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RESTRUCTURING AND PRODUCTIVITY GROWTH IN UK MANUFACTURING*

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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 contribution to productivity growth of 'internal' restructuring (such as new technology and organisational change among survivors) and 'external' restructuring (exit, entry and market share change). We find that (a) 'external restructuring' accounts for 50% of establishment labour productivity growth and 80–90% of establishment *TFP* growth; (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.

> '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).

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, 2000), new technology and organisational change (Gregg *et al.* 1993; Haskel and Szymanski, 1997) and increased competition (Blanchflower and Machin, 1996; Nickell *et al.* 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

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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 (1998). 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.

requires representative longitudinal data on survivors, entrants and exitors. Such data are available in only a few countries, notably the US; 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, for 1980-92, 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, 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 establishment labour productivity growth and 80–90% of establishment *TFP* growth.

Second, we extend the US literature on contributions to growth in order to examine the role of multi-establishment firms. Around 75% of manufacturing employment is in establishments that 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 novel and 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 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 of external restructuring is a lower bound on the overall contribution. Moreover, 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 that 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,

[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 (2000), and Oulton (1997, 2000). An earlier study of productivity issues using successive UK *Censuses of Production* directly for 1980–90 is Mayes (1996).

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?

Mayes (1996) and Oulton (2000) are the only analyses, which we are aware of, that look at the accounting contribution of restructuring to UK labour productivity growth (Oulton also studies downsizing). In this paper we go beyond them 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 1 describes the data and measures of labour productivity and *TFP*. Section 2 sets out the data on productivity of entrants, exitors and survivors by time and cohort. Section 3 presents the decompositions and Section 4 looks at the role of external pressures on *TFP* and productivity growth within surviving establishments. Section 5 summarises.

1. Data

1.1. *The ARD Data Set*

Details of the ARD data can be found in Griffith (1999), Oulton (1997) and 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 Appendix A.

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.

[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 (1999) for Chile or Aw *et al.* (1997) for Taiwan). We are not aware of any studies of the competition/productivity link that control for selection.

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' (note an establishment may also be a number of local units that a firm decides to report together). 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 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, it is given a new establishment number and so counts 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 4). We can of course distinguish establishments that exit or enter but are part of a firm from 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 (which asks for outputs and input use). 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 at local unit level if appropriate. Data on these sampled establishments is held in what is called the 'selected' ARD file and the reported output and input information means we can calculate productivity and TFP for these establishments. The 'non-selected' file holds data on the rest of the local units/establishments giving their industry, postcode, reported employment (if they are local units being reported on by a sampled establishment) and

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

[6] For example, in 1986 and 1988, 50% (25%) of units with employment between 50–100 (20–50) were sampled.

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 of whom	142,722	100		4,585,700	100	
Single establishment	119,207		83.6	1,064,100		23.2
Part of enterprise	23,515		16.4	3,521,600		76.8
Survivors of whom	89,231	62.6		4,092,500	89.3	
Single establishment	71,208		79.8	843,500		20.6
Part of enterprise	18,023		20.2	3,249,000		79.4
Entrants of whom	25,890	18.1		194,200	4.2	
Single establishment	23,963		92.6	106,900		55.0
Part of enterprise	1,927		7.4	87,300		45.0
Exitors of whom	27,601	19.3		299,000	6.5	
Single establishment	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 1986–92. 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.

imputed employment (based on register information such as turnover if they are not).[7]

Since the non-selected file does not have independent output and employment information, we cannot calculate productivity for these units. We do use the information on the non-selected file however in two ways. First, because of this sampling method, entry and exit to the selected data is due in part to establishments being sampled or not. Hence we use the both the selected and non-selected data to calculate entry and exit correctly. Second, we use the selected and non-selected data to calculate population weights for the selected data (see note 14 below).[8]

Table 1 shows some basic data. This Table merges the selected and non-selected data for each year 1986-92 (since the calculation of entry and exit in the early 1980s is complicated by changes to the sampling frame) and computes the number of establishments which at any stage entered or exited. The Table shows annual averages. As column 1 shows, on average each year there were around 140,000 establishments. Almost 120,000 were single establishments whilst around 24,000 were businesses consisting of more than one establishment. Of the total number of

[7] ONS reported to us that employment for the non-selected local units was imputed from turnover (turnover coming from tax information) using banded employment/turnover ratios from small local units in the selected data.

[8] Oulton (2000) uses only the selected data in calculating the contribution of entry and exit to productivity, although he also examines the 1970s as well as the period considered here. As he acknowledges, use of only the selected data is likely to overstate entry and exit. Note too that we do not calculate productivity for the non-selected local units given the ONS's statement that the non-selected employment data is interpolated from the turnover data. Finally, Oulton (2000) shows that 65% of establishments, accounting for most of employment, had no change in the numbers of associated local units 1980–9.

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 employment of 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 establishment numbers.

1.2. *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. 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 hour variable that is easily available and interpretable is two-digit manual hours. We calculate (log) *TFP* as

$$\ln TFP_{it} = \ln Y_{it} - \alpha_K \ln K_{it} - \alpha_L \ln L_{it} - \alpha_M \ln M_{it} \tag{1}$$

where Y is real gross output, K real capital, L is worker hours and M real material use, the αs are shares of each factor in gross output and i denotes establishment. M and L are recorded directly from the ARD.[9] 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).[10]

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). A significant issue is the method used to estimate the capital stock. We experimented with a number of different methods of calculation, but whilst these tended to give different measures of $\Delta\ln TFP$, it did not affect the decompositions of $\Delta\ln TFP$ into the parts due to internal and external restructuring. For example, varying the depreciation rates affects $\Delta\ln K$ and $\Delta\ln TFP$ but does not affect the decompositions. On a 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

[9] The ARD also gives labour split into manual and non-manual employment, but this is missing in some cases so to maximise coverage we calculated TFP as shown. Calculations using different employment types gave fewer observations but similar results for the decompositions below.

[10] Bailey *et al.* (1992) construct a similar measure with output and inputs expressed as deviations from industry means. Aw *et al.* (1997) 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).

are of course working with establishment data and hence avoid this particular problem.[11]

A number of other complications affect measures of both $\ln TFP$ and $\ln(Y/L)$. First, we only have average two-digit manual hours on our data, and thus have no measures of non-manual hours.[12] Also, recorded hours may not reflect under-working (overworking) in recessions (booms) (Muellbauer, 1984), thus understating (overstating) $\Delta\ln TFP$. Finally, if there are differences in hours between establishments in the same industry this would bias measures as well; comparisons between entrants and survivors for example might be biased if new entrants work longer hours. We therefore also computed all of our results without an hours correction. The uncorrected results are set out in Appendix B available on www.res.org.uk/economic/ta/tahome.asp.

Third, we only have available four-digit industry deflators. So, for example, an establishment within a four-digit industry charging a higher price for a higher quality good, *ceteris paribus* will have higher measured productivity, and changes in relative prices will show up in our data as apparent productivity differentials and affect the data depending on the quality distribution between survivors, entrants and exitors. Finally, we experimented with calculating α as establishment and industry-specific cost shares, averaging over time periods or choosing contemporaneous values. This made some difference to *TFP* but made no difference to the decompositions. As in Baily *et al.* (1992) and Foster *et al.* (1998), we chose four-digit industry-averages, averaging over beginning and end years over which the productivity is calculated.

Concerning *TFP* and labour productivity, 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 for example changes in ideas and efficiency are primarily due to new establishments with new ideas, then *TFP* growth should be dominated by external factors. If changes in ideas and in efficiency occur within firms (e.g. learning by doing) then the bulk of *TFP* growth should be

[11] Harris and Drinkwater (2000) 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 local units in order 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 that 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 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 (2000) since we use an initial capital stock level for each establishment, allocated pro-rata from the capital stock levels in 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.

[12] Only industry-level manual hours were published regularly in the 1980s; industry non-manual hours would require special calculations and are typically viewed as being badly measured.

Table 2
Summary Statistics (% per annum)

	1980–92	1980–2	1982–9	1989–92
$\Delta\ln Y_t$	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.

due to internal factors. However, if *TFP* is badly measured, $\ln(Y/L)$ gives a better reflection of how markets select establishments of different productivity.[13] Empirically, we find that $\Delta\ln(Y/L)$is very high in the major recession of 1980-82 whilst $\Delta\ln TFP$ is very low, highlighting the divergence of the two measures in periods of capital-labour substitution.

Table 2 sets out summary statistics of whole economy changes, annualised and population employment-weighted.[14] 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 closely with reported changes in official statistics.[15]

2. A First Look at the Disaggregated Data

2.1. *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 defined as

[13] The contributions of entry and exit are likely to differ when using $\ln(Y/L)$ and $\Delta\ln TFP$ if for example, 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, the role of new entry would be no different in accounting term for both methods.

[14] Population weights are applied to the selected sample and are calculated 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.

[15] For example $\Delta\ln(Y/L)$ for manufacturing, 1980–92 was 4.44% p.a. (*Economic Trends*, Annual Supplement, Table 3.5). Note these numbers are on the basis of different output and employment surveys to the ARD. There are no official *TFP* growth statistics. Cameron *et al.* (1998) report growth in value added per head and *TFP* of 4.68% and 3.10% respectively for 1979–89 (1998, Table 1, panel 3 and Table 2, panel 3).

Table 3

Levels of Productivity and TFP for Entrants, Exitors and Survivors (survivors = 100)

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

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

establishments that 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. As we show formally below, entry and exit will raise overall productivity so long as exitors are less productive than entrants. This is clear from Table 3 where, in addition, entrants are more productive than stayers and stayers than exitors.

There are of course several possible reasons for this finding. First, there 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.[16] 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 1*a* and 1*b* show (smoothed) data for the individual years. For both labour productivity and *TFP*, exitor productivity is less than entrant productivity for most of the period, except from 1988–90 for *TFP*. The disparity in *TFP* levels is particularly clear in the sharp recession of the early 1980s.

2.2. *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,[17] 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.

[16] Details of which can be provided by the authors on request.

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

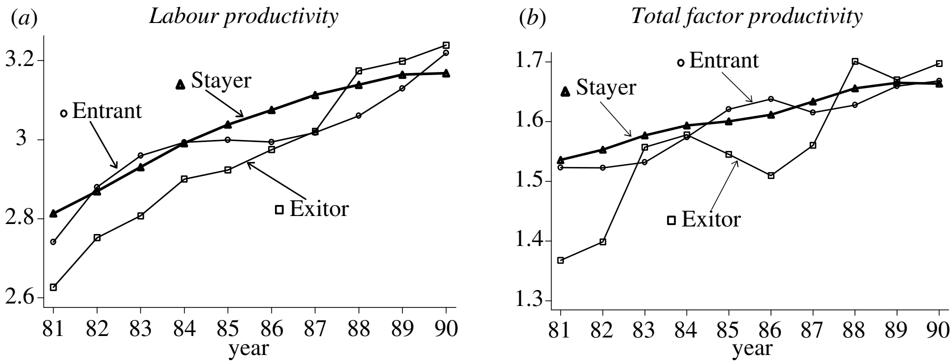

Fig. 1*a,b*. *Average Annual Productivity by Establishment Type*
Note: Population weighted. Smoothed by three year moving averages.
Source: Authors' own calculations using the ARD.

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 explicit models of productivity variance have been proposed; see for example the review in Foster *et al.* (1998) (FHK).[18] 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 by establishment *cohort*.[19] The bottom panel of Table 4 shows the compression of the spread in productivity for the 1982 cohort in 1982, 1987 and 1991. The differentials fall steadily over time, regardless of measure.

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).[20] 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:

[18] 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.

[19] 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.

[20] 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.* (2003) we estimated a more 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.

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 1980–91, selected data only.
Source: Authors' calculations from the ARD.

$$\lambda_{it} = \lambda_0(t)\exp[\alpha_1 relprod(t) + \alpha_2 single(t) + \alpha_3 size(t) + \alpha_4 dummies] \quad (2)$$

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.[21]

If the lowest productivity establishments exited, we would expect a negative coefficient on *relprod*. In Table 5, columns 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 three columns *relprod* is well-determined.

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.

3. Quantifying the Contribution of Restructuring to Productivity Growth

3.1. *Aggregate Decompositions*

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:

[21] 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.* (2003) for more discussion).

Table 5

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

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

Note: In each column *relprod* is measured using *Y/L* or *TFP* as indicated in the column headings. Absolute t-statistics in parenthesis. 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.

$$P_t = \sum_i \theta_{it} p_{it} \tag{3}$$

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 *et al.* (1992) (BHC) relates to the change in manufacturing-wide labour productivity or ln*TFP* between $t-k$ and t, ΔP_t and is written:

$$\Delta P_t = \sum_{i \in S} \theta_{i,t-k} \Delta p_{it} + \sum_{i \in S} \Delta\theta_{it} p_{it} + \sum_{i \in N} \theta_{it} p_{it} - \sum_{i \in X} \theta_{i,t-k} p_{i,t-k} \quad BHC \tag{4}$$

where S, N and X denote the establishments that survive, enter and exit respectively between t and $t-k$. We denote 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 (relative to the establishment). 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.[22]

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 FHK suggest a decomposition in terms of productivity relative to the average:

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

[22] 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. One might argue that rising market share is due to increased productivity, so that the between and covariance terms are also internal restructuring effects. We prefer to call them external since they are a consequence of market activity. Finally, 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.[23] They also suggest using a decomposition due to Griliches and Regev (1992) (GR)

$$\Delta P_t = \sum_{i\in S}\bar{\theta}_i\Delta p_{it} + \sum_{i\in S}\Delta\theta_{it}(\bar{p}_i - \bar{P}) + \sum_{i\in N}\theta_{it}(p_{it} - \bar{P}) - \sum_{i\in X}\theta_{it-k}(p_{i,t-k} - \bar{P}) \quad (6)$$

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, to a certain extent, reflect external restructuring effects since they affect θ.[24]

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) for manufacturing and selected industries (with chemicals and 'computers & office equipment' broadly reflecting 'hi-tech' industries and textiles and 'leather and footwear' reflecting 'low-tech' industries). The Table suggests, as in the discussion in Section 3, that entry and exit are likely to be important in examining productivity change. Columns 1 and 2 show that the market shares of entrants in t and exitors in $t-k$ are substantial in all cases (especially for entrants in computers and exitors in textiles and footwear). Comparing columns 3 and 6, and 4 and 5, reveals that entrants are always more productive than exitors and often more productive than survivors.

[23] 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.

[24] 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.

Table 6

Productivity and Market Shares for Survivors, Exitors and Entrants

	Shares		Relative to whole economy manufacturing productivity, $t-k$			
	(1) Entrants, t	(2) Exitors, $t-k$	(3) Entrants, t	(4) Exitors, $t-k$	(5) Survivors, $t-k$	(6) Survivors, t
Manufacturing						
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 employment population weighted.

Stayers are almost always 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.

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 time periods (see Appendix B on www.res.org.uk/economic/ta/tahome.asp). Our results for the whole period 1980–92, using the employment weights, are set out in Table 7 (for output weights results see Appendix B on www.res.org.uk/economic/ta/tahome.asp). The panels of the Table show the results for $\Delta\ln(Y/L)$ and $\Delta\ln(TFP)$. Each cell shows the percentage of total growth accounted for by each component of the disaggregation. Consider first the results for $\Delta\ln(Y/L)$ in 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 show that the 'internal restructuring/within' effects accounts for about 47-8% of $\Delta\ln(Y/L)$ over the whole period.

The next columns in the panel show the between, cross and net entry effects, which vary across methods. The between effect is 38% under the BHC method and small for the other methods.[25] In the BHC measure, there are no cross-terms and

[25] 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
$\Delta\ln(Y/L)$ 1980–92, (Average productivity growth 4.53% per annum.)				
BHC	48	38	–	14
FHK	48	4	−1	49
GR	47	−1	–	53
$\Delta\ln TFP$ 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).

the net entry effect is small and positive. The net entry effects is much larger using the other 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. In (4), this renders the net entry effect smaller. In addition, with many exitors, 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. Contrast this with the FHK and GR decompositions. 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 $\Delta\ln(Y/L)$ (similar to FHK's results on US data, 1977–87).

The lower panel of Table 7 shows the decompositions for $\Delta\ln TFP$. The *TFP* decompositions are fairly consistent but the results contrast with the $\Delta\ln(Y/L)$ 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. 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 between 1980 and 1992? First, concerning labour productivity, internal and external factors each account for around 50% each of labour productivity growth 1980–92, a picture that is consistent across measures. Second, net entry accounts for most of the external restructuring effect. Third, concerning *TFP* growth, what we term external restructuring accounts for around 80–90% of it with internal restructuring the rest. Fourth, net entry consistently accounts for just over 50% of TFP growth. 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.[26]

3.2. *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. So far as we know, this has not been done in the US literature. Consider the top row, which provides the decomposition for 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 a multi-establishment business. It shows that single surviving establishments accounted for an almost negligible portion (about a half a percentage point) of total productivity growth. By contrast, surviving establishments that were part of a group accounted for 44.6% of overall labour 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 establishment groups accounts for about double this amount. In other words, around a third of total labour productivity growth in manufacturing 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 interesting. Very little *TFP* growth is due to within-establishment 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 calling this 'external' restructuring since around half of it might be regarded as internal in the sense of being within the multi-establishment firm.

3.3. *Robustness Checks*

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 describe our checks on the robustness of these findings. Appendix B, on www.res.org.uk/economic/ta/tahome.asp, provides greater detail, and the calculations on which we base the arguments made here. We consider three issues in this sub-section and the web Appendix: the consequences

[26] Oulton (2000) uses the FHK method to decompose $\Delta\ln(Y/L)$ 1979–89, and finds a net entry contribution of 35.4% (p. 72). Our results in part differ since we use a different sample period. They also differ for three other reasons. First, he uses a shorter period than, which may lower the net entry component (see Appendix B on www.res.org.uk/economic/ta/tahome.asp). Second, he classifies entry and exit using only the selected data, which is likely to raise the net entry component. Third, we use population weights (the θs are population weighted employment shares). His share of exiting plants in 1979 is 37% and entering plants is 33% in 1989 (see his Table 3). Our shares are 42% in 1980 and 50% in 1992 (see our Table 6). This is because our population weights give higher weight to smaller establishments (since the majority of establishments in the non-selected file are small). See also Section 1.1 above, and footnote 8.

Table 8

Productivity Decompositions, Labour Productivity and Total Factor Productivity 1980–92: Singles and Groups

	Within		Between		Cross		Net entry	
	Single	Group	Single	Group	Single	Group	Single	Group
$\Delta\ln(Y/L)$ (Average productivity growth 4.53% per annum.)								
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.)								
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).

of measurement error, sensitivity to length of period and the post-entry productivity growth of entrants.

There are three possible sources of measurement error. First, as mentioned in footnote 23, 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 energy use. If, for example, small establishments have lower capital-energy 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.[27] 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 1992 are at roughly the same point in the cycle the bias from hours is unlikely to be important. Moreover, since measurement error is likely to overstate 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.

Next, there are several arguments concerning the sensitivity of the relative contributions of entry, exit and survival to various assumptions and procedures that we have adopted. First, there is the sensitivity of the results to whether employment is adjusted for hours. Second, there is the issue of whether establishments should be weighted by employment (as is the case in the results illustrated here) or by output. Third, the results may be sensitive to the period chosen. In turn, there are at least two issues here: a long period reduces the number of survivors and increases the number of entrants, potentially raising the net entry effect, while different periods cover recessions and booms which may have differential impacts on the quality of entrants and exitors.

These arguments are explored in greater detail in Appendix B on www.res.org.uk/economic/ta/tahome.asp. The conclusions of that analysis are as follows. First, whether labour input is adjusted for hours or not makes very little difference to the

[27] The survivors' initial capital error is substantially depreciated by 1991.

decomposition results. Second, however, weighting establishments by output rather than employment only marginally reduces the net entry effect, raises the cross (covariance) effect in the FHK decomposition, and reduces the 'within' effect. Third, the $\Delta\ln(Y/L)$ contributions for entry, exit and survival are largely invariant to whether the economy is booming or in recession. However measured $\Delta\ln TFP$ becomes volatile over very short periods and no conclusions can be drawn concerning the cyclical components of $\Delta\ln TFP$ (although this does not refute the evidence that $\Delta\ln TFP$ as a whole is procyclical, illustrated in Table 2 above).

In considering the impact of length of period on contributions to productivity growth, Appendix B, on www.res.org.uk/economic/ta/tahome.asp, provides two general robustness checks. First, shortening the period under review does not reduce the size of the net entry effect, especially for $\Delta\ln(Y/L)$; at least until very short periods (of not more than four years) are considered. Thus the impacts of entry, exit and survival are not specific to the length of period chosen within 1980–92. Second, we consider the possibility that part of the 'entry effect' arises post-entry, since, for example, a 1980 entrant is still considered as an 'entrant' in 1992. We find however that the contribution of successive cohorts to overall measured productivity growth is not simply a function of time elapsed: in fact the cumulative contribution of the entrants in the early 1980s is rather small while that of the establishments that entered in the boom of the mid-1980s to end point productivity is much greater. This may suggest that entrant quality does indeed differ over the economic cycle, although we cannot confirm this without a greater run of data. Finally, using the econometric methodology suggested by Aw *et al.* (1997) we show that much of the productivity growth contribution of entrants is high productivity at entry rather than growth since entry.

Finally, as a further comparison, Table 9 compares our results to the US, using Haltiwanger's (1997) results for 1982–7 for all US manufacturing. Both decompositions are output weighted, but our UK figures are also population weighted,

Table 9

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, Tables 3 and 4.) Source of UK data: authors' own calculations using ARD.

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 that 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 larger in the UK. Without more detailed knowledge of data, weighting etc, we are cautious about coming to precise conclusions.

4. 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 the extent to which 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.[28] To estimate the productivity-competition relation, we run the following equation

$$\ln Y_{it} = \alpha_1 \ln K_{it} + \alpha_2 \ln M_{it} + \alpha_3 \ln L^S_{it} + \alpha_4 \ln L^U_{it} + \alpha_5 \ln h_{It} + \beta_1 Z_{1it} + \beta_2 Z_{2it} t + \mu_i + \mu_I + \mu_t + \varepsilon_{it} \quad \text{if} \quad i \in S \tag{7}$$

which simply says that the level of output Y depends on the inputs K, M, L^S (non-manual employment), L^U (manual employment), (industry) hours, h, a vector of variables $\mathbf{Z}_1$, fixed effects, industry effects, time effects (μ_i, μ_I, μ_t) and a random error, whilst output *growth* depends on a vector $\mathbf{Z}_2$. S denotes the set of survivors. In contrast to ln *TFP*, but we do not constrain the output elasticities of the inputs to be the factor shares, but estimate them (results were the same when we allowed them to vary by industry). For shorthand let us call $\mathbf{Z}_1$ and $\mathbf{Z}_2$ the determinants of estimated ln *TFP* where $\mathbf{Z}_1$ ($\mathbf{Z}_2$) determines the level (growth) of estimated ln *TFP*. Market competition will enter in vectors $\mathbf{Z}_1$ and $\mathbf{Z}_2$.

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 several possible methods of identifying this selection. For example, Olley and Pakes (1996) attempt to model selection structurally by postulating an explicit model of exit; see also Pavcnik (1999), and Levinsohn and 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

[28] 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 (1999) regressed estimated *TFP* on various trade liberalisation measures.

depends on what might be strong assumptions in the model.[29] 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.[30] 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, among small firms, 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 $\mathbf{Z}_1$ and $\mathbf{Z}_2$ have been considered in the literature. First, product market competition, our main focus, might appear in $\mathbf{Z}_1$, if high competition raises the level of estimated *TFP* (Nickell *et al.*, 1992; Nickell, 1996), and in $\mathbf{Z}_2$ if competition raises its growth (Nickell, 1996). Second, ownership might appear in $\mathbf{Z}_1$ or $\mathbf{Z}_2$ 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

[29] 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.

[30] Whether fallback and exit profits are the same depends upon the exact structure of the effort bargaining game. In the exogenous breakdown case (Binmore *et al.*, 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.

we have omitted variables (as we surely have), they would have to be over and above establishment, time and industry effects.[31]

Following Nickell (1996), we have four potential measures of market competition, industry concentration ($CONC_{It}$), industry import penetration ($IMPORT_{It}$), market share ($MSHARE_{it}$) and rents ($RENTS_{it}$). The first two are standard industry-level variables; we have no establishment-specific trade data (as with other industry variables) so this is likely to be insignificant if it is uncorrelated with the extent of foreign competition across establishments. $MSHARE_{it}$ 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 coefficient. They are of course both potentially endogenous, since higher efficiency would raise rents and market share, attracting a positive coefficient. We therefore lag both measures by two years, noting that any endogeneity would bias the estimated coefficients 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

$$\begin{aligned}\Delta \ln Y_{it} = {} & \alpha_1 \Delta \ln K_{it} + \alpha_2 \Delta \ln M_{it} + \alpha_3 \Delta \ln L^S_{it} + \alpha_4 \Delta \ln L^U_{it} + \alpha_5 \Delta \ln h_{It} \\ & + \beta_{11} \Delta MSHARE_{it-2} + \beta_{12} \Delta RENTS_{it-2} + \beta_{13} \Delta CONC_{It} + \beta_{14} \Delta IMPORT_{It} \\ & + \beta_{15} \Delta OWNER_{it-2} + \beta_{21} RENTS_{it-2} + \beta_{22} CONC_{It} + \beta_{23} IMPORT_{It} \\ & + \beta_{24} OWNER_{it-2} + \mu_I + \mu_t + \Delta \varepsilon_{1it} \qquad (8)\end{aligned}$$

[31] Unions might appear in $\mathbf{Z}_1$ or $\mathbf{Z}_2$; see, e.g. Freeman and Medoff (1985) or Gregg *et al.* (1993). Our only panel union information is a two-digit measure that is unlikely to capture the establishment-level union variation. It was never significant in any regressions and we therefore dropped it.

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 10 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 but available from the authors) and as the final row of Table 10 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 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. $\Delta MSHARE_{it-2}$ is not significant however. Turning to the level variables, $RENTS_{it-2}$ is highly 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 other effects are insignificant.[35] The second column retains the key competition variables, and the effects of $\Delta MSHARE_{it-2}$, $\Delta RENTS_{it-2}$, $RENTS_{it-2}$ and UK_{it-2} remain.

[32] 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 coefficients on K, M, L^S, L^U are in fact similar to their average output shares. The coefficient 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.

[35] ΔFOR is when a previously UK establishment becomes foreign owned, ΔUK is when a previously foreign establishment becomes British owned, $\Delta SINGLE$ is when a previously single establishment becomes part of a multi-establishment firm and $\Delta MULTI$ is when a previously multi-establishment becomes single.

Table 10

The Productivity/Competition Relation with Selection (dependent variable $\Delta \ln Y_{it}$)

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Selectivity corrected estimates						
Instruments	$\ln K$, $\ln I$ + powers	As (1)	Variable 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	0.09	0.12
	(15.58)	(15.76)	(18.00)	(8.66)	(17.99)	(15.76)	(7.22)
$\Delta \ln M_{it}$	0.46	0.46	0.46	0.46	0.46	0.45	0.42
	(137.08)	(138.41)	(201.60)	(106.54)	(201.59)	(123.44)	(35.51)
$\Delta \ln S_{it}$	0.10	0.10	0.10	0.11	0.10	0.10	0.12
	(33.53)	(34.21)	(41.81)	(22.64)	(41.76)	(30.85)	(12.44)
$\Delta \ln U_{it}$	0.26	0.26	0.26	0.25	0.26	0.26	0.30
	(63.38)	(63.91)	(80.63)	(42.70)	(80.55)	(56.54)	(21.61)
$\Delta \ln h_{It}$	0.76	0.77	0.77	0.88	0.77	0.69	0.74
	(7.51)	(7.63)	(8.69)	(5.34)	(8.69)	(6.48)	(2.14)
Compet vars							
$\Delta MSHARE_{it-2}$	−0.07	−0.06	−0.06	−0.04	−0.07	−0.05	0.13
	(1.24)	(1.17)	(1.15)	(0.39)	(1.16)	(0.90)	(1.19)
$\Delta RENTS_{it-2}$*	−0.14	−0.13	−0.14	−0.14	−0.14	−0.13	−0.01
	(4.44)	(4.32)	(4.97)	(2.70)	(4.99)	(3.56)	(0.13)
$RENTS_{it-2}$	−0.03	−0.03	−0.03	−0.03	−0.03	−0.03	−0.05
	(12.86)	(13.43)	(14.87)	(8.34)	(14.82)	(12.34)	(6.91)
UK_{it-2}*	−0.05	−0.05	−0.06	−0.06	−0.06	−0.06	−0.01
	(3.43)	(3.84)	(4.39)	(2.89)	(4.47)	(3.54)	(3.01)
$\Delta CONC_{It}$*	0.09						
	(0.70)						
$\Delta IMPORT_{It}$	−0.01						
	(1.17)						
ΔFOR_{it-2}*	0.01						
	(1.26)						
ΔUK_{it-2}*	0.01						
	(0.21)						
$\Delta MULTI_{it-2}$*	0.02						
	(0.65)						
$\Delta SINGLE_{it-2}$*	−0.04						
	(1.08)						
$CONC_{It}$*	0.03						
	(1.11)						
$IMPORT_{It}$*	0.06						
	(1.69)						
$SINGLE_{it}$**	0.06						
	(0.47)						
Observations	57,988	62,188	59,605	16,526	59,605	48,380	6,900
R-squared	–	–	–	–	–	0.57	0.56
Signif. of ρ	7.81	8.07	3.98	2.41	6.97	–	–

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

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 (48,380 observations) and column 7 further restricts the sample to establishments of over 600 (here the sample size falls to 6,900 and the average size of firm is now about 1,400 which is close to the average size in Nickell's sample).[37] The competition variables are robust in column 6, but in column 7 $\Delta MSHARE_{it-2}$ becomes positive (but insignificant) and $\Delta RENTS_{it-2}$ becomes insignificant. $RENTS_{it-2}$ is still well-determined.

To interpret the coefficients on $\Delta MSHARE_{it-2}$ and $RENTS_{it-2}$ more easily, Table 11 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 give some support to the theoretical prediction that sample selection bias renders the competition effects overstated in the most selected sample. The $RENTS_i$ effects fall steadily (in absolute value) as the sample becomes less selected. The effect of $MSHARE_i$, which is positive in the first column, is higher in absolute value in column 2 than column 3 (recall that this variable was insignificant and hence not too much can be read into this).

The rest of Table 11 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 larger than those for our bigger sample as theory predicts. Second, the right hand panel shows how, *ceteris paribus*, productivity *growth*

[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 11

Elasticities of Competition Terms at Sample Means

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
					Effect on $\Delta \ln TFP$ from *RENTS*		
					Our results		
	emp > 600	1980–92 survivors	All establishments	Nickell (1996)	emp > 600	all	Nickell
Elasticity							
$MSHARE_i$	0.00604	−0.0012	−0.00096	−0.035			
$RENTS_i$	−0.01699	−0.00781	−0.00765		0.016	0.013	0.042
Sample means							
$MSHARE_i$	0.050	0.024	0.015				
$RENTS_i$	0.3448	0.2821	0.2750		0.34	0.49	0.29
Observations	6,900	48,380	62,188	978/4,423			
Average emp	1,486	341	279				

Notes: elasticities use coefficients of $\Delta MSHARE_i$ and $RENTS_i$ from Table 10, columns 2, 6 and 7. Elasticities are calculated at sample means using averages shown in the lower panel of the 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 $\Delta \ln TFP$ 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.

differs between establishments at the 80th and 20th percentile of the rents distribution. On our full data, such differences amount to about 1.3 percentage points in estimated *TFP*. The sample of over 600 employees finds differences of about 1.6 percentage points and Nickell finds differences of around 4 percentage points, suggesting again that more selected samples give higher competition effects.

Finally, we tried out a number of different experiments (not reported but available on request from the authors). 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. Third, we added 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.

5. Conclusion

Our main 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 extensively. 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 80–90% of TFP growth in establishments. The contribution of entry and exit, which accounts for around 50% of labour productivity and TFP growth over the period, arises because entrants are more productive than exitors. The difference between the results for labour productivity and *TFP* growth is likely to be due to capital-labour substitution among survivors. We examine the sensitivity of these results to a variety of different assumptions.
(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) Comparing the US and the UK, 1982–7, 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 three speculative remarks. First, using US TFP data, FHK argue that recessions are periods of large external restructuring whilst the productivity of surviving firms remains static. We are more tentative about concluding this for the UK due to measurement worries. Second, 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). Third, 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. 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.

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Appendix A: Data

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 the Institue for Fiscal Studies. 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 two-digit 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 $(t-2)$.
$CONC_{It}$	Current concentration ratio. It is the five largest establishments' gross output share of four digit industry total gross output.
$\Delta CONC_{It}$.	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.

Appendix A *Continued*

ΔFOR_{it-2}.	Dummy variable indicating if an establishment was UK owned in $(t-3)$ but foreign owned in $(t-2)$.
$IMPORT_{It}$	Import penetration. Imports as a fraction of (imports – exports + sales) measured at three digit industry level.
$\Delta IMPORT_{It}$.	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 was a single establishment firm in $(t-2)$.

Technical Appendix is available for this paper: www.res.org.uk/economic/ta/tahome.asp

References

Aw, B. Y., Chen, X. and Roberts, M. J. (1997). 'Firm-level evidence on productivity differentials, turnover, and exports in Taiwanese manufacturing', NBER working paper 6235, October.

Baden-Fuller, C. (1989). 'Exit from declining industries and the case of steel castings', ECONOMIC JOURNAL, vol. 99 (December), pp. 949–69.

Bartelsman, E. and Doms, M. (2000). 'Understanding productivity: lessons from longitudinal microdata', *Journal of Economic Literature*, vol. 38 (September), pp. 569–94.

Baily, M.N., Hulten, C. and Campbell, D. (1992). 'Productivity dynamics in manufacturing plants', *Brookings Papers on Economic Activity, Microeconomics*, pp. 187–249.

Binmore, K., Rubinstein, A. and Wolinsky, A. (1986). 'The Nash bargaining solution in economic modelling', *Rand Journal of Economics*, vol. 17(2), Summer, pp.. 176–88.

Blanchflower, D. and Machin, S. (1996). 'Product market competition, wages and productivity: international evidence from establishment-level data', London School of Economics, Centre for Economic Performance Discussion Paper 286, April.

Cabral, L. M. B. (1993). 'Experience advantages and entry dynamics', *Journal of Economic Theory*, vol. 59(2), pp. 403–16.

Cameron, G., Proudman, J. and Redding, S. (1998). 'Openness and its association with productivity growth in UK manufacturing industry', in: (J. Proudman and S. Redding, eds.), *Openness and Growth*, London: Bank of England.

Caves, R. E. (1998). 'Industrial organization and new findings on the turnover and mobility of firms', *Journal of Economic Literature*, vol. 36 (8 December), pp. 1947–82.

Cox, D. R. (1972). 'Regression models and life tables', *Journal of the Royal Statistical Society*, vol. 34 (May/August), pp. 187–220.

Disney, R., Haskel, J. and Heden, Y. (2003). 'Exit entry and establishment survival in UK manufacturing', *Journal of Industrial Economics*, vol. 51 (March), pp. 93–115.

Foster, L., Haltiwanger J. and Krizan C. (1998). 'Aggregate productivity growth: lessons from microeconomic evidence', NBER working paper 6803.

Freeman, R. B. and Medoff, J. L. (1985). *'What Do Unions Do?'*, Basic Books Inc.

Gregg, P, Machin, S. and Metcalf, D. (1993). 'Signals and cycles: productivity growth and changes in union status in British companies 1984-1989', ECONOMIC JOURNAL, vol. 103 (July), pp. 894–907.

Griffith, R. (1999). 'Using the ARD establishment level data to look at foreign ownership and productivity in the UK', ECONOMIC JOURNAL, vol. 109 (June), pp. F416–42.

Griliches, Z. and Regev, H. (1992). 'Productivity and firm turnover in Israeli industry 1979–88', NBER working paper 4059.

Griliches, Z. and Marisse, J. (1995). 'Production functions: the search for identification', Harvard Economics Department Working Paper, 1719, April.

Haltiwanger, J. (1997), 'Measuring and analyzing aggregate fluctuations: the importance of building from microeconomic evidence', Mimeo, University of Maryland.

Harris, R. I. D. and Drinkwater, S. (2000), 'UK plant and machinery capital stocks and plant closures', *Oxford Bulletin of Economics and Statistics*, vol. 62, pp. 239–61.

Haskel, J. (1991). 'Imperfect competition, work practices and productivity growth', *Oxford Bulletin of Economics and Statistics*, vol. 53(3), (August), vol. 265–80.

Haskel, J. and Heden Y. (1999). 'Computers and the demand for labour: industry and establishment-level evidence for the UK', ECONOMIC JOURNAL, vol. 109 (454), pp. C68–79.

Haskel, J. and Szymanski, S. (1997), 'The effects of privatisation, competition and restructuring on productivity growth in UK manufacturing', Queen Mary and Westfield College, Department of Economics, Discussion Paper 286, January.

Helpman, E. and Rangel, A, (1999). 'Adjusting to a new technology: experience and training', *Journal of Economic Growth*, vol. 4(4), (December), pp. 359–83.

Hopehayn, H. A. (1992). 'Entry, exit and firm dynamics in long run equilibrium', *Econometrica*, vol. 60(3), pp. 1127–50.

Hulten, C. R. (2000). 'Total factor productivity: a short biography', NBER working paper 7471.

Jovanovic, B. (1982). 'Selection and the evolution of firms'. *Econometrica*, vol. 50 (May), pp. 649–70.

Levinsohn, J. and Petrin, A. (1999). 'When industries become more productive, do firms? Investigating productivity dynamics', NBER working paper 6893.

Mayes, D. G. (1996). *Sources of Productivity Growth*, Cambridge: Cambridge University Press.

Muellbauer, J. (1984). 'Aggregate production functions and productivity measurement: a new look', CEPR, Discussion Paper no. 34.

Nickell, S. (1996). 'Competition and corporate performance', *Journal of Political Economy*, vol. 104 (August), pp. 724–46.

Nickell, S., Wadhwani, S. and Wall, M. (1992). 'Productivity growth in UK companies', *European Economic Review*, vol. 36, pp. 1055–91.

O'Mahony, M. and Oulton, N. (1990). 'Industry-level estimates of the capital stock in UK manufacturing, 1948–85', NIESR Discussion paper, no 172, London.

Olley, G. S. and Pakes, A. (1996). 'The dynamics of productivity in the telecommunications equipment industry', *Econometrica*, vol. 64(6), pp. 1263–97.

Oulton, N. (1997). 'The ABI respondents database: a new resource for industrial economics research', *Economic Trends*, vol. 528 (November), pp. 46–57.

Oulton, N. (2000). 'A tale of two cycles, closure downsizing and productivity growth in UK manufacturing, 1973–89'. *National Institute Economic Review*, no. 173 (July), pp. 66-79.

Pakes, A. and Ericson, R. (1998). 'Empirical implications of alternative models of firm dynamics'. *Journal of Economic Theory*, vol. 79(1), pp. 1–45.

Pavcnik, N. (1999). 'Trade liberalization, exit, and productivity improvements: evidence from Chilean plants', Dartmouth College, Mimeo.

Sutton, J. (1996), *Sunk Costs and Market Structure*, Cambridge and London: MIT Press.

Wadhwani, S. and Wall, M. (1986). 'The UK capital stock: new estimates of premature scrapping', *Oxford Review of Economic Policy*, vol. 2 (August).