UK	19.2	79.7
USA	66.7	90.9

Source: Barnes, Haskel and Maliranta (2002).
Note: STAN sectors includes both aggregated and bottom level industries/groups of industries. Data for all years for which results are available for each country.

It seems likely that the entry and exit terms are in some way related to the institutional environment in each country. For example, in the USA it is generally thought to be much easier to both enter and exit from the market which is born out by the large proportion of negative exit and especially entry terms in the US. To examine such relationships relies on data on institutions being available. However, data that shows changes in policies over time and refers to appropriate time periods is hard to obtain and in future work we hope to explore whether such data correlates with the entry and exit effects.

Conclusions

We document the decomposition of productivity growth in OECD member states using the early data from the OECD Firm Level Study. Our results suggest important roles for within and net entry effects in most countries and that relative to the US, countries typically have exitors who are more productive than average, but entrants who are also more productive than average.

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