Restructuring and Productivity Growth in UK Manufacturing*

Richard Disney
University of Nottingham and Institute for Fiscal Studies

Jonathan Haskel
Queen Mary and Westfield College and CEPR

Ylva Heden
Queen Mary and Westfield College

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Abstract

We analyse productivity growth in UK manufacturing 1980-92 using the newly available ARD panel of establishments drawn from the Census of Production. We examine the relative importance of 'internal' restructuring (such as new technology and organisational change) and 'external' restructuring (the process by which less efficient establishments exit and more efficient establishments enter and increase market share). We find that (a) 'external restructuring' accounts for 50% of labour productivity growth and 90% of *TFP* growth over the period; (b) much of the external restructuring effect comes from multi-establishment firms closing down poorly-performing plants and opening high-performing new ones, and (c) external competition is an important determinant of internal restructuring.

*Contact address: Jonathan Haskel, Department of Economics, Queen Mary and Westfield College, University of London, Mile End Rd, London E1 4NS, England; <j.e.haskel@qmw.ac.uk>, <www.qmw.ac.uk/~ugte153/>. For financial support we thank the U.K. Economic and Social Research Council for grants R000236653 and R000222730. Thanks also to Rachel Griffith, Richard Harris, Nick Oulton, Helen Simpson and staff at ONS for help in preparing the data and to Gavin Cameron, Francis Kramarz, Alan Manning, Steve Nickell, John van Reenen, Don Siegel, Jon Temple and seminar participants at the Bank of England, Cardiff Business School, CEPR, the Department of Trade and Industry, the Institute for Fiscal Studies, Leeds Business School, the London School of Economics, the University of Nottingham, and the Treasury for helpful comments on earlier drafts. Errors are our own.

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> *"We find ... a positive effect of competition on … total factor productivity at the firm level… It is worth entertaining the thought that we are barking up the wrong tree. Perhaps competition works not by forcing efficiency on individual firms but by letting many flowers bloom and ensuring only the best survive..."* (Nickell, 1996, p. 741).

1. Introduction

This paper examines the impact of restructuring on UK manufacturing productivity growth in the 1980s and early 1990s. It argues that restructuring can raise overall productivity in two ways. First, productivity can grow due to changes within existing enterprises, such as the introduction of new technology and organisational change. For convenience, we call this *internal* restructuring. Most micro-level productivity studies emphasise this mechanism focussing, for example, on the contribution of downsizing (Oulton, 1999), new technology and organisational change (Gregg, Machin and Metcalf, 1993, Haskel and Szymanski, 1997) and increased competition (Blanchflower and Machin, 1996, Nickell, Wadhwani and Wall, 1992, Nickell, 1996).

The second source of productivity growth is the process of market selection whereby low productivity establishments exit and are replaced by higher productivity entrants, while higher productivity incumbents gain market share. We call this process *external* restructuring. Despite a number of theoretical papers on the issue[1], hard evidence on *external* restructuring is difficult to come by because it requires representative longitudinal data on survivors, entrants and exitors. Such data are available in only a few countries, notably the United States (see e.g. Caves, 1998 and Bartelsman and Doms, 2000, for references).[2]

This paper presents evidence on both types of restructuring for the UK using the newly released ARD data set drawn from the *Census of Production*. The database is an unbalanced panel with around 140,000 manufacturing establishments per year, 1980-1992, in which we can identify entry, exit and survival. Since it is based on the *Census*, this is the most comprehensive UK manufacturing data set available[3].

With these data we have three main objectives. First, we measure the contributions of external and internal restructuring to productivity growth. We decompose productivity growth into the parts attributable to growth within surviving establishments and that due to external restructuring,

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[1] In Jovanovic (1982) for example entrants learn about their own productivity over time and grow if they are successful or exit if they are not. See also Cabral (1993), Hopehayn (1992) and Pakes and Ericson (1999). Although selection of this kind might seem intrinsic to the functioning of markets, specific models are needed to explain, for example, why market processes permit a flow of new entrants rather than simply leading to the domination of a market by a few highly successful businesses.

[2] There are some studies of selected industries e.g. US telecommunications (Olley and Pakes, 1996) and UK steel castings (Baden-Fuller, 1989).

[3] For other work that uses the ARD see Griffith (1999), Harris and Drinkwater (1999), and Oulton (1997, 1999).

the latter consisting of the net effects of entry, exit and changes in market shares of survivors. We calculate both labour and total factor productivity growth and use different decomposition methods to check our results. Our main finding is that for 1980-92, external restructuring accounts for around 50% of labour productivity growth and 90% of *TFP* growth.

Second, we extend the US literature and examine what turns out to be an empirically important issue, namely the role of multi-establishment firms. Around 75% of manufacturing employment is in establishments which are part of a larger firm. The contribution of entry and exit therefore consists of entry and exit by single establishment firms and entry and exit due to multi-establishment firms closing down or opening up new establishments. Our main finding here is striking. Between 1980 and 1992, surviving single-establishment firms had almost zero productivity growth. All of the productivity gains among single establishments came from the entry of more efficient establishments and the exit of less efficient ones. Among multi-establishment firms, about half of their productivity growth was due to differential productivity growth among survivors, whilst the other half was due to the closure of low productivity establishments and the opening of higher productivity ones. Thus much of the overall net entry effect consists of entry and exit within firms.

Third, whilst external restructuring contributes to productivity growth in this *accounting* sense, it may also contribute in a *behavioural* sense if, for example, entry and exit or changes in market shares are part of the competitive pressure that raises productivity growth among survivors. In this case the accounting contribution is a lower bound on the overall contribution. Furthermore, since many studies of productivity growth are based on balanced panels (or panels where firms are present for some minimum period of time), such results will be vulnerable to selection bias which might bias the link between competition and productivity. Thus our third objective is to examine the contribution of these external effects to survivor productivity growth controlling for selection. We regress establishment productivity growth on external market conditions, controlling for inputs, industry effects and selection. The results show that competition raises productivity levels and growth, so confirming the link between productivity efficiency and competition described by Nickell (1996) for a smaller sample of large establishments.

Whilst these are our major objectives we also provide evidence on a number of other interesting questions. First, how does the importance of UK restructuring compare with that in the US? Second, what is the mechanism by which restructuring contributes to productivity growth? Are entrants more productive or exitors less productive, for example? Third, how does the contribution of restructuring vary over the cycle? Are recessions periods of higher restructuring and booms of less?

Oulton (1999) is the only paper, that we are aware of, that looks at the accounting contribution of restructuring to UK labour productivity growth (he also studies downsizing). In this paper we go beyond his by (a) computing *TFP*, (b) using a number of different types of decompositions, (c) using a more accurate measure of entry and exit and (d) differentiating between multi- and single-establishment firms. For the contribution of external restructuring to internal productivity growth our work here is most closely related to Nickell (1996). He looked at the influence of changes in competition on productivity growth for an unbalanced panel of 147 firms, 1975-86 (835 observations), most of which were large. He did not examine selection. Our *Census* data enables us to look at a much larger sample (we have about 14,000 establishments per year, around 60,000 observations), to check for selection, to compute more preferable measures of productivity (e.g. using output rather than sales), to control for some inputs Nickell had no data on, e.g. skill (although we do not have his detailed union data) and to look at more measures of competition.[4]

The structure of the paper is as follows. Section 2 describes the data and measures of labour productivity and *TFP*. Section 3 sets out the data on productivity of entrants, exitors and survivors by time and cohort. Section 4 presents the decompositions and section 5 looks at the role of external pressures on *TFP* and productivity growth within surviving establishments. Section 6 summarises.

2. Data

2A The ARD data set

Details of the ARD data can be found in Griffith (1999), Oulton (1997), Haskel and Heden (1999). Here we briefly set out the main features of the data, and then concentrate on the problems involved in calculating *TFP* and entry and exit. More details are in the Data Appendix.

The ARD (*A*nnual Census of Production *R*espondents *D*atabase) is the micro-data underlying the industry-level aggregates published annually in the *UK Census of Production, Summary Volume*. The micro data is based on a register of businesses. Each record on the register can be thought of as an address, called a "local unit". There are then three categories that an address/local unit potentially falls into. A local unit may be deemed too small to provide reliable information on the full Census questionnaire (for example a sub-division of a firm whose purchasing etc. is handled by a central office). Alternatively, it may be large enough to provide information, in which case it is termed an "establishment". Finally, it may be a head office responsible for one or more establishments under common ownership or control, and so is called an "enterprise group" (we call this a firm). The statistical authorities then assign three unique identification numbers to each address, identifying its status as local unit, establishment and enterprise group.[5]

Our fundamental unit of analysis will be the establishment, since that is the lowest level of aggregation for which we have the information to calculate labour productivity and *TFP* (see below). Our focus is therefore on the establishment identity number. If between Censuses a new

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[4] Other micro-level work for other countries has performed decompositions (see e.g. Haltiwanger (1997) and Foster et al (1998) for the US, Levinsohn and Petrin (1999) and Pavcnik (1998) for Chile or Aw et al (1999) for Taiwan). We are not aware of any studies of the competition/productivity link that control for selection.

[5] For example, two establishments owned by the same firm will have separate local unit and establishment numbers but the same enterprise group number.

establishment reference number appears, we count this as entry. If one disappears we count this as exit. If the number survives, this is survival. This procedure raises a number of issues of interpretation. First, there are a number of reasons why reference numbers may appear and disappear. If an establishment shuts down (for a year or more) and then reopens in a different location, then they are given a new establishment number and so count as an entrant. We are unaware of how many establishments do this. Second, identification numbers might also change due to data error. We therefore dropped any establishment that disappeared for one or more periods and then reappeared with the *same* reference number, which, under the sampling rules, is due to data error (this occurred in very few establishments). Third, if there is a merger or take-over, the establishment number stays the same, but the enterprise group number changes. Thus we can identify take-overs, but these will not count as entry and exit in our scheme (we look at changes in ownership in Section 5). We can of course distinguish between establishments that exit or enter but are part of a firm, and those that are independently owned.

Finally, identification of entry, exit and survivorship is complicated by the sampling method used by the Census. All establishments with employment over a certain size (generally 100 employees) have to complete a full Census form. Smaller establishments are sampled (with the sampling rules changing every so often, Oulton, 1997).[6] Sampled establishments report full census information on themselves if sufficiently large, and in addition must give information on employment and investment at local unit level if appropriate. For each year, the ARD consists of two files. The selected file holds data on all establishments that were then sent a Census form. The non-selected file holds data on the rest of the establishments giving their industrial classification, postcode, reported employment (if they are local units being reported on by a sampled establishment) and imputed employment (based on register information such as turnover if they are not).[7]

Because of this sampling method, entry and exit to the selected data is due in part to establishments being sampled or not. Hence we have to use the both the selected and non-selected data to calculate entry and exit correctly. Oulton (1999) uses only the selected data in calculating the contribution of entry and exit to productivity and as he acknowledges, this may induce an error. In addition, the data on employment for the non-selected sample are missing from the computer files for the 1970s. So we can calculate the numbers of entrants/exits for this period but not labour productivity or *TFP*.

Table 1 shows some basic data. To construct this table we merged the selected and non-selected data for each year 1986-92 (since the calculations of entry and exit in the early 1980s is complicated by changes to the sampling frame) and computed the number of establishments which at any stage entered or exited. The table shows annual averages. As column 1 shows, on average each

[6] For example, in 1986 and 1988, 50% (25%) of units with employment between 50-100 (20-50) were sampled.
[7] The non-selected establishments are overwhelmingly small, so whilst we are cautious about using imputed employment 80% of employment is in establishments with non-imputed data.

year there were around 140,000 establishments. Almost 120,000 were single establishments whilst around 24,000 were entities consisting of more than one establishment. Of these establishments, almost 90,000 were survivors, 26,000 establishments had entered and there were around 28,000 exitors. Of the entrants and exitors about 2,000 and 3,500 were part of a larger enterprise.

The second column of Table 1 shows the employment accounted for by each component. Although there are many single establishments, they account for 23% of total employment: 77% of total employment is in multi-establishment firms. Note too that among entrants and exitors, multi-establishment firms account for around half of employment, although much less in terms of numbers.

Table 1
Averages per year

		Number of establish-ments	Percent of number		Employ-ment total	Percent of employment	
			total	sub group		Total	sub group
Establishments		142,722	100		4,585,700	100	
of whom	Single estab	119,207		83.6	1,064,100		23.2
	part of enterprise	23,515		16.4	3,521,600		76.8
Survivors		89,231	62.6		4,092,500	89.3	
of whom	Single estab	71,208		79.8	843,500		20.6
	part of enterprise	18,023		20.2	3,249,000		79.4
Entrants		25,890	18.1		194,200	4.2	
of whom	Single estab	23,963		92.6	106,900		55.0
	part of enterprise	1,927		7.4	87,300		45.0
Exitors		27,601	19.3		299,000	6.5	
of whom	Single estab	24,036		87.0	113,700		38.0
	part of enterprise	3,565		13.0	185,300		62

Source: Authors' own calculations using the ARD.
Note: Selected and non-selected data for the period 1986-1992. Figures are averages for each year. An entrant is an establishment that is new in time *t*, a survivor was present in *t* and *t-1*, and an exitor was present in *t-1* but absent in *t*.

2B Calculation of Total Factor Productivity (TFP)

In principle, *TFP* contains more information than labour productivity (Hulten, 2000), although *TFP* is likely to have more measurement error. As we discuss below, our results are robust to many different ways of measuring *TFP* but we present both labour productivity *Y/L* and *TFP* measures for completeness. The log of labour productivity ln*(Y/L)* is defined as real gross output per person hour, calculated using a four-digit industry output price deflator. *Y* and *L* are available directly from the Census. The only hours variables available are (two-digit) manual hours. We calculate (log) *TFP* as

$$\ln TFP_{it} = \ln Y_{it} - \alpha_K \ln K_{it} - \alpha_S \ln L_{it}^S - \alpha_U \ln L_{it}^U - \alpha_M \ln M_{it} \qquad \textbf{(1)}$$

where Y is real gross output, K real capital, L^S are non-manual worker hours, L^U are manual worker hours and M real material use, the αs are shares of each factor in gross output and i denotes establishment. M, L^S and L^U are recorded directly from the ARD. Capital stock is estimated from establishment-level investment in plant, vehicles and buildings, using perpetual inventory methods with the starting values and depreciation rates taken from O'Mahony and Oulton (1990). Labour input is person hours as above. Capital and materials are deflated by the appropriate four-digit industry price deflator. Following Foster et al (1998), the factor shares are calculated at the four-digit industry level to minimise the effects of measurement error (see below).[8]

There are of course a large number of complications that arise in calculating *TFP* (which is why results for both ln*TFP* and ln*(Y/L)* are presented here). First, concerning capital, we experimented with a number of different methods of calculation, but whilst these tended to give different measures of Δln*TFP*, it did not affect the decompositions of Δln*TFP* into the parts due to internal and external restructuring. For example, varying the depreciation rates affects Δln*K* and Δln*TFP* but does not affect the decompositions.

On a more conceptual issue, the perpetual inventory method is frequently criticised when applied to *industry* data since it ignores premature scrapping due for example to closure of plants (Wadhwani and Wall, 1986). We are of course working with establishment data and hence avoid this problem.[9] The second complication with calculating *TFP* is hours. We only have average three-digit manual hours on our data, and thus have no measures of non-manual hours. Also, recorded hours may not reflect underworking (overworking) in recessions (booms) (Muellbauer, 1984), thus understating (overstating) Δln*TFP*. Comparisons between entrants and survivors for example might be biased if new entrants work longer hours.

Third, we only have available four-digit industry deflators. An establishment within an industry producing a higher quality good, *ceteris paribus*, will have higher productivity. Thus within-industry productivity growth might reflect between-establishment restructuring if low quality

[8] Bailey, Hulten and Campbell (1992) construct a similar measure with output and inputs expressed as deviations from industry means. Aw, Chen and Roberts (1999) construct a superlative Tornquist-Theil index expressed in terms of deviations from a base-year representative firm. We choose the Solow – type exact index since it is relatively transparent and eases comparison with other work e.g. Foster et al. (1998).

[9] Harris and Drinkwater (1999) point out that using the perpetual inventory method with the establishment as a base, as we do, may mismeasure capital stock if local units shut down (analogous to the industry case). They therefore prefer to work at the local unit level. However, since the only data at local unit level is employment, they use employment to allocate, pro-rata, value-added, labour and investment to calculate capital stocks and *TFP*. The main focus of their paper is capital stock, and they show that the official capital stock, which ignores premature scrapping, greatly overstates capital calculated in this way. In fact, their economy-wide capital data look very similar to ours which are computed at the establishment level. They then go on to calculate local unit (value-added based) *TFP* (they do not explore the roles of entry and exit). Since our main focus is *TFP*, we have chosen to work at establishment level because we were worried that allocating value added, wage costs and employment to local units using employment data might induce more measurement error to *TFP* than the possible error in the capital stock that it might cure. We also differ from Harris and Drinkwater (1999) since we use an initial capital stock level for each establishment (allocated pro-rata from the capital stock levels in

establishments within industries lose market share. To the extent that higher quality goods require more skilled labour then this effect would be picked up in the labour measure, but, as in other studies, we cannot rule this effect out. Finally, we experimented with calculating α as establishment- and industry-specific cost shares, and averaging over time periods or choosing contemporaneous values. Whilst this made some difference to *TFP* it made no difference to the decompositions. As in Baily, Hulten and Campbell (1992) and Foster, Haltiwanger and Krizan (1998), we chose four-digit industry-averages, averaging over beginning and end years over which productivity is calculated.

A fundamental question is whether we prefer $\Delta\ln TFP$ or $\Delta\ln(Y/L)$. If measured correctly, $\Delta\ln TFP$ should capture the technical and efficiency advantage of establishments over and above measured inputs and so may be regarded as summarising the productivity advantage accruing to competitive establishments after the employment of inputs at market rates (Hulten, 2000). Hence the decompositions reflect how the market process sorts these types of advantages. If changes in ideas and efficiency occurs within firms (e.g. learning by doing) then the bulk of *TFP* growth should be due to internal factors. If on the other hand changes in ideas and efficiency are primarily due to new establishments with new ideas, then *TFP* growth should be dominated by external factors. Against this, it might be argued that *TFP* is so badly measured that working with $\ln(Y/L)$ gives a better reflection of how markets select establishments of different productivity.[10] One obvious problem with $\Delta\ln(Y/L)$ is that it is very high in the major recession of 1980-82 whilst $\Delta\ln TFP$ is very low, suggesting that $\Delta\ln(Y/L)$ is not a good measure of productivity growth in periods of capital-labour substitution.

Table 2 sets out some summary statistics of whole economy changes, annualised and population employment-weighted.[11] Column 1 shows growth over the entire data period, which is roughly a trough to trough measure. The other columns show different time periods. The first four rows show changes in outputs and inputs. These correspond almost exactly with reported changes in official statistics, with the exception of the capital measure which shows a slower growth rate of capital (the ONS growth rate of gross capital stock for manufacturing is 0.82% p.a., 1980-1992).[12]

O'Mahony and Oulton, 1990) rather than allowing initial investment to proxy new establishments start-up capital stock. We did this following advice from the ONS.

[10] As for entry and exit, suppose that new establishments achieve high productivity by entering with new capital stock. Mismeasurement aside, we would expect the share of productivity growth accounted for by net entry to be greater for $\Delta\ln(Y/L)$ than for $\Delta\ln TFP$. On the other hand, suppose new establishments achieve high productivity by entering with innovative managers. Unless this is reflected in the wage data we have then that the role of new entry would be no different in accounting term for both methods.

[11] Population weights are used here since we can only calculate *Y/L* and *TFP* using the selected sample (the non-selected sample does not have any output data). We calculated employment-based population weights as follows. We calculated employment by size group from the non-selected and selected files together and from the selected files only and constructed weights as the ratio of these two figures thus aiming to mimic both files by weighting the selected files. We experimented with different size groups but in the end used groups of 1-19, 20-39, 40-59, 60-79, 80-99 and 100 and above.

[12] For example $\Delta\ln(Y/L)$ for manufacturing, 1980-92 was 4.44% pa (Economic Trends, Annual Supplement, table 3.5). Note these numbers are on the basis of different output and employment surveys to the ARD. There

However, the ONS growth rate uses industry-based perpetual inventory methods that assumes that capital depreciates uniformly, and so misses plant closures. Since we compute capital for each establishment and then (for the table) aggregate to the manufacturing level, our data picks up this establishment 'death' (see, however, footnote 9). The large recessions 1980-82 and 1989-92 mean ONS data is likely to overstate the capital stock relative to the establishment data, so we should not be too surprised by our lower capital growth rate.

Table 2
Summary statistics
(% per annum)

	1980-1992	1980-1982	1982-1989	1989-1992
$\Delta \ln Y_t$	2.07	-2.10	4.78	-2.06
$\Delta \ln K_t$	0.84	-0.30	0.92	0.53
$\Delta \ln L_t$	-3.17	-9.12	-1.22	-4.06
$\Delta \ln M_t$	2.30	-2.05	4.94	-1.07
$\Delta \ln (Y/L)_t$	4.53	7.06	4.75	2.36
$\Delta \ln TFP_t$	1.06	0.20	2.02	-1.39

Note: All numbers are average annual percentage growth, employment-population weighted and per hour. The years are chosen to correspond with troughs and peaks taken from CBI survey on skilled shortages, source BEQB, chart 3.13. $\Delta \ln(Y/L)$ is $\Delta \ln TFP$ are calculated by calculating each establishments $\ln(Y/L)$ and $\ln(TFP)$ and weighting by employment. These calculations therefore include entrants, exitors and survivors. 1980 was in the middle of a downturn, 1982 and 1992 were ends of a downturn, 1989 was the end of an upturn.

3. A first look at the disaggregated data

The level of productivity. Table 3 sets out the (employment-weighted) levels of labour productivity and *TFP* for entrants, exitors and survivors for whole manufacturing, with survivors normalised to 100. These data are annual averages 1980-92. Entrants are establishments which were absent in *t-1* but appeared in *t*, exitors those that were present in *t-1* but absent in *t* and survivors those that were present in both periods. A consistent picture emerges. Entrants are more productive than stayers, stayers are more productive than exitors and, hence, entrants are more productive than exitors. These differences are significant. This immediately suggests that external restructuring i.e. the process of entry and exit will raise productivity growth.

Table 3
Levels of productivity and *TFP* for entrants, exitors and survivors
(survivors=100)

	Entrants	Survivors	Exitors
Y/L	102.4	100	97.2
	(7.23)		(3.17)
TFP	103.9	100	94.5
	(10.18)		(14.13)

Note: data are annual averages, 1980-92. Data in brackets are t-statistics measuring the significance of the difference from the surviving establishment.
Source: authors' calculations from the ARD.

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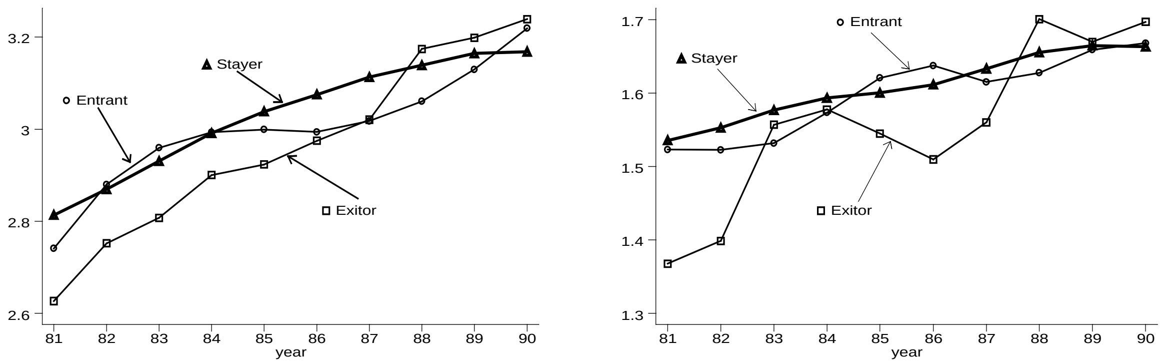
are no official *TFP* growth statistics. Cameron, Proudman and Redding (1998) report growth in value added per

Nevertheless there are of course several possible reasons for this finding. First, it could be a compositional effect, whereby exit is concentrated in low productivity industries and entry in high-productivity industries. To examine this, we computed average productivity and *TFP* for entrants, survivors and exitors for 19 two-digit SIC manufacturing industries. Here there is a more mixed picture, but overall the aggregate picture is representative. *TFP* is higher among survivors than exitors in 15 of the 19 industries, covering both high- and low technology sectors.

Second, the averaged data may hide cyclical factors if for example productivity varies pro-cyclically, whereas entry and exit vary pro- and counter-cyclically respectively. Figures 1a and 1b show (smoothed) data for the individual years. In the (unsmoothed) data, labour productivity of exitors is lower than survivors in all years until 1989 and lower than entrants in all years. In the case of *TFP* levels, exitors have lower *TFP* than survivors in all years bar 1989 and 1991. The disparity in *TFP* levels is particularly clear in the sharp recession of the early 1980s.

Figure 1a and 1b
Average annual productivity by establishment type

1a. Labour productivity **1b. Total factor productivity**



Note: Population weighted. Smoothed by three year moving averages.
Source: Authors' own calculations using the ARD.

The variance of productivity. The top panel of table 4 sets out the data on a number of different measures of the variability of ln*(Y/L)* and ln*TFP*. Column 1 shows the average 90-10 differential[13], and suggests a large variation in productivity, with establishments at the top decile 150% more productive than those at the first decile (we chose decile comparisons to avoid outliers due to measurement error). The 90-50 and 50-10 differentials, shown in the next columns suggest a lower spread at the bottom, suggesting there is a lower cut-off point. The final column shows considerable variance in ln*(Y/L)*. The second row shows less variation in ln*TFP*. The latter is to be expected since at least some of the variation in ln*(Y/L)* should be due to variation in input proportions.

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head and *TFP* of 4.68% and 3.10% respectively for 1979-1989 (1998, table 1, panel 3 and table 2, panel 3).

In the textbook representative agent model there should be no variance in productivity since all firms have access to the same inputs (including knowledge, technology etc). More recently some more explicit models of productivity variance have been proposed, see e.g. the review in Foster, Haltiwanger and Krizan (1998).[14] In most of these models the distribution of productivity evolves as firms acquire new information after entry. Attempting to discriminate between different theories of productivity is beyond the scope of this paper, but a first step in evaluating these models should be to look at the evolution of the distribution of productivity across *cohorts* of establishments.[15] The bottom panel of table 4 shows the different measures of spread in productivity for the 1982 cohort in 1982, 1987 and 1991. All differentials fall steadily over the period, regardless of measure.

Table 4
Variability of ln*(Y/L)* and ln*TFP*

	90-10		**90-50**		**50-10**		**95-5**		**Variance**	
ln Y/L	1.557		0.855		0.702		2.110		0.444	
ln*TFP*	0.906		0.483		0.423		1.223		0.163	
1982 cohort	ln*TFP*	ln *Y/L*	ln*TFP*	ln *Y/L*	ln*TFP*	ln *Y/L*	ln*TFP*	ln *Y/L*	ln*TFP*	ln *Y/L*
1982	1.476	1.616	0.805	0.933	0.672	0.683	1.910	3.594	0.326	0.959
1987	0.808	1.433	0.391	0.776	0.417	0.657	0.808	1.508	0.112	0.412
1991	0.662	1.279	0.359	0.684	0.303	0.596	0.885	1.931	0.126	0.376

Note: For ln *Y/L* and ln *TFP* the percentile differences were calculated for each year and the numbers in the table are the means across the years, for the period 1980-1991, selected data only.
Source: Authors' calculations from the ARD.

This provides indirect evidence of trimming at the bottom of the distribution. To test explicitly whether the lowest productivity establishments exit, we can model the (conditional) probability of exit as a function of ln*(Y/L)* and ln(*TFP*) relative to the respective average industry levels (denoted *relprod* below), and other variables common in the exit hazard literature (single, size, cohort and industry dummies).[16] Denote the hazard rate of establishment *i* by λ_i (i.e. the probability that the establishment exits in interval *t* to *t+1*, conditional upon having survived until period t). Thus we estimate

[13] The log of productivity for the establishment at the 90th percentile less the log of productivity for the establishment at the 10th percentile.

[14] FHK list a number of reasons: (i) uncertainty (e.g. about costs etc. that generates different outcomes), (ii) differences in managerial ability (iii) capital vintage (iv) location and disturbances (v) diffusion of knowledge. There might also be variance due to measurement error; if, say output is randomly mismeasured. In this case, we would expect low productivity establishments to regress towards the mean.

[15] For example, models where firms are uncertain about their costs and learn about them, or learn from the technology of others, or where good management improves the progress of a firm, would suggest the variance of productivity falls over the life of a entry cohort as poor firms do worse and perhaps exit. The variance might rise if very good firms become very large; Jovanovic (1982) assumes rising marginal costs to rule this out.

[16] For similar regressions, see Baily et al (1992). They run exit probits and find that higher than average *TFP* lowers the probability of establishment death (table 10, p 229). In Disney et al (1999) we estimated a more

$$\lambda_{it} = \lambda_0(t)\exp(\alpha_1 relprod(t) + \alpha_2 single(t) + \alpha_3 size(t) + \alpha_4 dummy) \qquad \textbf{(2)}$$

where $\lambda_0(t)$ is the baseline hazard, size is measured by log employment, single denotes whether an establishment is not part of a larger group, and the dummies are cohort and industry dummies. We estimate this model on all cohorts of establishments born between 1980 and 1990. We adopted the Cox (1972) specification, which being non-parametric permits a flexible baseline hazard.[17]

If the lowest productivity establishments exited, we would expect a negative coefficient on *relprod*. In table 5, column 1 and 2 use ln*(Y/L)* and ln(*TFP*) as *relprod*. Both are negatively signed showing that establishments with below average productivity are more likely to exit. Columns 3 and 4 add the single and size terms. The signs are robust to these additions and in the last two columns *relprod* is well-determined.

Table 5
Estimates of the Conditional Probability of Exit
(by Cox proportional hazard method)

	Y/L	***TFP***	***Y/L***	***TFP***
Relprod	-0.017	-0.240	-0.124	-0.254
	(0.357)	(2.632)	(2.557)	(2.749)
Single	-	-	-1.058	-1.036
			(13.295)	(13.161)
Size	-	-	-0.039	-0.044
			(1.110)	(1.257)

Note: In each column relprod is measured using *Y/L* or *TFP* as indicated in the column headings. Absolute t-statistics in brackets. Size measured by log employment. Regressions run on selected data only for the period 1980-92. Number of observations 22, 287. All regressions include cohort and industry dummies.

These results have two general implications. First, since low productivity establishments are more likely to exit, at least some of the trimming of the distribution of establishments we saw in the figures and tables above is due to the exit of low productivity establishments. Second, productivity studies based on either a balanced panel of surviving firms, or large firms, are using a selected sample. Such firms are less likely to exit, either by sample design, or because they have higher productivity, and hence such a panel is likely to be a biased sample of firms.

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complicated specification with the same basic regressors but a series of interactions with age and quadratic terms. We re-ran that specification on the sample used here and the results on relative productivity are robust.

[17] We also entered a time dummy to account for the increase in registrations associated with the change in the sampling base to VAT records in 1983, and dummies for 1984 and 1988 cohorts interacted with time (see Disney et al (1999) for more discussion).

4. Quantifying the contribution of restructuring to productivity growth

The findings above suggest that external restructuring raises overall productivity. In this section we try to *quantify* this contribution. For robustness, we implement three different methods of accounting for the effect of restructuring on productivity growth. Write manufacturing-wide productivity in year t, P_t as

$$P_t = \sum_i \theta_{it} p_{it} \qquad \textbf{(3)}$$

where θ_i is the share of establishment i (output or employment shares) and P_t and p_{it} are a productivity measure. The decomposition proposed by Bailey, Hulten and Campbell (1992) relates to the change in manufacturing-wide labour productivity or ln*TFP* between t-k and t, ΔP_t and is written

$$\Delta P_t = \sum_{i\in S} \theta_{it-k} \Delta p_{it} + \sum_{i\in S} \Delta\theta_{it} p_{it} + \sum_{i\in N} \theta_{it} p_{it} - \sum_{i\in X} \theta_{it-k} p_{it-k} \qquad \textbf{\textit{BHC}} \quad \textbf{(4)}$$

where S, N and X denotes the establishments that survive, enter and exit respectively between t and t-k and we shall call this the BHC decomposition. The first term in (4) shows the contribution to productivity growth of growth within the surviving establishments, or the "within" effect. We think of this as the "internal restructuring" effect. The rest of the terms are what we shall call the "external restructuring" effects. The second term shows the contribution of changes in shares of the survivors weighted by final period productivity (often termed the "between" effect). So, productivity grows if the shares of higher productivity establishments increase. The third and fourth terms show the contribution of entry and exit.[18]

Haltiwanger (1997) argues that the interpretation of entry and exit in the BHC decomposition may be problematic. Suppose entrants are highly productive and exitors highly unproductive. One would expect net entry to raise productivity growth. Looking at (4) however, if the θs (market shares) of the entrants are sufficiently low and exitors sufficiently high, then the impact of net entry might be negative even if entrants were more productive. To overcome this problem, Foster, Haltiwanger and Krizan (1998) (FHK) suggest a decomposition in terms of productivity relative to the average:

$$\begin{aligned} \Delta P_t = &\sum_{i\in S} \theta_{it-k} \Delta p_{it} + \sum_{i\in S} \Delta\theta_{it} (p_{it-k} - P_{it-k}) + \sum_{i\in S} \Delta\theta_{it} \Delta p_{it} \\ &+ \sum_{i\in N} \theta_{it} (p_{it} - P_{it-k}) - \sum_{i\in X} \theta_{it-k} (p_{it-k} - P_{it-k}) \end{aligned} \qquad \textbf{\textit{FHK}} \quad \textbf{(5)}$$

[18] With industry data one can decompose ΔP_t into the within and between terms, but cannot of course account for net entry. See Cameron et al (1998) for implementation of this on UK data.

The first term is the same within-survivors effect as (4). The second term shows the between-survivors effect. This is positive when market shares increase for those survivors with above-average base year productivity. The third term is an additional covariance term that is positive when market share increases (falls) for establishments with growing (falling) productivity.[19] The entry and exit terms are positive when there is entry (exit) of above- (below-) average productivity establishments. The advantage of this method is interpretation: a positive entry effect arises from entrants with high productivity relative to the average, irrespective of market share.

As FHK point out however, this method is vulnerable to measurement error. Suppose that employment is measured with error and that the θs are employment weights. Measurement error would give a spuriously high correlation between $\Delta\theta$ and Δp understating the covariance effect. In addition it would give a spuriously high correlation between θ_{it-k} and Δp, giving a spuriously low within-plant effect.[20] They also suggest using a decomposition due to Griliches and Regev (1992)

$$\Delta P_t = \sum_{i\in S} \overline{\theta}_i \Delta p_{it} + \sum_{i\in S} \Delta\theta_{it}(\overline{p}_i - \overline{P}_i) + \sum_{i\in N} \theta_{it}(p_{it} - \overline{P}_i) - \sum_{i\in X} \theta_{it-k}(p_i - \overline{P}_i) \qquad \textbf{\textit{GR}} \qquad \textbf{(6)}$$

where the bar indicates a time average over the base and end year. The first term measures the within contribution of survivors' productivity growth weighted by time-average market shares. The other terms are all relative to time-average productivity. The advantage of this procedure is that averaging removes some of the measurement error. The disadvantage is that interpretation is more obscure. The within effect will reflect, to a certain extent, external restructuring effects since they affect θ.[21]

As a preview to the decompositions, table 6 details the productivity of entrants (present in 1992, but not in 1980), exitors (those present in 1980, but not in 1992) and survivors (present in both 1980 and 1992). The top panel immediately confirms, as in the discussion in Section 3, that entry and exit are likely to be important in examining productivity change. The first two columns show that the market shares of entrants and exitors are substantial. The key to the decompositions lies in comparing columns 3 and 4, which reveal that entrants are more productive than exitors, whether measured by *TFP* or *Y/L*, but especially by the former. Note, too, stayers' productivity has grown over the period, especially when measured as $\Delta\ln(Y/L)$.

The lower panel of table 6 shows some other industries, with chemicals and 'computers & office equipment' broadly reflecting 'hi-tech' industries and textiles and 'leather and footwear'

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[19] One might argue that rising market share is due to increased productivity so that the covariance term is also an internal restructuring effect. We call it external since it is a consequence of market activity.

[20] Classical measurement error in employment that gave a spuriously high θ and hence low p in t-k, would give a high p in t, thus giving a spuriously high Δp.

reflecting 'low-tech' industries. The same pattern emerges, of high rates of entry and exit (the latter being significantly greater than entry for the two 'low tech' industries and higher entry than exit in computers), and of higher productivity of entrants and survivors than exitors. These results therefore suggest the aggregate findings are not simply due to industry composition.

Table 6
Productivity and market shares for Survivors, Exitors and Entrants

Manufacturing	Shares		Relative to whole economy manufacturing productivity, t-k			
	Entrants, t	Exitors, t-k	Entrants, t	Exitors, t-k	Survivors, t-k	Survivors, t
Ln*(Y/L)*	0.42	0.50	1.22	0.95	1.06	1.26
Ln *TFP*	0.42	0.50	1.16	1.03	0.99	1.08
Selected industries						
Chemicals (sic80=25)						
Ln*(Y/L)*	0.30	0.35	1.20	0.97	1.01	1.16
Ln *TFP*	0.30	0.35	1.16	0.96	1.03	1.20
Computers (sic80=33)						
Ln*(Y/L)*	0.66	0.42	1.62	1.00	1.00	1.56
Ln *TFP*	0.66	0.42	1.75	0.87	1.09	1.61
Textiles (sic80=43)						
Ln*(Y/L)*	0.32	0.60	1.28	0.96	1.07	1.26
Ln *TFP*	0.32	0.60	1.30	0.95	1.08	1.32
Leather and Footwear (sic80=45)						
Ln*(Y/L)*	0.40	0.69	1.29	0.95	1.12	1.38
Ln *TFP*	0.40	0.69	1.18	1.06	1.03	1.16

Notes: Entrants are establishments absent in 1980, present in 1992, survivors are present in 1980 and 1992, exitors are present in 1980 and absent in 1992. Average productivity for all types of establishments in *t-k* is normalised at 100. Growth rates are 1980-92. Column 1 (2) are shares in *t* (*t-k*). Data are population weighted.

Turning to the decompositions, we used the three alternative decompositions set out above, using two measures of *P* (ln*(Y/L)* and ln*TFP*) and employment and gross output as θ. We also used different years. Our results for 1980-92, using the employment weights, are set out in table 7 (output weights gave very similar results). The panels of the table shows the results for Δln*(Y/L)* and Δln(*TFP*). Each cell shows the percentage of total growth accounted for by each component of the disaggregation. Consider first the BHC results for Δln*(Y/L)* in the top row of the top panel. The first column shows the contribution of the "within/internal restructuring" effect using employment as a weight. The answers are very close regardless of decomposition and suggest that the "internal restructuring/within" effects accounts for about 47-48% of Δln*(Y/L)* over the whole period.

The next columns show the between, cross and net entry effects. The between effect is 38% under the BHC method, and small for the other methods.[22] In the BHC measure, there are no cross-terms and the net entry effect is small and positive. The net entry effects are larger under the other

[21] FHK note that Olley and Pakes (1996) write a cross-sectional decomposition of productivity *levels* as $P_{it}=p^*_t+\Sigma_I(\theta_{it}-\theta^*_t)(p_{it}-p^*_t)$ where a * denotes a cross-sectional average across establishments. Since this method cannot address the contribution of entry and exit directly, we do not consider it here.

[22] If the between effect is positive this suggests that market selection is generating faster growth among more efficient establishments, which would be consistent with the Jovanovic (1982) model for example.

Table 7
Productivity decompositions, Labour productivity and Total factor productivity
(see equations 4, 5, 6)

	Within	Between	Cross	Net entry
Δln*(Y/L)* 1980-92, (Average productivity growth 4.53% per annum.)				
BHC	48	38	-	14
FHK	48	4	-1	49
GR	47	-1	-	53
Δln*TFP* 1980-92, (Average *TFP* growth 1.16% per annum.)				
BHC	5	110	-	-15
FHK	5	15	26	54
GR	18	23	-	58

Note: All employment weighted. All values are per cent of total change. BHC, FHK and GR refer to decomposition methods described by (4), (5) and (6).

methods. The smaller net entry effect using BHC is an exact example of the Haltiwanger observation that using this decomposition the between and net entry effects conflate changes in market shares and entry/exit relative productivities. Recall from table 6 that the exitors have a larger market share than the entrants. Looking at (4), this renders the net entry effect smaller. In addition, with many exitors disappearing, the market share of the survivors rises, giving the large between effect. Thus the BHC method does not allow an easy interpretation of the restructuring effects.

Consider now the FHK and GR decompositions. The within effect is of course the same for the BHC and FHK methods so the same figure is to be expected. The higher GR within effect arises since it includes some of the between/cross effect. Interestingly, the net entry effects are consistent, explaining about 50% of Δln*(Y/L)* (similar to FHK's results on US data, 1977-87).

The lower panel of table 7 shows the decompositions for Δln*TFP*. The *TFP* decompositions are fairly consistent but the results are in striking contrast with the Δ(*Y/L)* measure. The negative BHC net entry effect again illustrates the interpretation biases of the BHC decomposition. Focussing on the FHK and GR decompositions, therefore, the within effect contributes only between 5% and 18% of the growth of productivity, with the latter an upper bound since it has some between effect in it, in contrast to Δln*(Y/L)*. The between effects for the FHK decomposition are about 20%, again depending somewhat on weighting. The cross effect is positive at about 26%. Finally, net entry is about 55% of productivity growth.

What can be concluded about the relative importance of external and internal restructuring in accounting for productivity growth according to the decompositions over this period? First, internal and external factors account for around 50% each of labour productivity growth 1980-92, a picture that is consistent across measures. Second, concerning *TFP* growth, net entry consistently accounts for over half of it and the within effect is, at most, 18% (the latter being the GR figure). Thus external restructuring accounts for over 80% of *TFP* growth. Even if one counts the cross effect as an internal effect, external factors still account for 70% of *TFP* growth, which is substantial. Finally, the stronger within contribution to labour productivity growth indicates that much of the labour productivity growth of survivors was driven by downsizing and consequent capital-labour substitution.[23]

4B Multi-establishment firms

Table 8 further divides the effects into those due to firms that are singles and those where firms are multi-establishment, for the 1980-92 period, using the FHK method. The results are most interesting. Consider the top row, which decomposes the 1980-92 period for $\Delta\ln(Y/L)$. The first two columns show the within effect for survivors, split into productivity growth within single establishment survivors and productivity growth within surviving establishments which are part of larger group of firms. As the table shows, single surviving establishments accounted for an almost negligible portion (about a half a percentage point) of total productivity growth. By contrast, the surviving establishments who were part of a group of establishments accounted for 44.6 percent of overall productivity growth. Looking at the net entry column, net entry by singles raised productivity growth, accounting for about 16% of overall productivity growth. Interestingly however, the net entry effect of groups accounts for about double this amount. In other words, around a third of productivity growth was due to the closure of low productivity plants within existing firms and the opening of high productivity plants.

The figures for *TFP* are also very interesting. Very little of *TFP* growth is due to within effects, as we saw above. But 41% of productivity growth is due to the net entry of establishments within multi-establishment firms. Thus entry and exit are important, but we have perhaps to be careful about "external" restructuring since around half of it might be regarded as internal in the sense of being within the multi-establishment firm.

Table 8
Productivity decompositions, Labour productivity and Total factor productivity 1980-92: Singles and Groups

	Within		**Between**		**Cross**		**Net entry**	
$\Delta\ln(Y/L)$ (Average productivity growth 4.53% per annum.)								
	Single	Group	Single	Group	Single	Group	Single	Group
FHK	0.58	44.62	-0.36	3.87	0.42	-2.80	15.89	33.20
$\Delta\ln$ *TFP* (Average *TFP* growth 1.16% per annum.)								
	Single	Group	Single	Group	Single	Group	Single	Group
FHK	0.23	4.37	0.11	13.94	0.43	23.19	12.75	41.06

Note: There are two extra within and between terms not displayed in the table for stayers who change from single to group and vice versa. For labour productivity they sum to 4.59%, and for total factor productivity they sum to 3.92%. Data are employment weighted. Decomposition method described in (5).

[23] Oulton (1999) measures $\Delta\ln(Y/L)$. He uses the FHK method to decompose $\Delta\ln(Y/L)$ 1979-89, and finds a net entry contribution of 35.4% (p. 17). However, he has a shorter period than us and classifies entry and exit using only the selected data, so his share of exiting plants is 37% (ours is 50%)and we would expect the net entry effect to be less.

4C Robustness

Previous sub-sections suggested that entry and exit made a major contribution to productivity growth over the period 1980-92, and that the within-establishment effect was relatively small, particularly when the productivity measure used was $\Delta \ln TFP$. In this section we examine the robustness of these findings to measurement error, sensitivity to length of period and the growth of entrants.

There are three possible sources of measurement error. First, as mentioned above, classical measurement error in employment is likely to give a spuriously high within-plant effect for employment-weighted $\Delta \ln TFP$ and $\Delta \ln (Y/L)$. A second source of measurement error arises from our construction of *K*. In 1980, each establishment is allocated capital, pro-rata, on the basis of its employment. If, for example, small establishments have lower capital-employment ratios, this allocates too much capital to smaller establishment and too little to larger ones. Therefore if exitors are predominantly small and survivors are large, then exitors have spuriously low *TFP* levels and survivors spuriously low *TFP* growth.[24] Third, if, due to mismeasurement of hours, *TFP* is overstated in booms and understated in slumps, then looking at a boom (recession) will overstate (understate) the within and cross effect. Since 1980 and 92 are at roughly the same point in the cycle the bias from hours is unlikely to be important. Since measurement error likely overstates within effects for $\Delta \ln (Y/L)$ and gives offsetting effects for $\Delta \ln TFP$, it seems unlikely that measurement error is giving spuriously large external effects.

Second, one might argue that the contributions of entry, exit and survival are sensitive to the length of period chosen, for extending the period reduces the number of survivors and increases the number of entrants. Whether a longer period automatically raises the contribution of net entry is not clear however. First, the effect on the number of exitors is ambiguous since extending the period loses exitors from previously initial cohorts but gains exitors from newly included initial cohorts. Second, as well as this "accounting" effect there is the "economic" effect that different cohorts in different years are likely to have different characteristics. Hence lengthening the period might raise the contribution of entry in an accounting sense, but might lower it if the less productive cohorts are included in the calculation.[25]

To explore this, table 9 sets out the FHK and GR results for $\Delta \ln (Y/L)$ and $\Delta \ln TFP$ using three subperiods, two slumps, 1980-82 and 1989-92 and one boom 1982-89. For $\Delta \ln (Y/L)$ the results are remarkably consistent, the net entry effect remains at over 40% regardless of period. For $\Delta \ln TFP$ the net entry effect is indeed lower for shorter periods. Three points are worth making. First, understatement of hours over the boom probably overstates the within effect and so reduces the net entry effect over this time. Second, we suspect that mismeasurement problems are likely to be severe

[24] The survivors' initial capital error substantially depreciates out by 1991.

over the shorter periods and hence we are cautious about the 1980-82 and 1989-92 results. Third, US data suggests within effects are more important in booms (Foster et al, 1999) and our results are consistent with this.

Table 9
Productivity decompositions for sub periods
(see equations 4, 5, 6)

	Within	Between	Cross	Net entry
Δln*(Y/L)* 1982-89, (Average productivity growth 4.75% pa.)				
FHK	64	0	-7	43
GR	60	-4	-	43
Δln*TFP* 1982-89, (Average *TFP* growth 2.46% pa.)				
FHK	38	8	15	39
GR	45	15	-	40
Δln*(Y/L)* 1989-92, (Average productivity growth 2.36% pa.)				
FHK	61	5	-9	43
GR	57	-4	-	48
Δln*TFP* 1989-92, (Average *TFP* growth –1.16% pa.)				
FHK	152	-49	-15	13
GR	145	-62	-	17
Δln*(Y/L)* 1980-82, (Average productivity growth 7.06% pa.)				
FHK	59	-2	2	41
GR	60	-3	-	43
Δln*TFP* 1980-82, (Average *TFP* growth 0.17% pa.)				
FHK	-194	18	254	22
GR	-67	143	-	24

Note: See notes to table 7.

We further examined the time period effect by performing the decompositions using overlapping five year cross-sections 1980-85, 1981-86 and so forth. This ensures that variation in the internal and external contribution is only due to cohort and cyclical effects, rather then length of time period. For 1980-85 to 1983-88, TFP growth was 2% pa. In each of these decompositions internal effects accounted for 30% of TFP growth and net entry 20% with very little variation in the figures. Over the next cohorts, 1984-89 to 1987-92 TFP growth fell sharply. The within contribution also fell sharply whilst the net entry contribution rose.[26]

All this suggests the following. First, in slowdowns, i.e. periods of lower than average *TFP* growth, the contribution of net entry is greater. Second, whether the contribution of net entry

[25] Note that the net entry effect for a given period cannot be "overstated". Since it is an accounting result, all effects add up to the overall change so the contribution of any effect is exact for the period chosen.
[26] Still another method is to decompose productivity growth for each year and cumulate the survival, cross and net entry effects. Whilst his correctly accounts for productivity growth over the whole period, in the sense that it adds up, it is not a helpful calculation since it is difficult to interpret. For example, the within effect for each year is the base year survivor market share times survivor productivity growth. However, since each different year's within effect has a new base year the cumulated total of within effects is a combination of each year's survivor productivity growth and each years base market shares. Thus to the extent the cumulated within effect is driven by changes in base year market shares it is a between effect (in fact the cumulated within effects 1980-92 account for 48% of TFP growth and 76% of Y/L growth. Both figures are greater than those for the (non-cumulated) long decomposition and so consistent with the idea that the cumulated within effect includes some between effect as well).

increases when the time period is longer is hard to discern since the contribution varies even with the same time period depending on the cycle. Thus the contribution of net entry in a given time period is more likely to depend on the cycle rather than the time period.

The third robustness check concerns the argument that at least some of the contribution of entry might be due to growth in productivity of entrants subsequent to entry and might therefore be in part a within effect. Consider for example establishments that entered in 1981. They are counted as an entrant in the decompositions (since they are new in 1992) but their productivity in 1992 might reflect productivity growth between 1981 and 1992.[27] We examined this in two ways. First, in table 10 we decomposed the contribution of entrants into the contribution of each successive cohort of entrants. If the entry effect was due mostly to growth subsequent to entry then the contribution of the longer-established cohorts would be greatest. Column 1 shows the contribution of each cohort to the entry effect and column 2 shows each cohort's percentage of the overall entry effect. As the columns show, it is *not* the case that the longest lived cohorts contribute the most to the overall entry effect. Rather, the biggest contributors are the cohorts that entered in the mid 1980s. The calculation is obscured however by the fact that the contribution of each cohort to the final entry term is that cohorts' productivity in 1992 (relative to 1980) weighted by the cohort's share in 1992. Hence a long-established cohort might have a small market share by 1992. Columns 3 and 4 therefore show the market shares of each entering cohort in 1992 and each cohort's relative productivity. As column

Table 10
Entry productivity by cohorts, from FHK decomposition 1980-1992

Cohort	Actual entry productivity contribution	% productivity contribution of entrants only	Entry cohort market share	Average relative productivity
Cohort 81	0.0017	2.3%	1.59%	0.1062
Cohort 82	0.0019	2.7%	1.58%	0.1212
Cohort 83	0.0009	1.3%	1.85%	0.0504
Cohort 84	0.0112	15.6%	5.52%	0.2025
Cohort 85	0.0072	10.1%	3.37%	0.2154
Cohort 86	0.0050	6.9%	3.54%	0.1413
Cohort 87	0.0085	11.8%	4.20%	0.2020
Cohort 88	0.0104	14.5%	3.90%	0.2675
Cohort 89	0.0097	13.5%	3.91%	0.2486
Cohort 90	0.0098	13.7%	3.95%	0.2490
Cohort 91	0.0034	4.7%	3.65%	0.0924
Cohort 92	0.0021	2.9%	2.91%	0.0727
All cohorts	0.0719	100%	39.96%	0.1799

Note: Entry cohort market share is the share of each cohort in total employment in 1992.

3 shows the distribution of market shares among cohorts is fairly even, regardless of cohort year, aside from the earlier cohorts having rather lower market shares. Column 4 confirms again that the

[27] Note too that exiting establishments might have declining within establishment productivity until they exit and hence there might be a negative within effect from the exitors.

most productive cohorts were in the mid to late 1980s. Overall then, there seems little evidence that the entry term is excessively driven by growth of long-surviving establishments in separate cohorts.[28]

A second route to look at the balance between initial entry and subsequent growth is to examine the productivity growth of cohorts. Following Aw et al (1997), for each cohort we regressed their *TFP* on a constant, a set of time dummies and an exit dummy. The constant for each cohort tells us the average productivity level of each successive cohort whilst the time dummy in each year says how the entire cohort's productivity has evolved in each year relative to its base level (the initial time dummy is omitted). If the 1992 productivity of entrants was predominantly due to high productivity growth since entry, then the 1992 time dummy should be positive and significant. This was the case for five out of 12 cohorts (1980, 81, 84, 85 and 88), suggesting that the main determinant of the 1992 productivity of entrants was high productivity at entry.

Finally, table 11 compares our results to the US, using Haltiwanger's (1997) results for 1982-87 for all US manufacturing. Both decompositions are output weighted, but our UK figures are also population weighted, whilst it is not clear from the text of Haltiwanger (1997) whether the US results are population weighted or not. The top panel of the table shows that UK entrants and exitors have higher market shares than those in the US, and about the same relative productivity. The lower panel shows the contribution of net entry is about the same (UK productivity growth is higher than that in the US, so net entry contributes more in the UK , but not more as a fraction of a larger total). The main difference is that the US within effect is larger than that in the UK whilst the negative between effect in the US is much lower in the UK. Since the relative productivities in the US among incumbent firms are about the same, it seems to be the case that the high productivity establishments are not as dominant in the UK as in the US, and that in the UK there is little rearrangement of market shares. In the US, higher productivity firms dominate the market to a greater extent, but output has moved more to low productivity firms. Without more detailed knowledge of data, weighting etc, we are cautious about making strong conclusions.

[28] In theory one could go further and fully decompose every cohort as above. This cannot be done on our data however because many of the entrants in 1992 are in the non-selected data in their entry period and so whilst we can identify them as new in that year we do not have enough information to calculate their productivity.

Table 11
US and UK decompositions, 1982-87
(FHK method)

a. Gross output shares comparison

	Shares		Relative to whole economy manufacturing productivity, t-k			
	Entrants, t	Exitors, t-k	Entrants, t	Exitors, t-k	Survivors, t-k	Survivors, t
US	0.083	0.122	1.09	0.99	1.01	1.11
UK	0.147	0.170	1.11	1.01	1.00	1.10

b. Decomposition comparison

	Total	**Within**	**Between**	**Cross**	**Net entry**
US	8.26	57.6%	-16.7%	47.5%	11.6%
UK	15.41	40.5%	-3.4%	50.8%	12.1%

Notes: all comparisons for *TFP*. Shares are output shares. Source of US data: Haltiwanger 1997, table 3 and 4. Source of UK data: authors' own calculations using ARD.

5. Market conditions and survivor productivity growth with sample selection

The previous section studied the accounting contribution of external restructuring to productivity growth. This may however understate the effect of external restructuring if market competition raises productivity growth among the survivors. This section therefore examines how much survivor productivity growth is affected by product market competition. An important objective of this section is to estimate the productivity-competition relation controlling for sample selection bias due to entry and exit.[29] To estimate the productivity-competition relation, we run the following equation

$$\begin{aligned} \ln Y_{it} = \alpha_{1I} \ln K_{it} + \alpha_{2I} \ln M_{it} + \alpha_{3I} \ln L^{S}{}_{it} + \alpha_{4I} \ln L^{S}{}_{it} + \alpha_{5} \ln h_{it} \\ \beta_{1} Z_{1it} + \beta_{2} Z_{2it} t + \mu_{i} + \mu_{I} + \mu_{t} + \varepsilon_{it} \qquad if\ i \in S \end{aligned} \tag{7}$$

which simply says that the level of output Y depends on the inputs K, M, L^S, L^U, hours, h, fixed effects, industry effects, time effects (μ_i, μ_I, μ_t) and a random error, whilst output *growth* depends on a vector Z_2. S denotes the set of survivors. The inputs are those used in (1) to construct ln*TFP*, but we do not constrain the output elasticities of the inputs to be the factor shares; rather, we allow them to vary by industry. For shorthand let us call Z_1 and Z_2 the determinants of estimated ln*TFP* where Z_1 (Z_2) determines the level (growth) of estimated ln*TFP*. Market competition will enter in vectors Z_1 and Z_2.

A standard approach to handling the selection issue is to condition (7) on an auxiliary equation containing variables that capture the probability of the establishment surviving. There are a variety of possible methods of identifying this selection. For example, Olley and Pakes (1992) attempt to model selection structurally by postulating an explicit model of exit (see also Pavcnik, 1999, and Levinsohn and

[29] The related literature that examines the role of selection bias is mostly concerned with the estimation of a production function without the explanatory competition regressors, the aim being to obtain what we have termed estimated *TFP* (which is then used in decompositions see e.g. Olley and Pakes, 1996). Pavcnik (1998) regressed estimated *TFP* on various trade liberalisation measures.

Petrin, 1999). In Olley and Pakes' model, exit depends on an unobserved shock (to the econometrician) to productivity that also enters in the production function. However Griliches and Marisse (1995) argue that a structural approach depends on what might be strong assumptions in the model.[30] One strategy we adopt therefore is to include as instruments in the selection probit terms that approximate this more structural approach. In practice, however, identification is likely to be difficult. In an effort bargaining model for example (Nickell et al, 1992, Haskel, 1991), effort, which affects the production function, depends on profits net of fallback profits. But exit also depends on profits net of exit profits.[31] Thus regressors in the selection equation are likely also to be in the exit equation and identification may only be possible on functional form even with an underlying "structural" model of exit.

This suggests exploring a second strategy to assess the robustness of the productivity-competition relationship. This is to consider the bias arising from using selected samples. Since (7) is only observed if establishment *i* is a survivor (since we estimate in differences, *i* must be present for at least two periods), studies such as Nickell *et al* (1992) and Nickell (1996) that are based on samples of large firms observed for a minimum period of time (in the latter case, at least six consecutive periods) are potentially biased due to selection both over survival and size. However, theory predicts the direction of the bias, and this bias can be examined explicitly. Assume that small firms are mostly in competitive markets and less likely to withstand adverse shocks. Thus only those with positive productivity shocks survive. This creates a positive correlation between competition and productivity shocks among survivors. Selection bias therefore overstates the expected positive correlation between productivity and competition and, equivalently, understates the expected negative effect between productivity and market power (i.e. renders the coefficient "more" negative) when only survivors are examined and there is no selection correction. We examine this explicitly, therefore, by selecting survivors on size and survival duration in order to see how this affects the estimated coefficients on competition. This also, allows a comparison with the smaller sample of large firms used by Nickell (1996).

Turning to the other regressors in (7), a number of possible determinants of Z_1 and Z_2 have been considered in the literature. First, product market competition, our main focus, might appear in Z_1, if high competition raises the level of estimated *TFP* (Nickell et al, 1992, Nickell, 1996), and in Z_2 if competition raises its growth (Nickell, 1996). Second, unions might also raise the level and/or growth of estimated *TFP* if exit/voice effects are important (Freeman and Medoff, 1989) or lower it if, for example, they bargain an easier pace of work (Gregg et al, 1993). Note, however, that union

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30 They argue for example that in Olley and Pakes (1996) the probability of exit depends only on the current realisation of productivity shocks not on its whole history (as in Jovanovic, 1982), and that the determinants of unobserved shocks (investment in their model) is measured without error. Olley and Pakes(1996) attempt to test for the validity of these assumptions in their paper.

31 Whether fallback and exit profits are the same depends upon the exact structure of the effort bargaining game. In the exogenous breakdown case (Binmore, Rubenstein and Wolinsky, 1986) the fallback for the firm is that bargaining breaks down and thus they may not exit in fact. Using the precise details of the bargain to identify the equations is unlikely to be credible. Olley and Pakes (1996) do not encounter such problems since they do not model output net of inputs, but estimate it.

presence is endogenous and likely to be associated with the presence of rents (Disney et al, 1996). Third, ownership might appear in Z_1 or Z_2 if, for example, foreign-owned or multiple unit establishments transfer technology faster then domestic or single unit establishments. Finally, as in any productivity study, there are of course a host of unobservables that are accounted for, as far as is possible by the fixed effects, industry effects and time dummies. Thus to the extent we have omitted variables (as we surely have), they would have to be over and above establishment, time and industry effects.

Following Nickell (1996), we have four potential measures of market competition, industry concentration ($CONC_{jt}$), import penetration ($IMPORT_{jt}$), market share ($MSHARE_{it}$) and rents ($RENTS_{it}$). The first two are standard industry-level variables; we have no establishment-specific trade data. $MSHARE_{it}$ is measured as establishment output as a proportion of four-digit industry output. This is unlikely to be a reliable cross-section measure of (the inverse of competition) since technological differences between industries affect their market structure (Sutton, 1996). However, changes in market share are likely to be a reasonably good time series measure of increased competitive pressure. The rents measure is designed to capture *ex ante* rents potentially available in the form of lower efficiency to workers and managers in the firms. It is defined as rents over net output, where rents are net output less material, capital and labour costs, expressed as a proportion of net output. Labour costs are measured as the region- and industry-specific average manual and non-manual wage, the latter two terms designed to capture the outside wages available. We expect rents and market shares to lower estimated *TFP* and so to have a negative co-efficient. They are of course both potentially endogenous, since higher efficiency would raise rents and market share, attracting a positive co-efficient. We therefore lag both measures by two years, noting that any endogeneity would bias the estimated co-efficients towards zero.

We also look at a number of other issues concerned with the definition of market share. First, data on firm market shares, as has been noted before, may be a misleading measure of competition since a firm might be responsible for a multitude of products. Instead we construct measures of establishment market shares, which, to the extent that establishments make different products, might be a better measure of the competitive pressure that multi-product firms face. Second, market shares are of necessity constructed using industry output as a base. We examine the effects of using shares of four-, three- and two-digit industries, where we expect the coefficient standard error to rise as we introduce more noise into the measure.

To eliminate the fixed effects we took first differences and so our estimating equation is

$$\Delta \ln Y_{it} = \alpha_{1I}\Delta \ln K_{it} + \alpha_{2I}\Delta \ln M_{it} + \alpha_{3I}\Delta \ln L^{S}{}_{it} + \alpha_{4I}\Delta \ln L^{S}{}_{it} + \alpha_{5}\Delta \ln h_{it}$$
$$\beta_{11}\Delta MSHARE_{it-2} + \beta_{12}\Delta RENTS_{it-2} + \beta_{13}\Delta CONC_{jt} + \beta_{14}\Delta IMPORT_{jt} + \beta_{15}\Delta OWNER_{it-2}$$
$$+ \beta_{21}RENTS_{it-2} + \beta_{22}CONC_{jt} + \beta_{23}IMPORT_{jt} + \beta_{24}OWNER_{it-2}$$
$$+ \mu_{I} + \mu_{t} + \Delta\varepsilon_{1it} \qquad \textbf{(8)}$$

where the second and third rows show how the level of the *Z* variables affects productivity levels and growth respectively (we have not included the level *MSHARE* in the growth term and we lag *RENTS*).[32]

Equation (8) uses all establishments with at least four years of data (we need two years to calculate productivity growth and another two years to calculate regressors lagged twice). To eliminate the possible contamination of results introduced by outliers from differencing with measurement error we deleted the top and bottom percentile of observations for all differenced regressors. Measurement error is exacerbated by annual differencing, suggesting that we take a long difference. But a long difference gives rise to a selection bias since it is only feasible to calculate a long difference for surviving establishments. Thus we took a one-year difference. Table 12 sets out the results of estimating (8). All regressions include a constant, time and industry dummies (not reported). Columns 1 to 5 are selectivity-corrected, but in each column the method of identification varies. In column 1, identification in the selection probit is obtained by entering polynomials in investment and capital, following Olley and Pakes (1996) and Pavcnik (1999), which derives from their structural model of exit applied to their production function. The instruments are jointly significant in the selection probit (not reported) and as the final row of table 12 sets out, the selection term is also significant.

In column 1, all inputs are highly significant.[33] Among our competition variables, $\Delta MSHARE_{it-2}$ and $\Delta RENTS_{it-2}$ are both significant and signed as expected. They suggest that a fall in market share and rents two periods ago, which we interpret as a rise in competition, raise productivity levels. Turning to the level variables, $RENTS_{it-2}$ is also significant, suggesting that an establishment with a high level of rents (in *t-2*) will have low productivity growth in *t*. Finally, establishments that are British-owned (UK_{it-2}) have slightly lower productivity growth than foreign owned ones.[34] The

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[32] Our only union information is a two-digit measure which was never significant in our regressions and we therefore dropped it. Regarding endogeneity of the inputs, we were wary about instrumenting differences in trended variables using lagged differences since such instruments are likely to be poor. Thus we prefer to lag potentially endogenous variables.

[33] The co-efficients on K, M, L^s, L^u are in fact similar to their average output shares. The co-efficient on K is rather smaller than the output share and may be downward-biased due to the endogeneity of the inputs (Griliches and Marisse, 1995). Since our focus here is on market competition we do not explore input biases in detail: see Griliches and Marisse and references therein for discussion. Lagging the inputs twice did not much affect the other regressors and so we are confident input endogeneity is not driving our competition results.

[34] The long run implications of this suggest caution in interpreting this variable. Results on competition are robust to its exclusion.

other effects are insignificant [35]. The second column drops the insignificant variables, and the effects of $\Delta MSHARE_{it-2}$, $\Delta RENTS_{it-2}$, $RENTS_{it-2}$ and UK_{it-2} remain.

This suggests that, controlling for selection, competition raises both the level and growth of estimated *TFP*. The remaining columns probe the robustness of this conclusion. In column 3 we start with different specifications of the selection mechanism.[36] A substantial IO theoretical literature shows how entry and exit depends on the sunk costs of rivals. We therefore computed the investment of all other establishments in the industry, to proxy rivals' sunk investment, and entered this, along with age and age^2 in the selection equation. Rival investment should not appear in the production function unless unobservable productivity shocks to establishments are common across industries: the industry dummies should pick this up to some extent. Age might appear in the production function if there is learning by doing, but this would be the age of workers at the firm which is not exactly equal to the age of the firm. As column 3 shows, the co-efficients on the competition variables are robust to this change.

Column 4 explores the idea that exit might depend on unobserved (to the econometrician) expectations of future profitability. To proxy this, we included lagged investment in buildings in the probit equation on the basis that previous such investment reveals expectations of future profitability; once again the competition variables are robust although the co-efficient on $\Delta MSHARE_{it}$ falls. In column 5, we included in the probit the regressors in the hazard regression (2), namely relative *TFP*, size, single and age and age^2 (the latter two regressors approximate the non-parametric specification of (2)). Again, the competition effects are hardly changed. All this suggests that the competition variables are fairly robust to the corrections for selection by these methods at least. Finally, to explore the selection bias further, column 6 restricts the sample to be only for firms who have survived all 12 years of the data period (20,947 observations) and column 7 further restricts the sample to establishments of over 600 (here the sample size falls to 5,851 and the average size of firm is now about 1,400 which is close to the average size in Nickell's sample).[37] In both these experiments $\Delta RENTS_{it-2}$ becomes insignificant but $\Delta MSHARE_{it-2}$ and $RENTS_{it-2}$ remain significant.

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[35] *ΔFOR* is when a previously UK establishment becomes foreign owned, *ΔUK* is when a previously foreign establishment becomes British owned, *ΔSINGLE* is when a previously single establishment becomes part of a multi-establishment firm and *ΔMULTI* is when a previously multi-establishment becomes single.

[36] These experiments are on the basis of column 2. We obtained similar results with different selection specifications on column 1.

[37] This is taken from table 1 in Nickell et al 1992, which uses the same data as Nickell 1996.

Table 12
The productivity/competition relation with selection
(dependent variable $\Delta \ln Y_{it}$)

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Selectivity corrected estimates						
Instruments	lnK, lnI + powers	As (1)	Variabl. I, age, age^2	Lagged own I	Hazard vars	Survived 12 years	Emp >600
Inputs							
$\Delta \ln K_{it}$	0.09	0.09	0.09	0.08	0.09	0.07	0.13
	(16.63)	(16.71)	(17.480	(7.59)	(17.49)	(8.70)	(7.52)
$\Delta \ln M_{it}$	0.45	0.45	0.45	0.46	0.45	0.46	0.42
	(138.11)	(139.41)	(139.33)	(71.88)	(139.36)	(80.07)	(36.52)
$\Delta \ln S_{it}$	0.10	0.10	0.10	0.10	0.10	0.11	0.12
	(33.34)	(34.01)	(33.95)	(18.18)	(33.94)	(20.46)	(11.39)
$\Delta \ln U_{it}$	0.26	0.26	0.26	0.26	0.26	0.26	0.30
	(64.28)	(64.86)	(64.79)	(34.27)	(64.80)	(36.60)	(21.41)
$\Delta \ln h_{It}$	0.80	0.80	0.80	0.82	0.80	0.31	0.50
	(7.91)	(8.02)	(8.02)	(4.47)	(8.03)	(1.82)	(1.30)
Compet vars							
$\Delta MSHARE_{it-2}$	-1.31	-1.32	-1.31	-0.97	-1.31	-1.09	-0.80
	(13.42)	(13.50)	(13.48)	(6.41)	(13.46)	(8.25)	(4.30)
$\Delta RENTS_{it-2}$*	-0.09	-0.01	-0.01	-0.01	-0.01	0.00	0.01
	(2.96)	(2.74)	(2.80)	(1.34)	(2.81)	(0.15)	(0.99)
$RENTS_{it-2}$	-0.02	-0.02	-0.02	-0.02	-0.02	-0.03	-0.05
	(11.85)	(12.32)	(12.23)	(5.93)	(12.16)	(9.01)	(6.30)
UK_{it-2}*	-0.05	-0.05	-0.06	-0.05	-0.06	-0.06	-0.06
	(3.05)	(3.24)	(3.52)	(2.07)	(3.59)	(2.95)	(1.43)
$\Delta CONC_{jt}$*	0.02						
	(0.15)						
ΔIMP_{jt}	0.01						
	(1.27)						
ΔFOR_{it-2} *	0.04						
	(0.82)						
ΔUK_{it-2} *	-0.02						
	(0.34)						
$\Delta MULTI_{it-2t}$*	0.08						
	(0.31)						
$\Delta SINGLE_{it-2t}$*	0.02						
	(0.56)						
$CONC_{jit}$*	0.01						
	(1.77)						
IMP_{jt} *	0.04						
	(0.98)						
$SINGLE_{it}$	0.08						
	(0.64)						
Observations	58,848	60,494	60,492	16,328	60,494	20,947	5,851
R-squared	-	-	-	-	-	0.59	0.57
Signif. Of ρ	5.65	6.19	2.19	0.16	2.60	-	-

Note: All regressions include time and industry dummies. * denotes coefficient multiplied by 10 and ** denotes coefficient multiplied by 100. $\rho=corr(u_1,u_2)$ where u_1 is the random error from the regression equation and where u_2 is the random error from the selection equation. When $\rho\neq0$, OLS is biased. Significance of ρ is a Wald test of ρ=0 distributed $\chi^2(1)$. Robust t-statistics in parentheses.

To interpret the coefficients on $\Delta MSHARE_{it-2}$ and $RENTS_{it-2}$ more easily, table 13 sets out their elasticities at their sample means. Column 1 starts with the most restrictive sample, 600 employees and above, column 2 uses the 1980-92 survivor sample and column 3 shows the full sample. The results amply support the theoretical prediction that sample selection bias renders the $\Delta MSHARE_{it-2}$

and $RENTS_{it-2}$ effects overstated in the most selected sample. Moving from column 1 to 3, both elasticities become less negative.

The rest of table 13 explores further implications of this result. First, column 4 shows Nickell's elasticity of output with respect to $MSHARE_{it-2}$. His results, at around 3.5%, are in line with ours for the large establishment sample, but the selection bias argument suggests they are overstatements. Second, right hand panel shows how, ceteris paribus, productivity growth differs between establishments at the 80th and 20th percentile of the rents distribution. On our full data, such differences amount to about one percentage point in estimated *TFP*. Nickell finds differences of around four percentage points, but this is not surprising for the reason described above.

Table 13
Elasticities of competition terms at sample means

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	emp>600	1980-92 survivors	All estab-lishments	Nickell (1996)	Effect on *TFP* from *RENTS*		
					Our results		
Elasticity					emp>600	all	Nickell
$\Delta MSHARE_I$	-0.040	-0.026	-0.019	-0.035			
$RENTS_i$	-0.016	-0.009	-0.007		0.016	0.009	0.042
Sample means							
$\Delta MSHARE_I$	0.050	0.024	0.015				
$RENTS_i$	0.341	0.302	0.272		0.34	0.49	0.29
Observations	5,851	20,947	60,492	978/4,423			
Average emp	1,456	480	253				

Notes: elasticities use coefficients from table 12 columns 5, 6 and 7. Elasticities are calculated at sample means using averages shown in table. Nickell's elasticities are averages of those used from his two samples of 147 firms (978 obs) and 676 firms (4,423 obs). The actual numbers are –0.042 and –0.028 for the market share elasticities and 3.8 and 4.6 percentage points from the rents differentials. The cells in the panel entitled "Effect on *TFP* from *RENTS*" are the implied differences in estimated $\Delta \ln TFP$ between establishments earning rents at the 80th and 20th percentiles of the sample distribution of rents. The sample 80-20 differentials are shown in the lower right panel of the table.

Finally, we tried out a number of different experiments (not reported, available on request). First, to allow input elasticities to vary by industry we interacted the input co-efficients with two digit dummies. The key competition terms were unaffected. Second, we calculated market share as the share of three- and two- digit industry output and, as expected, the t statistic fell to 5.23 and 2.74. Third, we tested for efficiency wage effects by including the wages of manuals and non-manuals normalised on industry region averages. The relative wage of manuals raised productivity growth but with little effect on the other regressors.

6. Conclusion

A major innovation in this paper is to use a unique longitudinal micro data set to study the sources of UK manufacturing productivity growth with particular attention to the role of entry, exit and survival.

Previous studies in the UK have been unable to look at these issues. In addition we extend the US literature to look at the contribution of multi-establishment firms, and the productivity-competition literature to look at various types of selectivity correction for survival. Following the objectives set out at the start of the paper, our key findings can be summarised as follows.

(a) Between 1980 and 1992, entry, exit and the reallocation of market shares (what we term external effects) accounted for 50% of labour productivity growth and 90% of TFP growth. The importance of entry and exits arises because entrants (exitors) are significantly more (less) productive than survivors. The difference between the results for labour productivity and *TFP* growth is likely to be due to capital-labour substitution among survivors.

(b) The contribution of internal and external effects varies between single- and multi-establishment firms. Between 1980 and 1992, single establishment firms (25% of manufacturing employment) experienced no productivity growth among survivors; all productivity gains for this group came from entry and exit. Most of TFP growth for multi-establishment firms was also due to entry and exit of establishments within the multi-establishment firms, the rest being productivity growth of surviving establishments.

(c) Market competition significantly raises both the level and growth of productivity. This result is robust to selectivity correction. Studies that have not corrected for selectivity overstate the magnitude of the competition effect.

(d) In booms, the fraction of productivity growth accounted for by net entry falls and the fraction due to productivity growth within survivors rises. Recessions are therefore periods of large external restructuring whilst the productivity of surviving firms remains static.

(e) Comparing the US and the UK, 1982-87, the impact of net entry was almost exactly the same, whilst in comparable US studies the within establishment effect was larger. We are cautious about drawing strong conclusions about the relative contributions in the US and UK without more detailed work on time periods, data, weighting etc.

We conclude with two speculative remarks. First, one has to interpret net entry carefully, since much of it is plant closure within multi-plant establishments. But it is intriguing that multi-establishment firms achieve productivity growth by closing plants. That firms have to resort to closure instead of re-arranging production in existing plants might support recent models that assume new technologies require new plants or new workers (Helpman and Rangel, 1999). Second, there may be important policy implications of our work. Increased competition boosts productivity. Likewise, keeping open poorly performing plants removes an important contribution to productivity growth. And with such large flows of entrants and exitors, the attitude of tax authorities and financial markets towards start-ups and bankruptcies is likely to be important.

Data Appendix

Data definitions and sources

$\Delta\ln Y_t$ — The log change in total manufacturing real gross output (£s in 1980) (direct from ARD), deflated by 4 digit annual output price deflators supplied by the ONS.

$\Delta\ln K_t$ — The log change in total manufacturing real net capital stock (£s in 1980). Capital stock is estimated from establishment level investment in plant and machinery, vehicles and buildings, using perpetual inventory methods with the starting values and depreciation rates taken from O'Mahony and Oulton (1990) using the selected sample only. Depreciation rates: buildings 2.91%, plant and machinery 11.097%, and vehicles 28.1%. Buildings and plant and machinery are deflated by two digit industry deflators, vehicles by annual deflators. Deflators were supplied, by Rachel Griffiths at IFS. In addition, establishments may disappear and appear from the ARD data due to sampling. This clearly creates problems for the perpetual inventory method. If we drop all establishments that disappear and reappear for at least one year we lose almost 50% of our selected sample. To fill in the missing year's investment data, we multiplied that year's industry investment by the establishment's average share of industry investment over the establishment's lifetime. After some experimentation we used this method to interpolate for establishments with at most three year's missing data. This means we only lose 10% of the sample. Although investment is of course volatile, establishments' investment shares by industry are in fact extremely stable and so we feel the induced inaccuracies are likely to be small relative to very large gain in sample size.

$\Delta\ln L_t$ — The log change in total manufacturing employment (direct from ARD).

$\Delta\ln S_t$ — The log change in total manufacturing non-manual employment (direct from ARD).

$\Delta\ln U_t$ — The log change in total manufacturing manual employment (direct from ARD).

$\Delta\ln M_t$ — The log change in total manufacturing real intermediate inputs (£s in 1980) (direct from ARD), deflated by four digit input price deflators supplied by the ONS.

$\Delta\ln(Y/L)_t$ — The log change in labour productivity. *Y/L* is the log of real gross output less the log of person hours. Person hours are employment times manual industry average weekly hours. Hours are taken from the Employment Gazette.

$\Delta\ln TFP_t$ — The log change in total factor productivity. See text around (1).

$relprod_t$ — Establishment relative productivity. Relative productivity is establishment productivity less average annual four digit industry productivity.

$\Delta MSHARE_{it-2}$. — The lagged change in market share, *(t-2)-(t-3)* . The market share is establishment nominal gross output as a share of four digit industry nominal gross output.

$RENTS_{it-2}$. — Rents lagged twice. It is defined as rents over net output, where rents are net output less material, capital and labour costs, expressed as a proportion of net output. Labour costs are the region- and four digit industry specific average manual and non-manual wage.

$\Delta RENTS_{it-2}$. — The lagged change in rents, *(t-2)-(t-3)* .

UK_{it-2} . — Dummy variable indicating if the establishment was UK owned two periods ago.

ΔUK_{it-2}. — Dummy variable indicating if an establishment was foreign owned in *(t-3)* but UK owned in *(t-2)*.

$CONC_{jit}$ — Current concentration ratio. It is the five largest establishments' gross output share of four digit industry total gross output.

$\Delta CONC_{jt}$. — The lagged change in industry concentration ratios, *(t)-(t-1)*.

FOR_{it-2} . — Dummy variable indicating if the establishment was foreign owned two periods ago.

ΔFOR_{it-2}. — Dummy variable indicating if an establishment was UK owned in *(t-3)* but foreign owned in *(t-2)*.

IMP_{jt} — Import penetration. Imports as a fraction of (imports – exports + sales) measured at three digit industry level.

ΔIMP_{it}. — The change in import penetration.

$SINGLE_{it}$ — Dummy variable indicating if an establishment is single and not part of a multi-establishment firm.

$\Delta MULTI_{it-2}$ — Dummy variable indicating if an establishment has been taken over, e.g. was a single in *(t-3)* but part of a multi-establishment firm in *(t-2)*.

$\Delta SINGLE_{it-2}$ — Dummy variable indicating if an establishment was part of a multi-establishment firm in *(t-3)* but part of a multi-establishment firm in *(t-2)*.

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